Licence Sciences Pour la Santé

Faculté de Médecine Lyon-Est

UNIVERSITÉ DE LYON

Université Claude Bernard Lyon 1

UE Bases en Sciences de la vie

PARTIE CHIMIE (JEAN-MARC LANCELIN)

COURS 4/4 DU LUNDI 7 OCTOBRE 2021

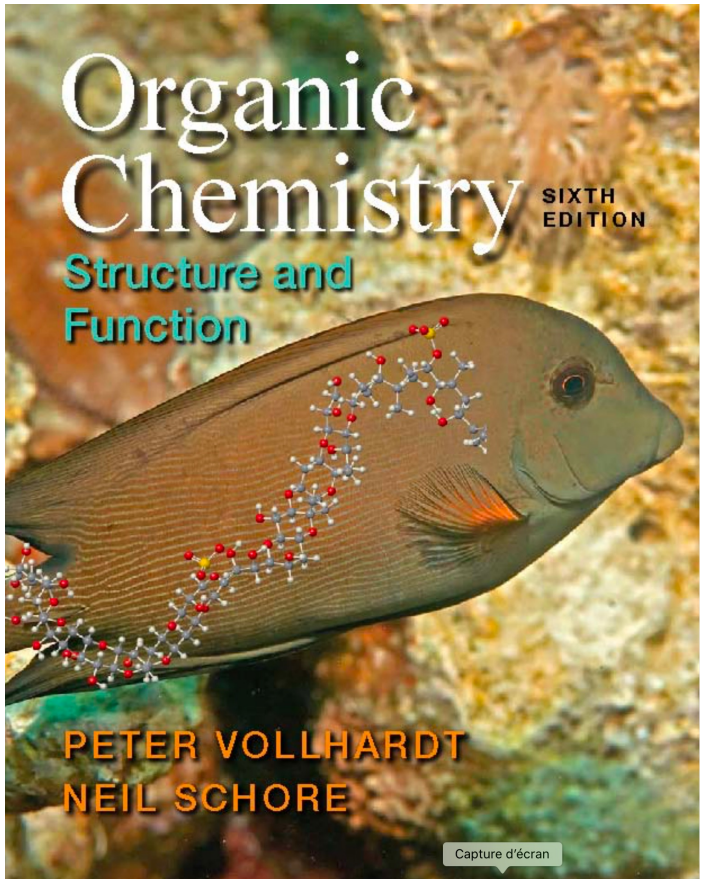
Buts de la partie chimie de l'UE bases en SV

Faculté des Sciences

- Donner les bases de chimie pour les Sciences de la Vie
- Eléments, liaisons, molécules,
- Acides-bases (faibles surtout) en solutions aqueuses
- **Corrections des exercices de la semaine dernière**
- **Structure moléculaire et fonctions organiques, différents types d'isomérismes**.
- 4 séances de cours / 2 TD

« Best seller » support

Volhardt & Shore , *Organic Chemistry*, Freeman, 2014



http://www.cchem.berkeley.edu/kpvgrp/Teaching.htm

- Chapitre 2, 4

Structure moléculaire et fonctio[illegible] organiques

Faculté [illegible] des Sciences [illegible]

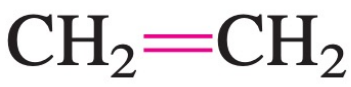
Alkanes

CH_4	$CH_3—CH_3$	$CH_3—CH_2—CH_3$	$CH_3—CH_2—CH_2—CH_3$
Methane	**Ethane**	**Propane**	**Butane**

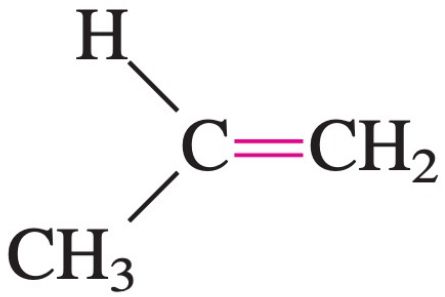
Structure moléculaire et fonctions organiques

Faculté des Sciences

Alkenes and Alkynes



Ethene (Ethylene)



Propene

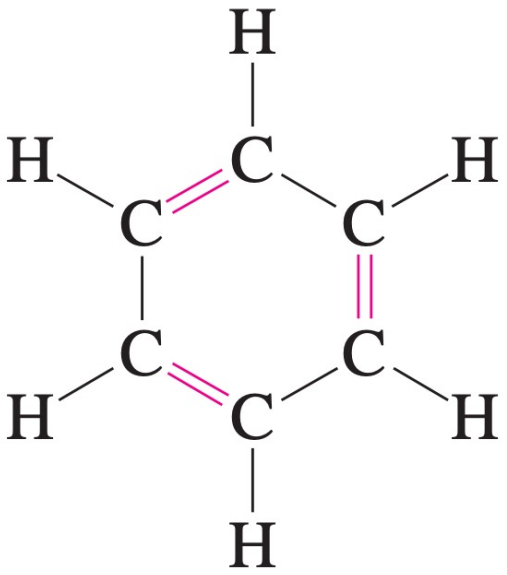
Ethyne (Acetylene)

Propyne

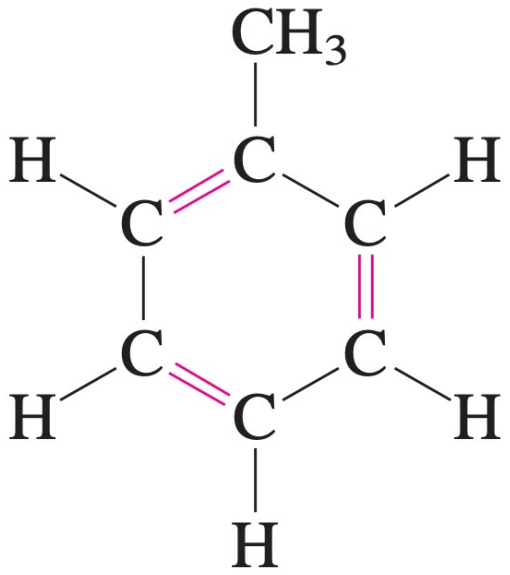
Structure moléculaire et fonctions organiques

Faculté des Sciences

Aromatic Compounds (Arenes)



Benzene



Methylbenzene (Toluene)

Structure moléculaire et fonctions organiques

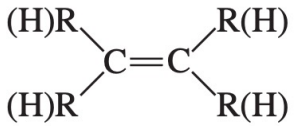
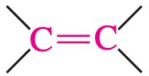
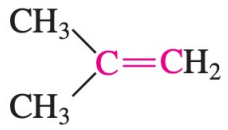
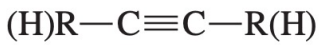
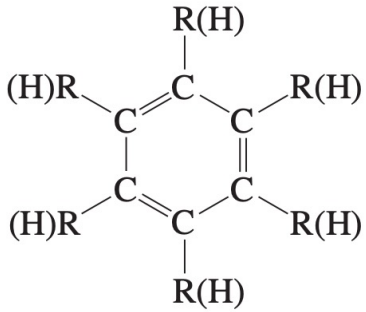
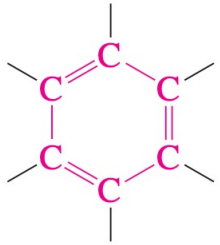
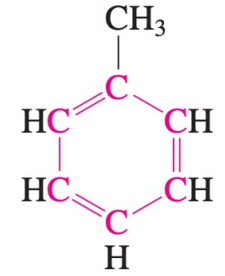
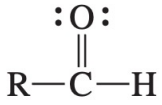
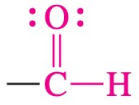
Faculté des Sciences

Table 2-3 Common Functional Groups

Compound class	General structure[a]	Functional group	Example
Alkanes (Chapters 3, 4)	R—H	None	$CH_3CH_2CH_2CH_3$ **Butane**
Haloalkanes (Chapters 6, 7)	R—X: (X = F, Cl, Br, I)	—X:	CH_3CH_2—Br: **Bromoethane**
Alcohols (Chapters 8, 9)	R—OH	—OH	$(CH_3)_2CH$—OH **2-Propanol (Isopropyl alcohol)**
Ethers (Chapter 9)	R—O—R′	—O—	CH_3CH_2—O—CH_3 **Methoxyethane (Ethyl methyl ether)**
Thiols (Chapter 9)	R—SH	—SH	CH_3CH_2—SH **Ethanethiol**

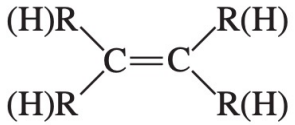
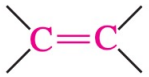
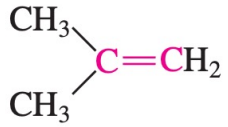
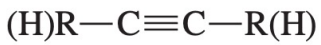
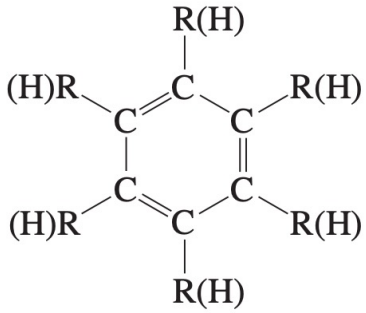
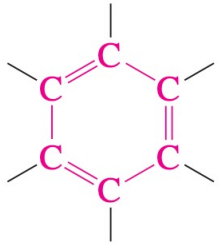
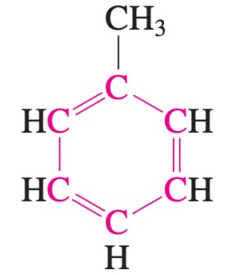
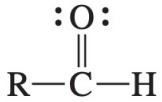
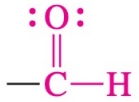
Structure moléculaire et fonctions organiques

Faculté des Sciences

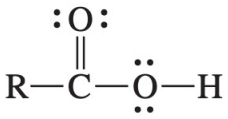
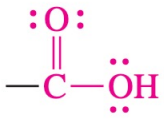
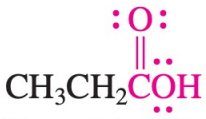
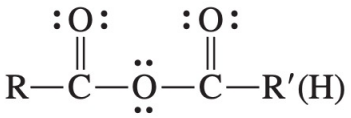
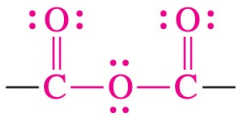
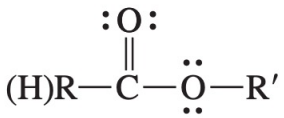
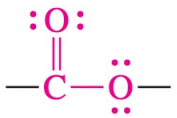
Alkenes (Chapters 11, 12)			 **2-Methylpropene**
Alkynes (Chapter 13)			 **2-Butyne**
Aromatic compounds (Chapters 15, 16, 22)			 **Methylbenzene (Toluene)**
Aldehydes (Chapters 17, 18)			 **Propanal**

Structure moléculaire et fonctions organiques

Faculté des Sciences

Alkenes (Chapters 11, 12)			 **2-Methylpropene**
Alkynes (Chapter 13)			 **2-Butyne**
Aromatic compounds (Chapters 15, 16, 22)			 **Methylbenzene (Toluene)**
Aldehydes (Chapters 17, 18)			 **Propanal**

Structure moléculaire et fonctions organiques

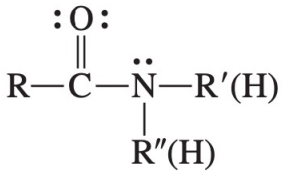
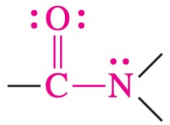
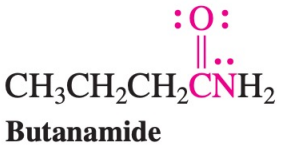
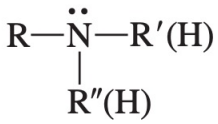
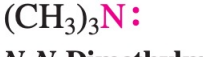
Ketones (Chapters 17, 18)			 **3-Hexanone**
Carboxylic acids (Chapters 19, 20)			 **Propanoic acid**
Anhydrides (Chapters 19, 20)			 **Propanoic anhydride**
Esters (Chapters 19, 20, 23)			 **Methyl propanoate (Methyl propionate)**

[a]The letter R denotes an alkyl group (see text). Different alkyl groups can be distinguished by adding primes to the letter R: R′, R″, and so forth.

Structure moléculaire et fonctions organiques

Faculté des Sciences

Table 2-3 (continued)

Compound class	General structure	Functional group	Example
Amides (Chapters 19, 20, 26)			 **Butanamide**
Nitriles (Chapter 20)			 **Ethanenitrile (Acetonitrile)**
Amines (Chapter 21)			 **N,N-Dimethylmethanamine (Trimethylamine)**

Structure moléculaire et fonctions organiques

Faculté des Sciences

Haloalkanes

Chloromethane
(Methyl chloride)

Chloroethane
(Ethyl chloride)

(Topical anesthetics)

Alcohols

Methanol

(Wood alcohol)

Ethanol

(Grain alcohol)

Ethers

Methoxymethane
(Dimethyl ether)

(A refrigerant)

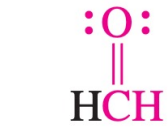
Ethoxyethane
(Diethyl ether)

(An inhalation anesthetic)

Structure moléculaire et fonctions organiques

Faculté des Sciences

Aldehydes



Formaldehyde

(A disinfectant)

Acetaldehyde

(A hypnotic)

Ketones

Acetone

Butanone
(Methyl ethyl ketone)

(Common solvents)

Carboxylic Acids

Formic acid

(Strong irritant)

Acetic acid

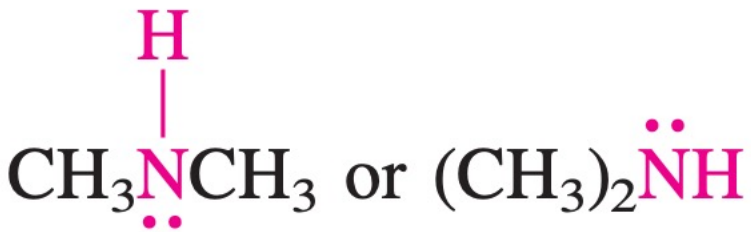
(In vinegar)

Structure moléculaire et fonctions organiques

Faculté des Sciences

Amines

Methanamine (Methylamine)



***N*-Methylmethanamine (Dimethylamine)**

(Used in tanning leather)

A Thiol

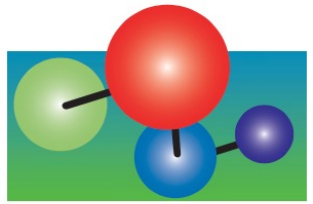
Methanethiol

(Excreted after we eat asparagus)

Structure moléculaire et fonctions organiques

Faculté des Sciences

MODEL BUILDING

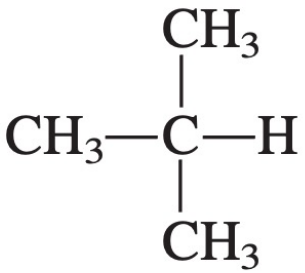


A Straight-Chain Alkane

$CH_3—CH_2—CH_2—CH_3$

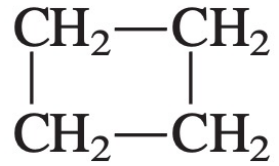
Butane, C_4H_{10}

A Branched Alkane



2-Methylpropane, C_4H_{10} (Isobutane)

A Cycloalkane

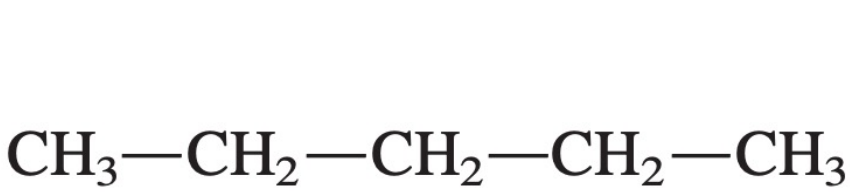


Cyclobutane, C_4H_8

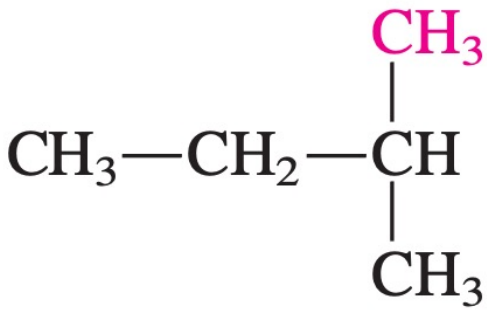
Structure moléculaire et fonctions organiques

Faculté des Sciences

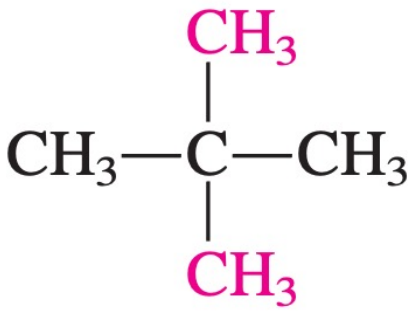
The Isomeric Pentanes



Pentane



2-Methylbutane (Isopentane)



2,2-Dimethylpropane (Neopentane)

Structure moléculaire et fonctions organiques

Faculté des Sciences

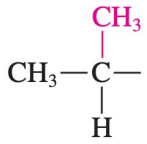
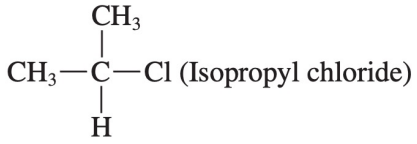
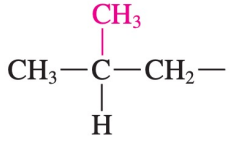
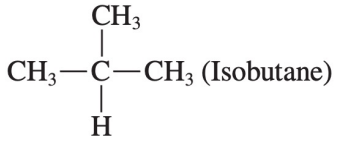
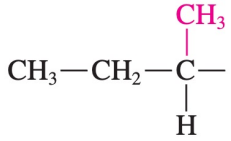
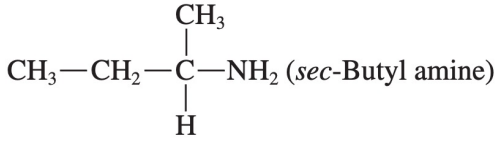
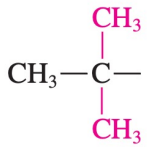
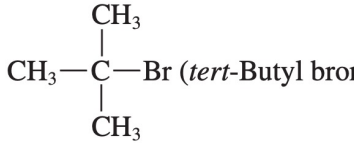
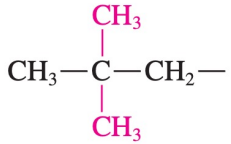
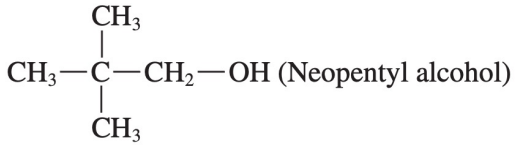
Table 2-5 Names and Physical Properties of Straight-Chain Alkanes, C_nH_{2n+2}

n	Name	Formula	Boiling point (°C)	Melting point (°C)	Density at 20°C (g mL^{-1})
1	Methane	CH_4	−161.7	−182.5	0.466 (at −164°C)
2	Ethane	CH_3CH_3	−88.6	−183.3	0.572 (at −100°C)
3	Propane	$CH_3CH_2CH_3$	−42.1	−187.7	0.5853 (at −45°C)
4	Butane	$CH_3CH_2CH_2CH_3$	−0.5	−138.3	0.5787
5	Pentane	$CH_3(CH_2)_3CH_3$	36.1	−129.8	0.6262
6	Hexane	$CH_3(CH_2)_4CH_3$	68.7	−95.3	0.6603
7	Heptane	$CH_3(CH_2)_5CH_3$	98.4	−90.6	0.6837
8	Octane	$CH_3(CH_2)_6CH_3$	125.7	−56.8	0.7026
9	Nonane	$CH_3(CH_2)_7CH_3$	150.8	−53.5	0.7177
10	Decane	$CH_3(CH_2)_8CH_3$	174.0	−29.7	0.7299
11	Undecane	$CH_3(CH_2)_9CH_3$	195.8	−25.6	0.7402
12	Dodecane	$CH_3(CH_2)_{10}CH_3$	216.3	−9.6	0.7487
13	Tridecane	$CH_3(CH_2)_{11}CH_3$	235.4	−5.5	0.7564
14	Tetradecane	$CH_3(CH_2)_{12}CH_3$	253.7	5.9	0.7628
15	Pentadecane	$CH_3(CH_2)_{13}CH_3$	270.6	10	0.7685
16	Hexadecane	$CH_3(CH_2)_{14}CH_3$	287	18.2	0.7733
17	Heptadecane	$CH_3(CH_2)_{15}CH_3$	301.8	22	0.7780
18	Octadecane	$CH_3(CH_2)_{16}CH_3$	316.1	28.2	0.7768
19	Nonadecane	$CH_3(CH_2)_{17}CH_3$	329.7	32.1	0.7855
20	Icosane	$CH_3(CH_2)_{18}CH_3$	343	36.8	0.7886

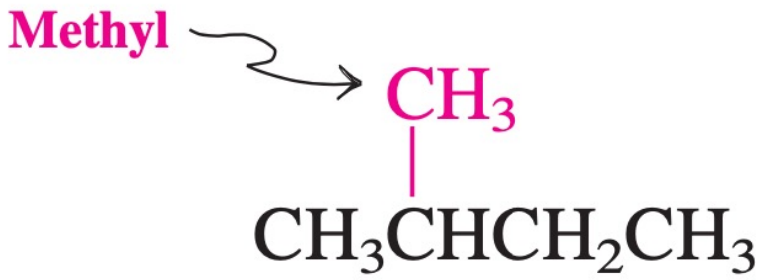
Structure moléculaire et fonctions organiques

Faculté des Sciences

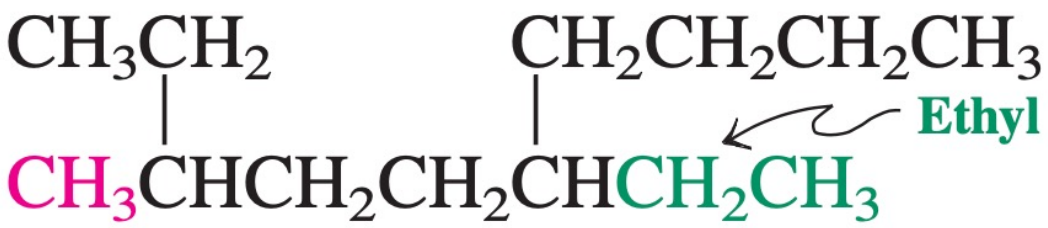
Table 2-6 Branched Alkyl Groups

Structure	Common name	Example of common name in use	Systematic name	Type of group
	Isopropyl	 (Isopropyl chloride)	1-Methylethyl	Secondary
	Isobutyl	 (Isobutane)	2-Methylpropyl	Primary
	*sec*-Butyl	 (*sec*-Butyl amine)	1-Methylpropyl	Secondary
	*tert*-Butyl	 (*tert*-Butyl bromide)	1,1-Dimethylethyl	Tertiary
	Neopentyl	 (Neopentyl alcohol)	2,2-Dimethylpropyl	Primary

Structure moléculaire et fonctions organiques



A methyl-substituted butane
(A methylbutane)



An ethyl- and methyl-substituted decane
(An ethylmethyldecane)

Structure moléculaire et fonctions organiques

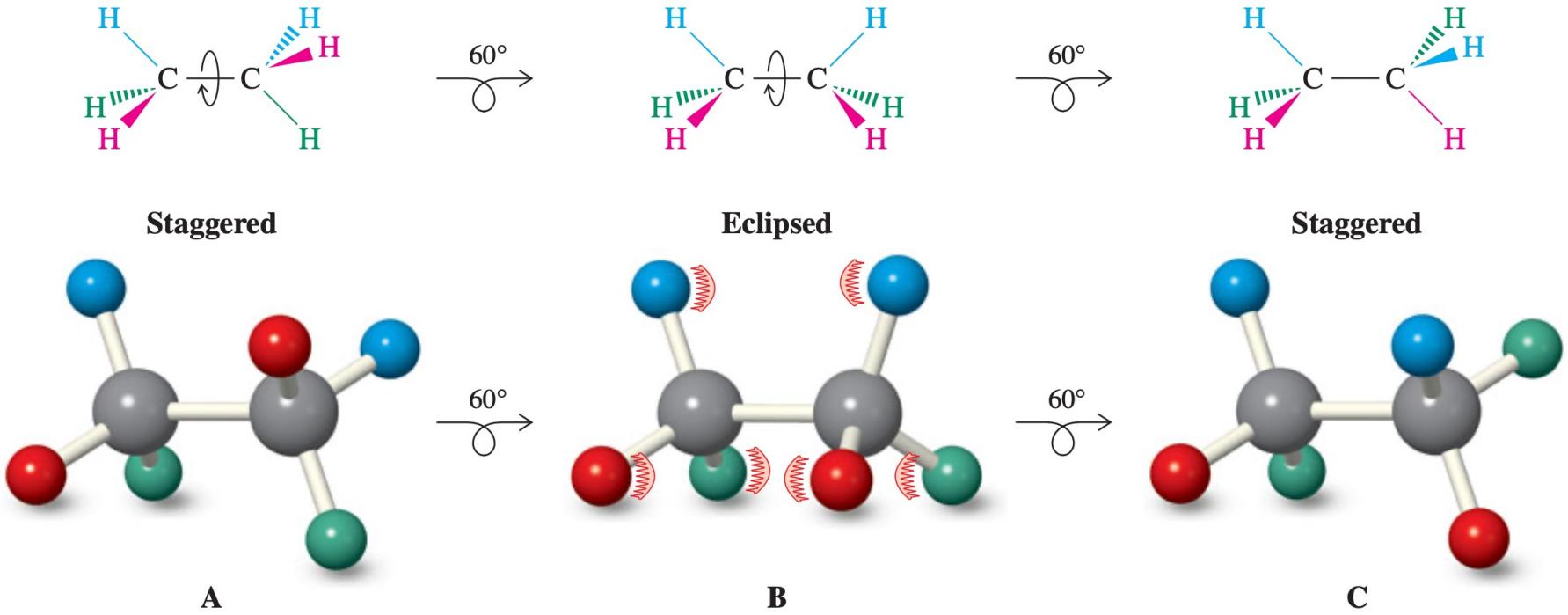
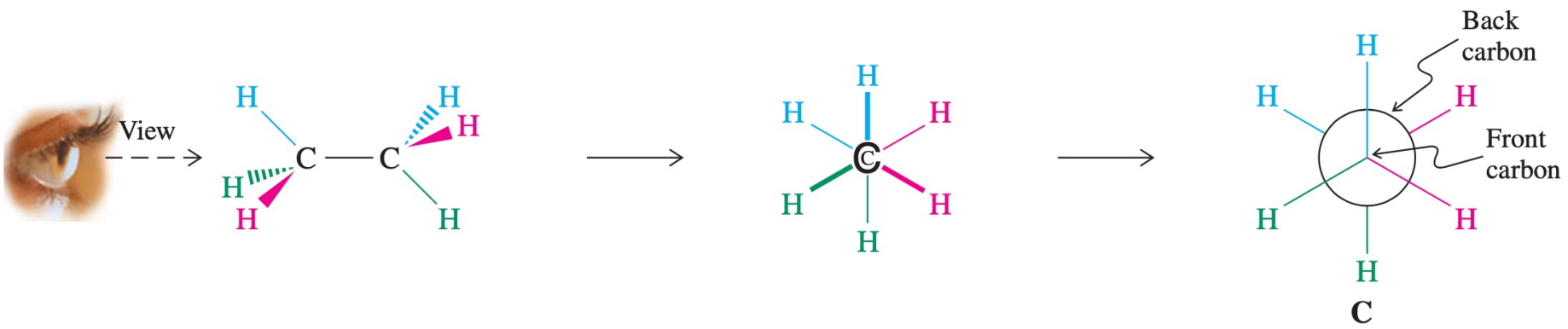
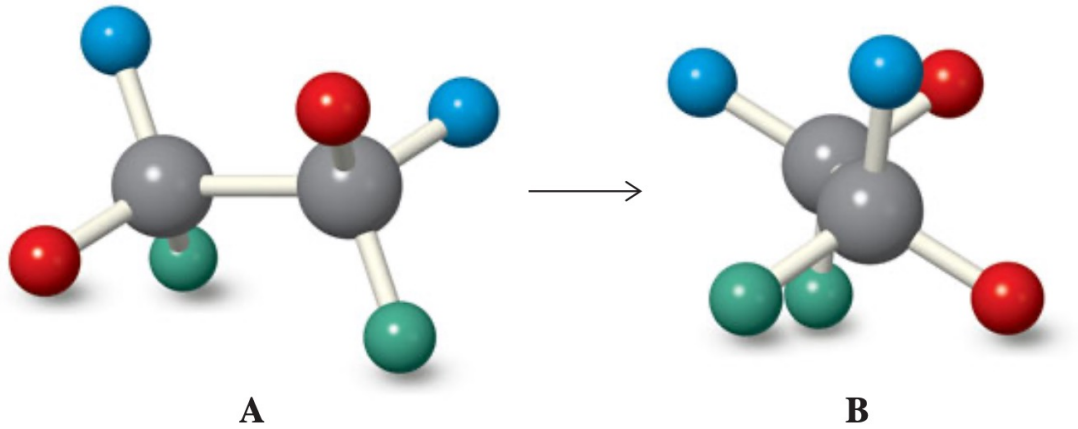


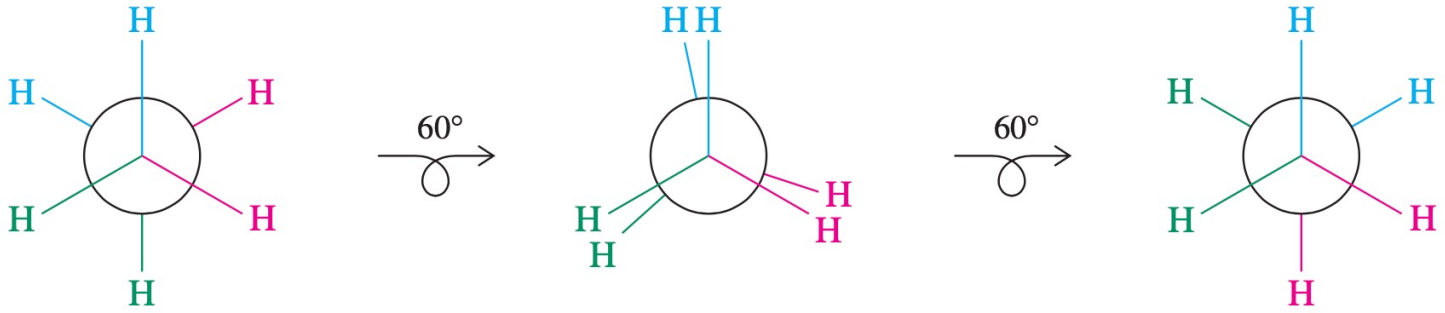
Figure 2-7 Rotation in ethane: (A and C) staggered conformations; (B) eclipsed. There is virtually "free rotation" between conformers.

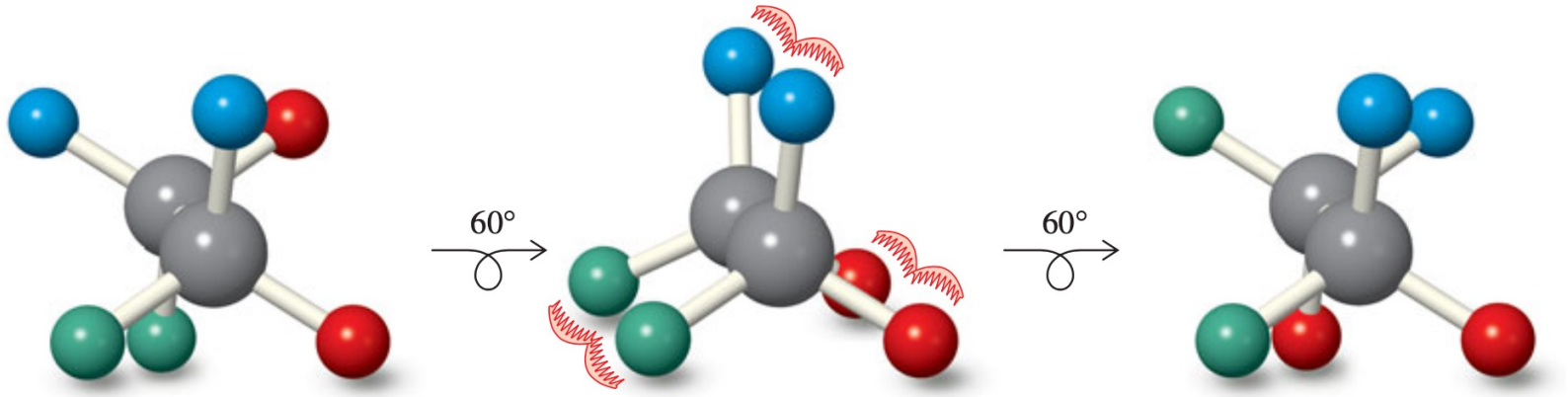
Structure moléculaire et fonctions organiques





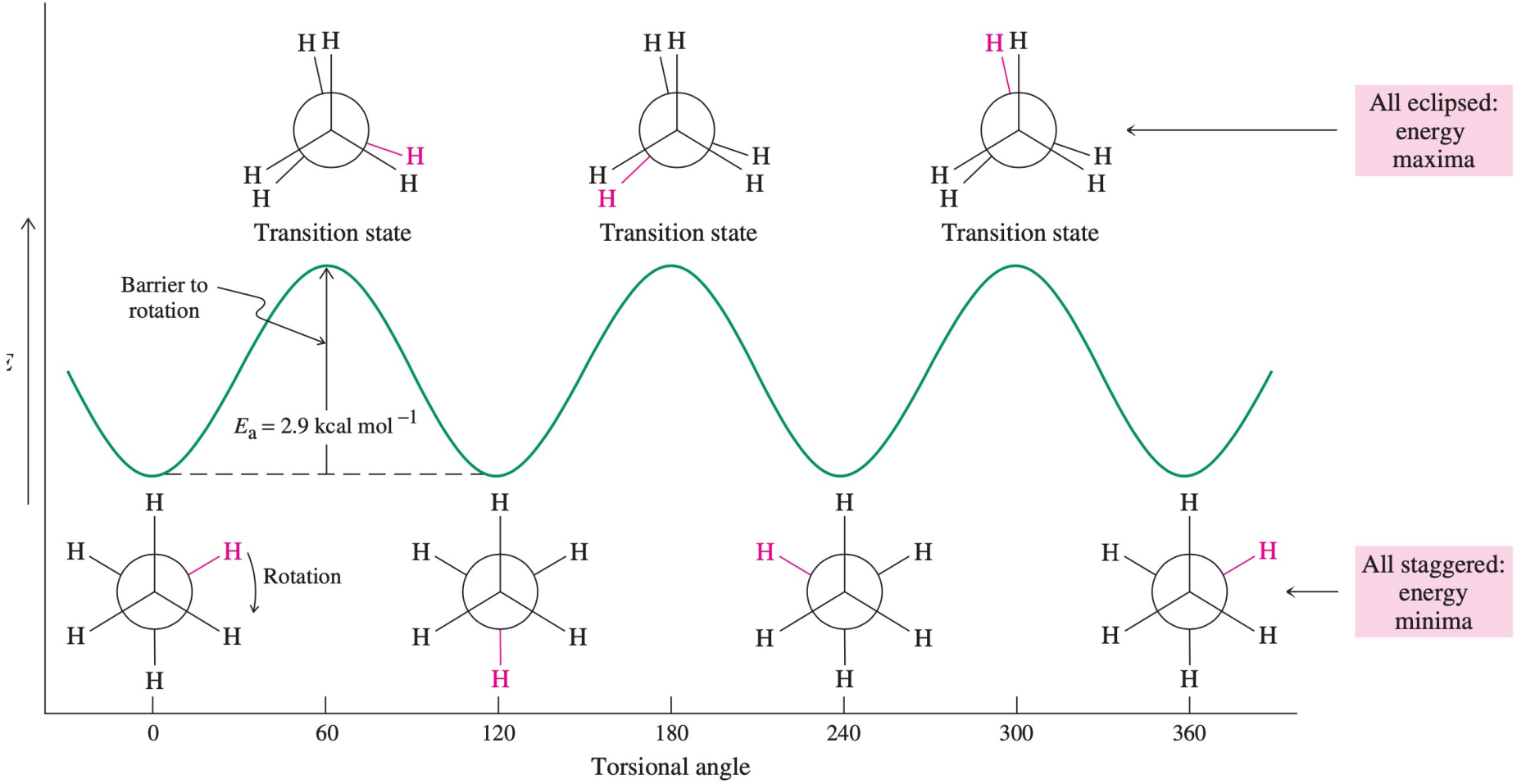
Structure moléculaire et fonctions organiques



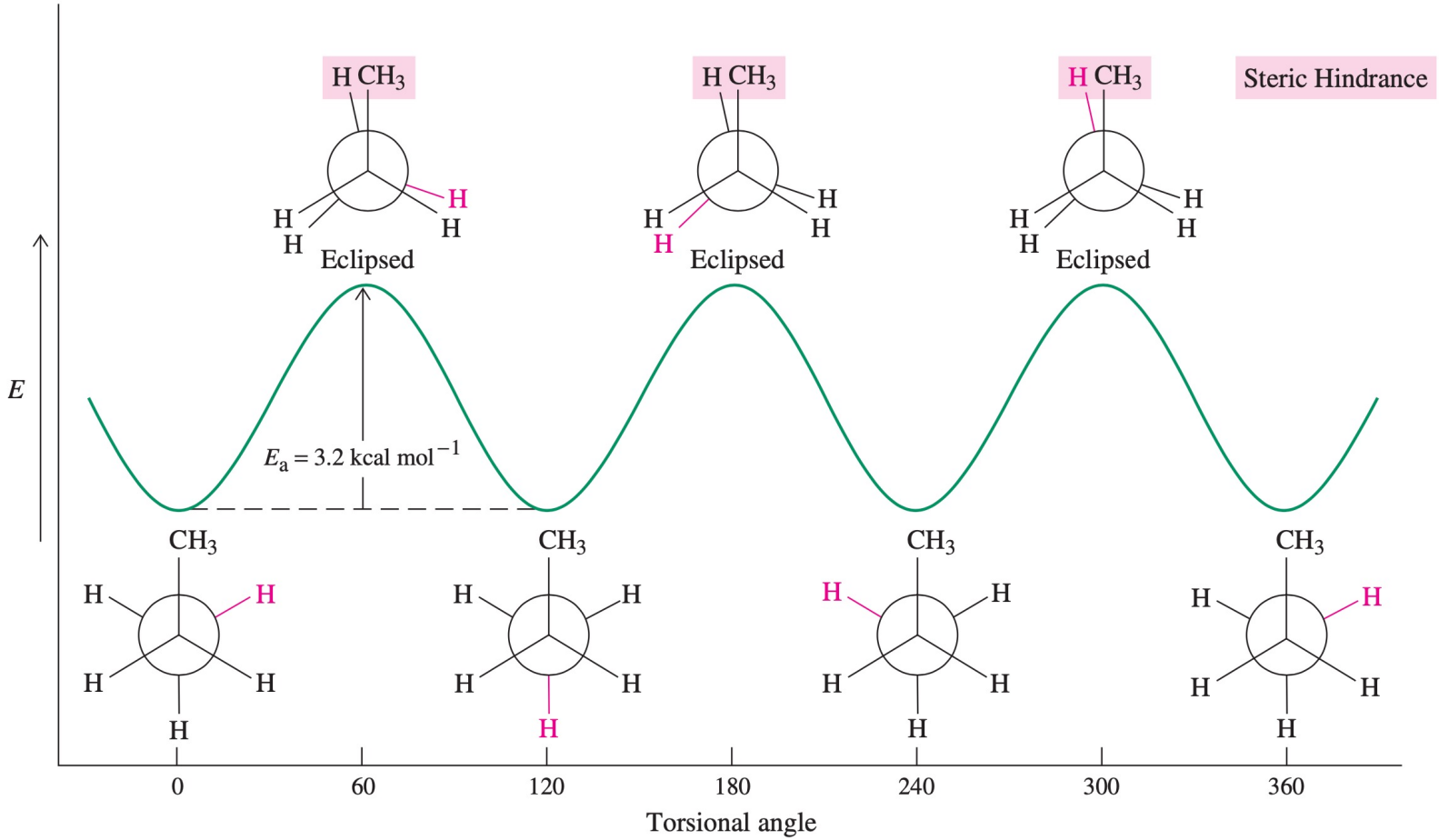


Staggered **Eclipsed** **Staggered**

Structure moléculaire et fonctions organiques



Structure moléculaire et fonctions organiques



Structure moléculaire et fonctions organiques

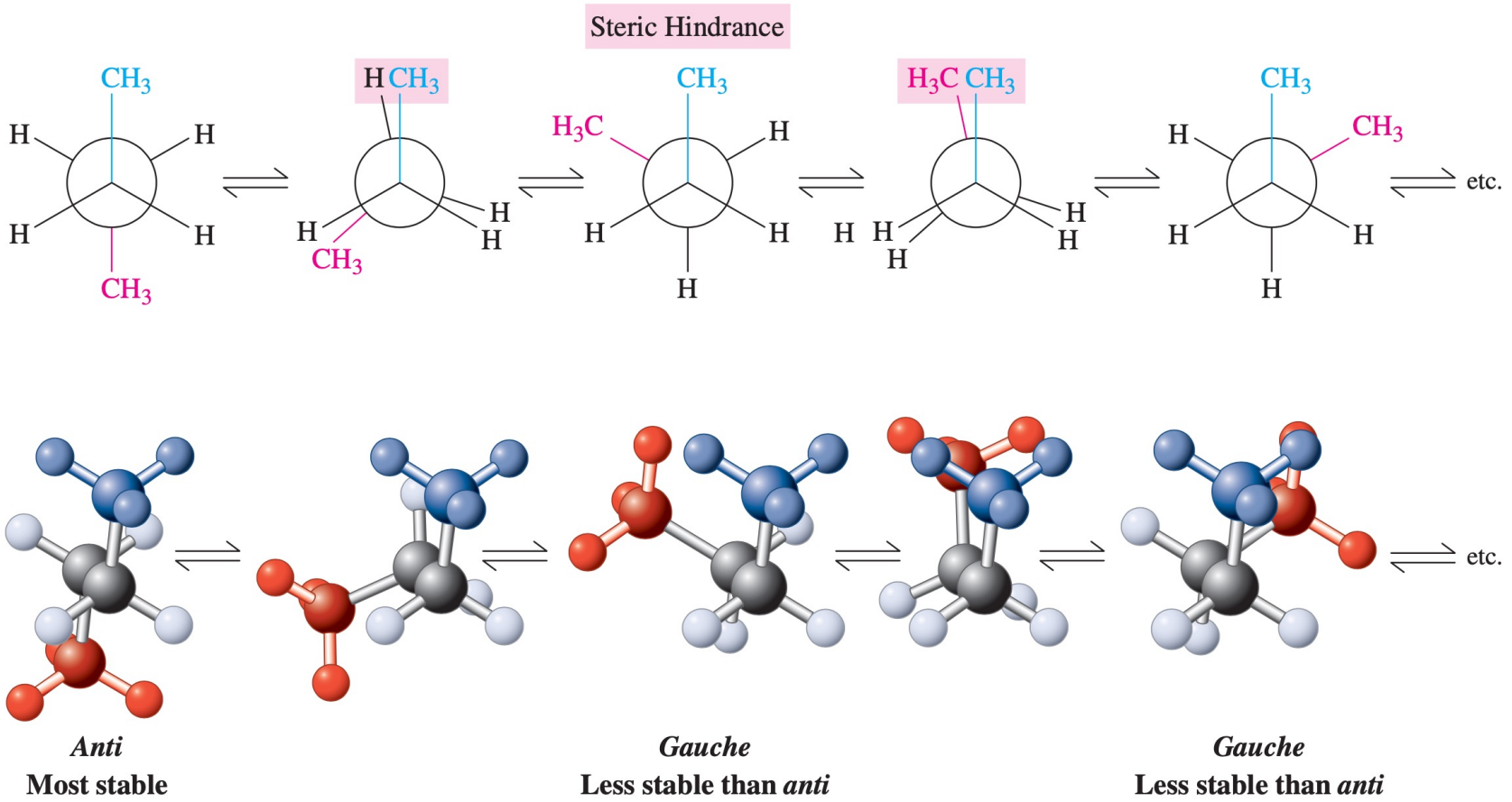
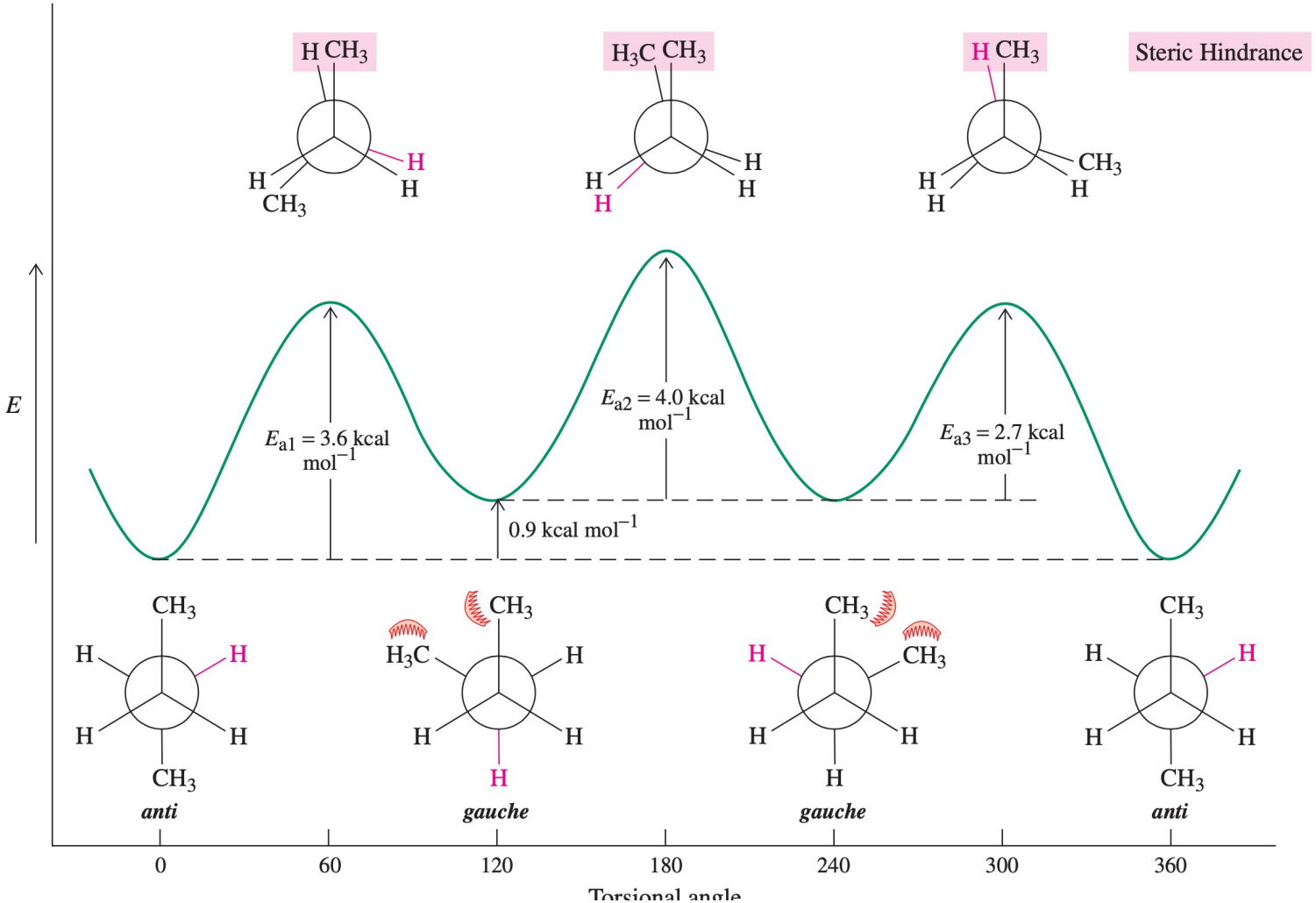


Figure 2-12 Clockwise rotation of the rear carbon along the C2–C3 bond in a Newman projection (top) and a ball-and-stick model (bottom) of butane.

Structure moléculaire et fonctions organiques

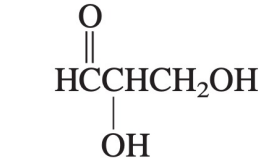
Faculté des Sciences



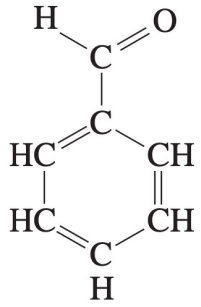
Structure moléculaire et fonctions organiques

Faculté des Sciences

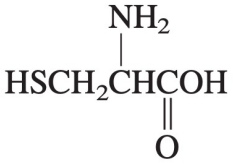
3-Methylbutyl acetate
(In banana oil)



2,3-Dihydroxypropanal
(The simplest sugar)

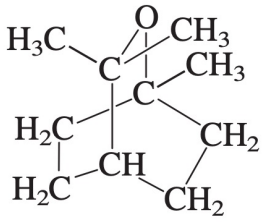


Benzaldehyde
(In fruit pits)

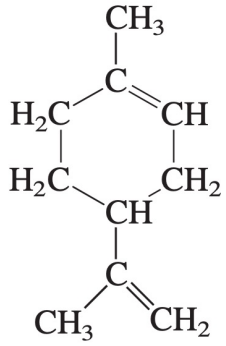


Cysteine
(In proteins)

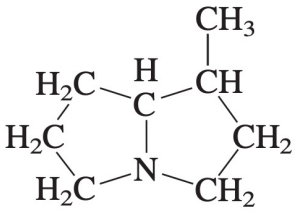
Matricarianol
(From chamomile)



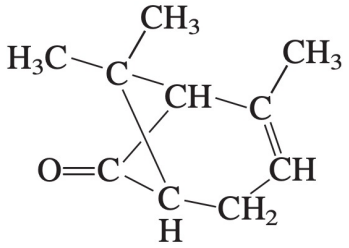
Cineole
(From eucalyptus)



Limonene
(In lemons)

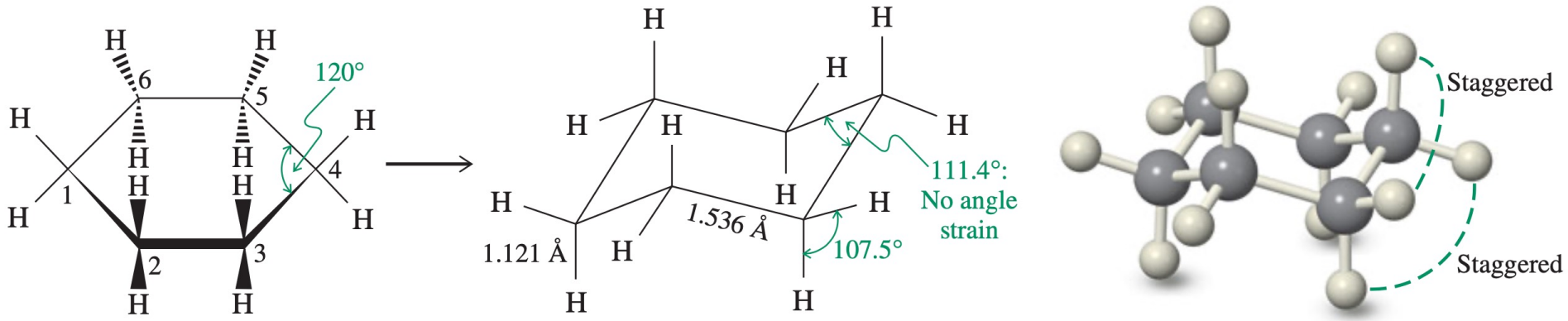


Heliotridane
(An alkaloid)



Chrysanthenone
(In chrysanthemums)

Structure moléculaire et fonctions organiques



A

Planar cyclohexane
(120° bond angles;
12 eclipsing hydrogens)

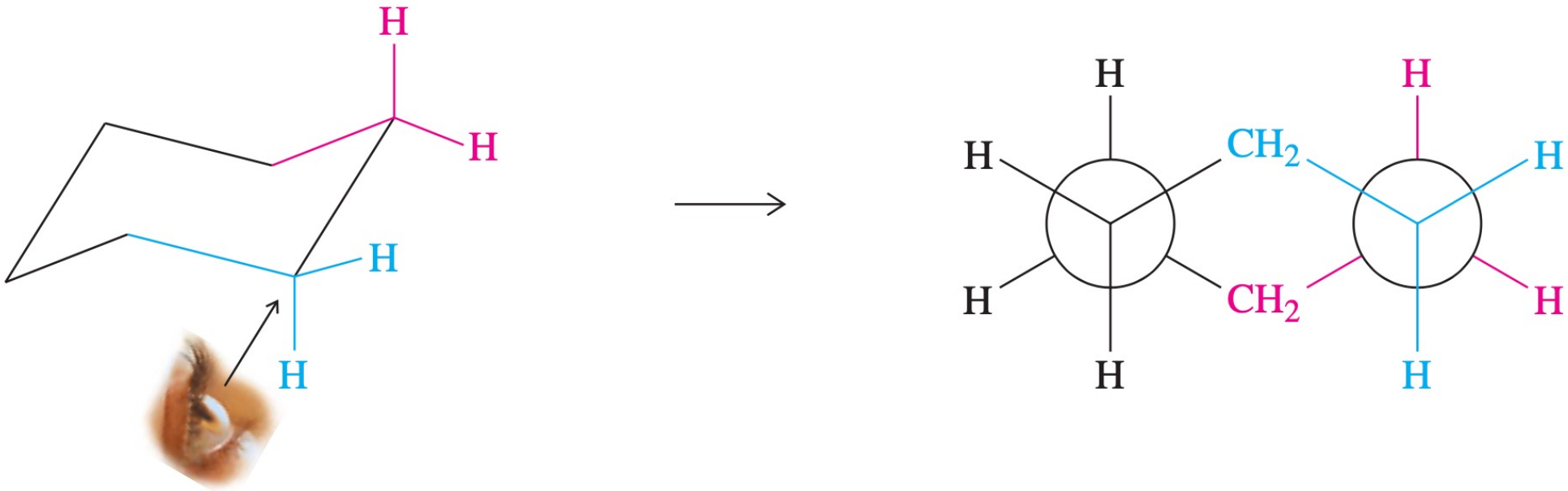
B

Chair cyclohexane
(Nearly tetrahedral bond angles;
no eclipsing hydrogens)

C

Figure 4-5 Conversion of the (A) hypothetical planar cyclohexane into the (B) chair conformation, showing bond lengths and angles; (C) molecular model. The chair conformation is strain free.

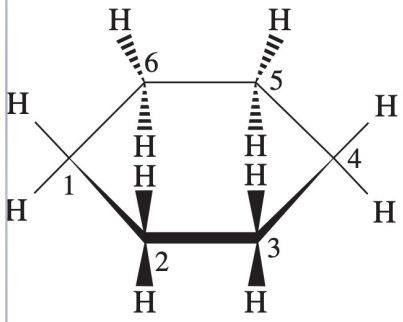
Structure moléculaire et fonctions organiques



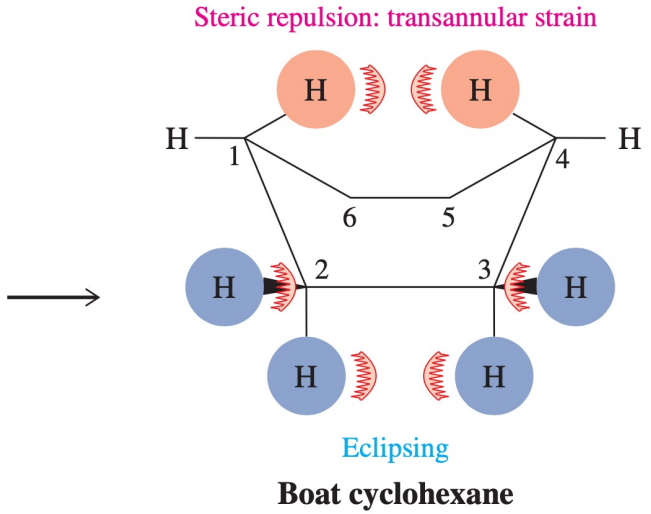
Structure moléculaire et fonctions organiques

Chair

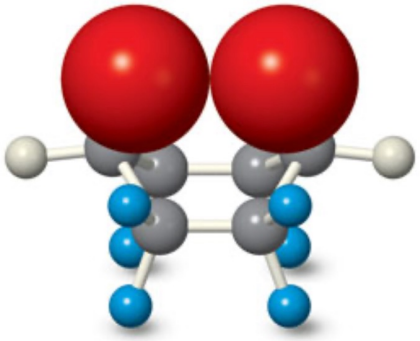
Boat



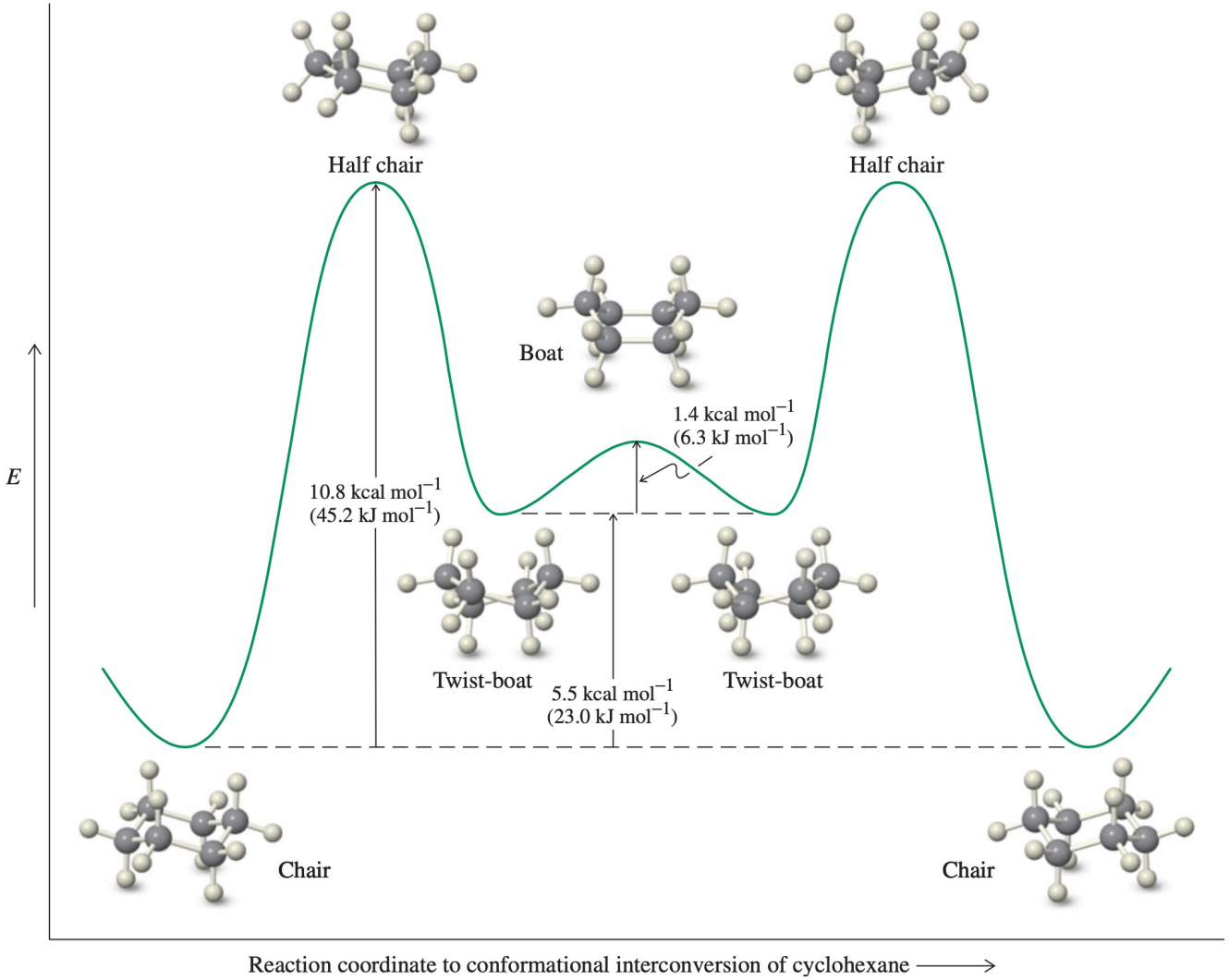
Planar cyclohexane



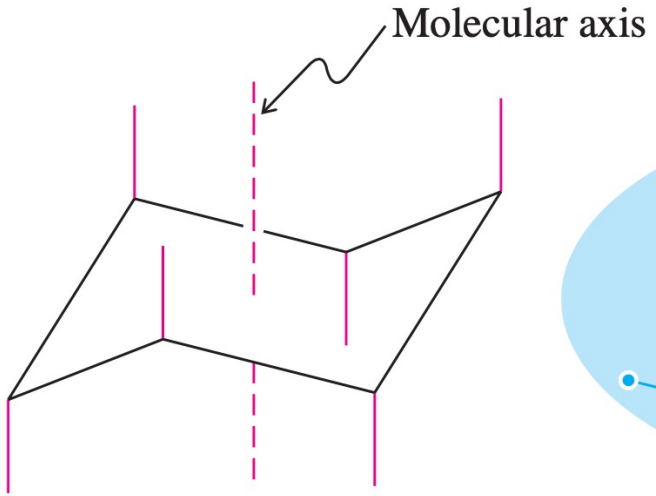
Boat cyclohexane



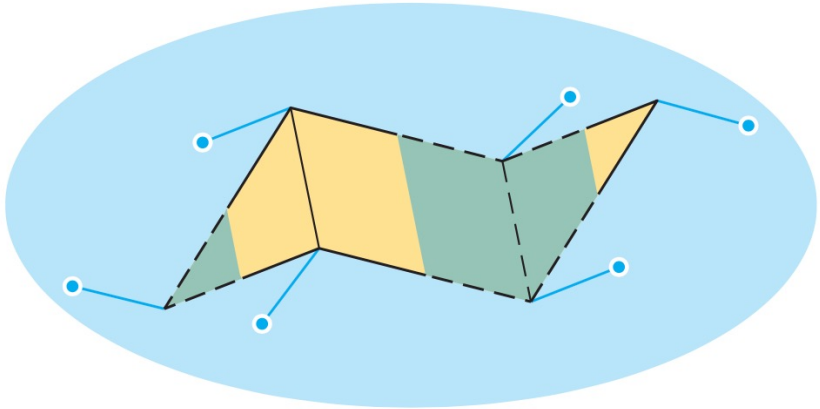
Structure moléculaire et fonctions organiques



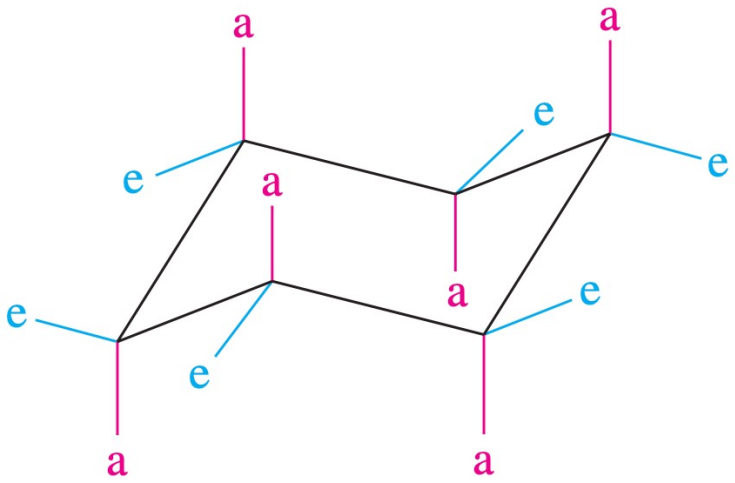
Structure moléculaire et fonctions organiques



Axial
positions

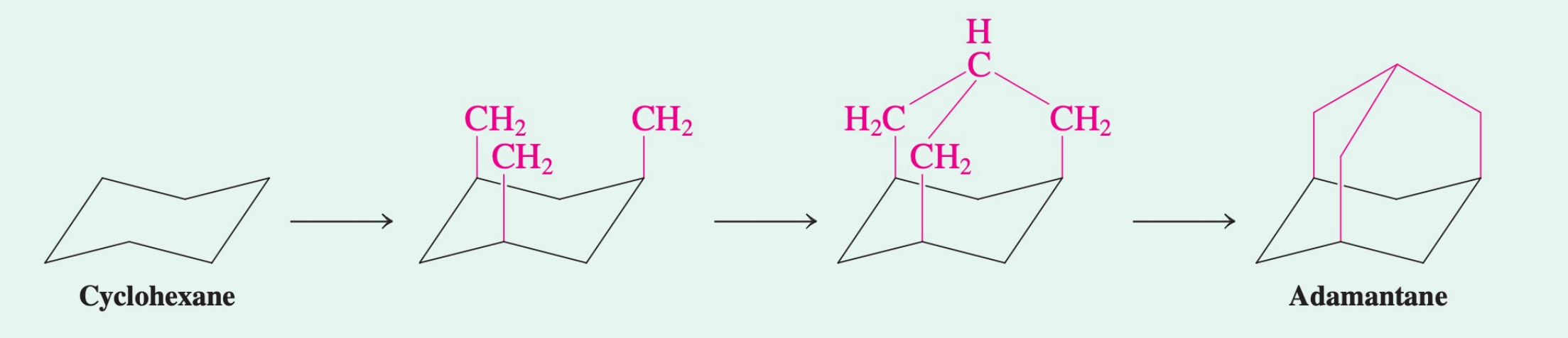


Equatorial
positions

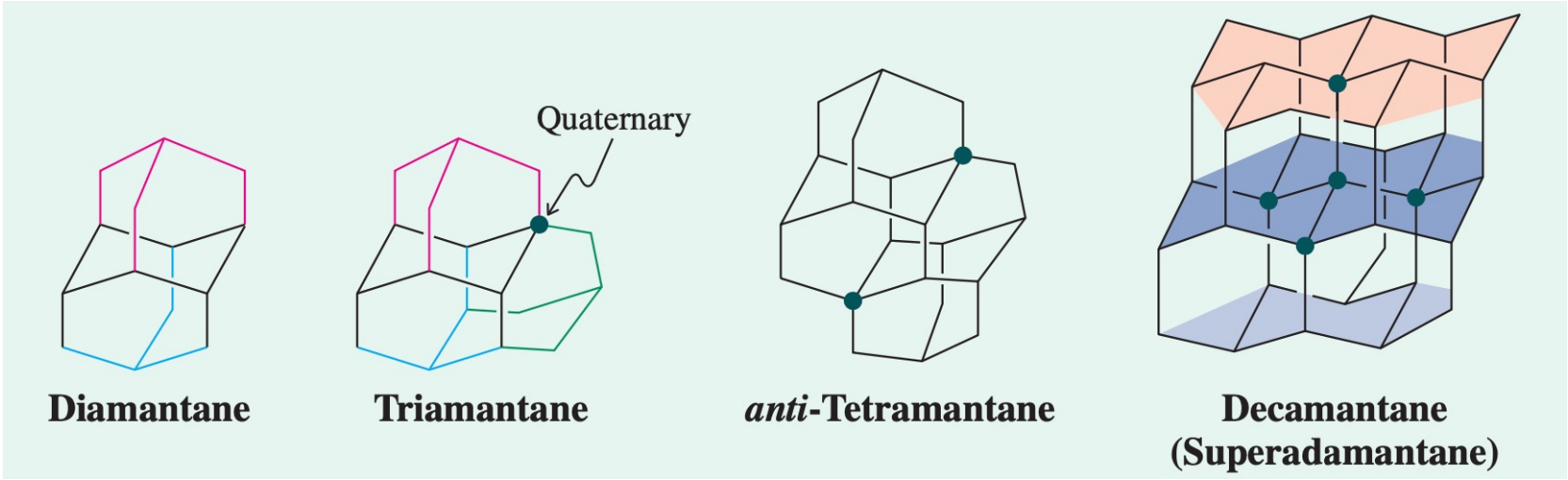


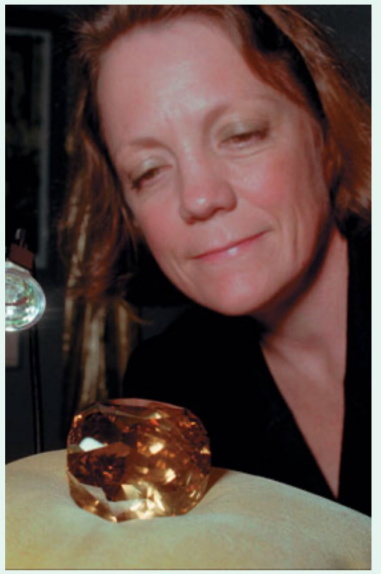
Axial (a) and equatorial (e)
positions

Structure moléculaire et fonctions organiques



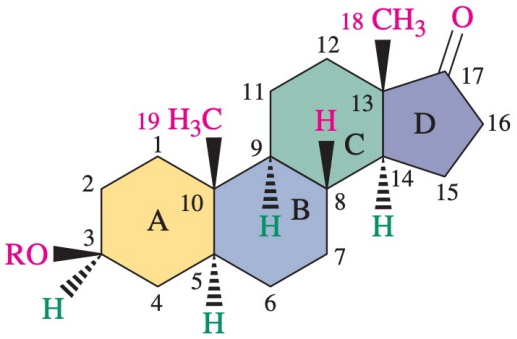
Structure moléculaire et fonctions organiques

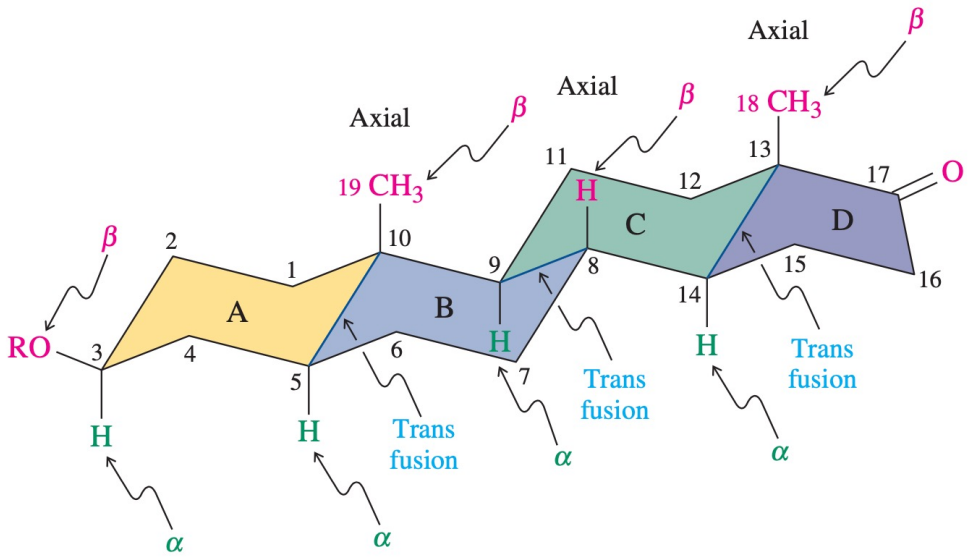


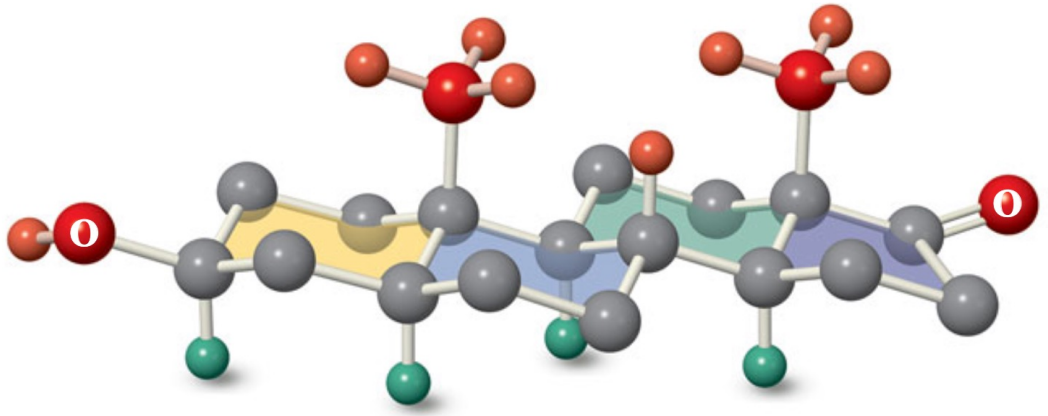


The Golden Jubilee, the world's biggest diamond.

Structure moléculaire et fonctions organiques







Epiandrosterone

Isomérismes

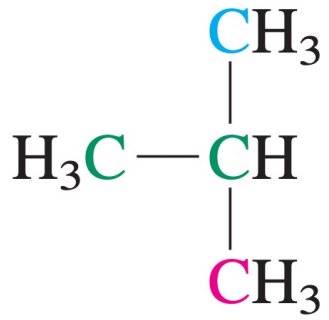
Faculté des Sciences

- Isomères de constitution (de positions)
- Stéréoisomères (arrangement dans l'espace différents)
  - Enantiomères
  - Diastéréoisomères
  - Isomères géométriques

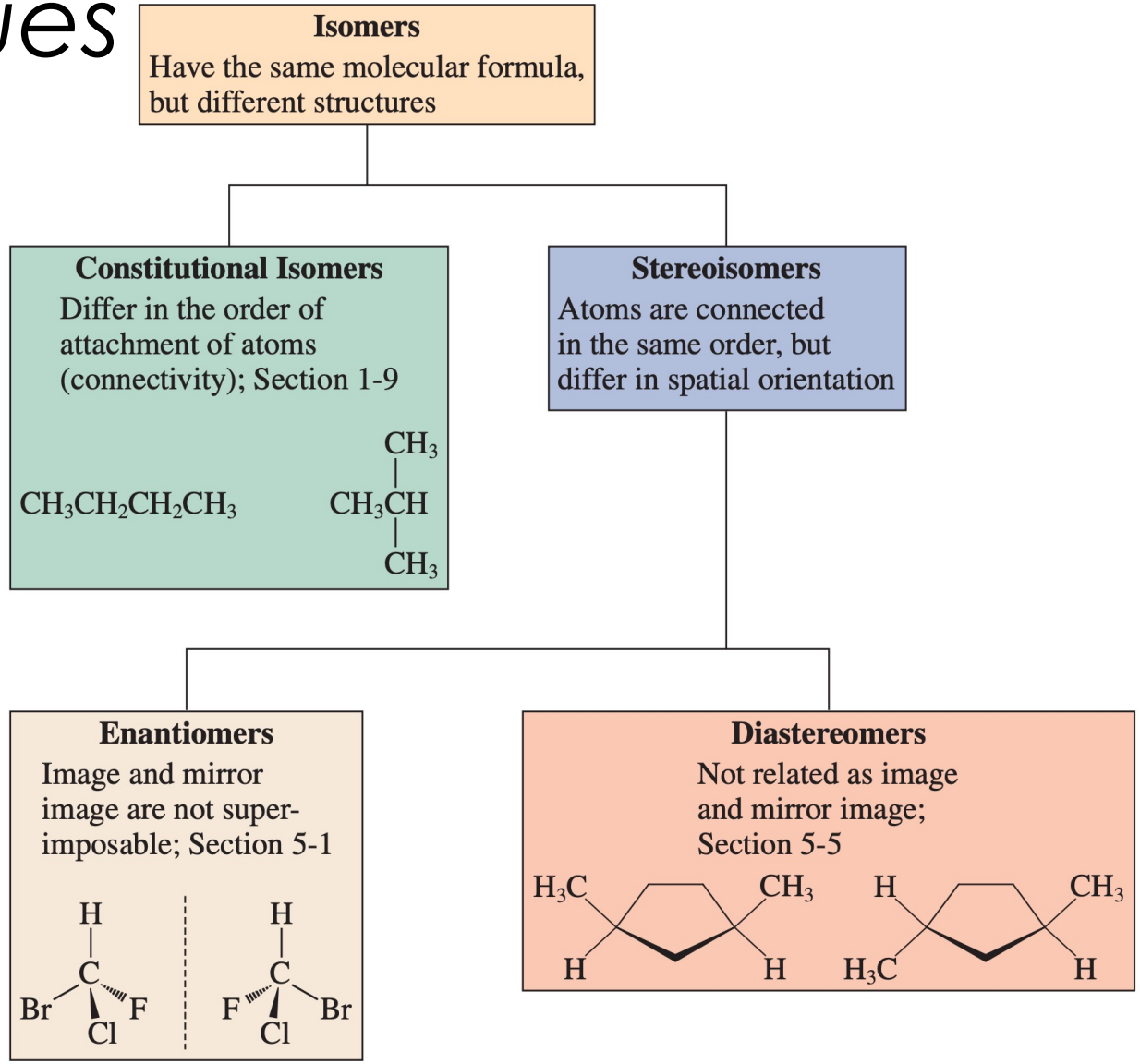
Isomèrismes

Faculté des Sciences

Constitutional Isomers

C_4H_{10}	$CH_3CH_2CH_2CH_3$	
	Butane	**2-Methylpropane**
C_2H_6O	CH_3CH_2OH	CH_3OCH_3
	Ethanol	**Methoxymethane (Dimethyl ether)**

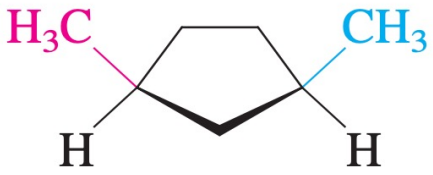
Structure moléculaire et fonctions organiques



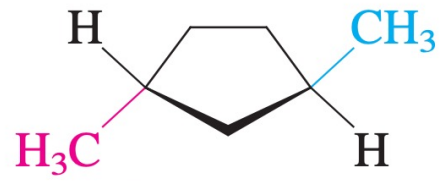
Stéréoisomères, conformères

Faculté des Sciences

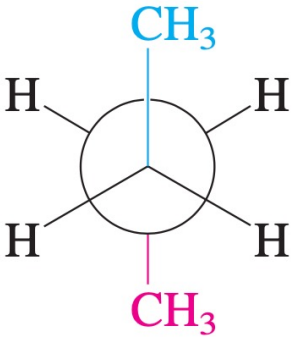
Stereoisomers



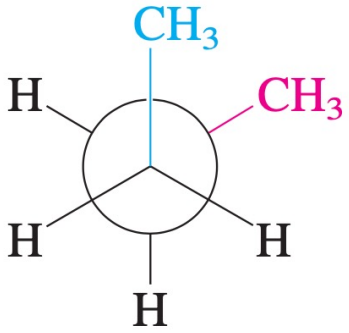
cis-1,3-Dimethylcyclopentane



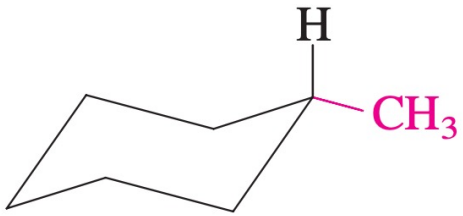
trans-1,3-Dimethylcyclopentane



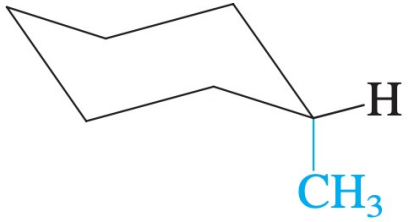
Anti conformer of butane



Gauche conformer of butane

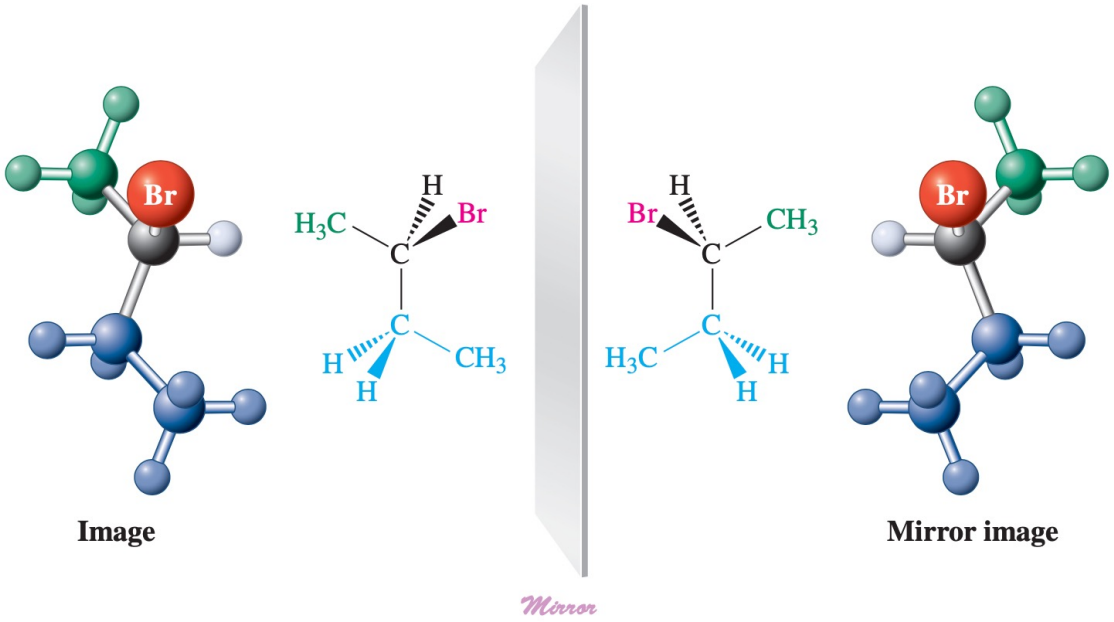


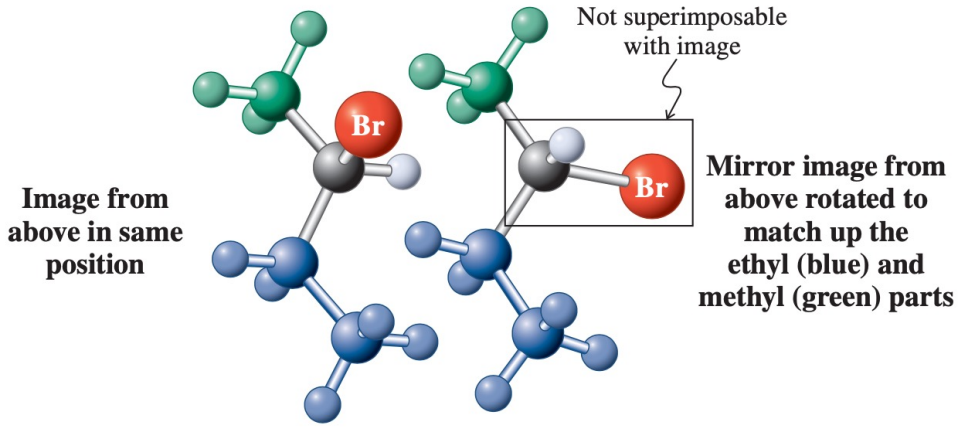
Equatorial methylcyclohexane



Axial methylcyclohexane

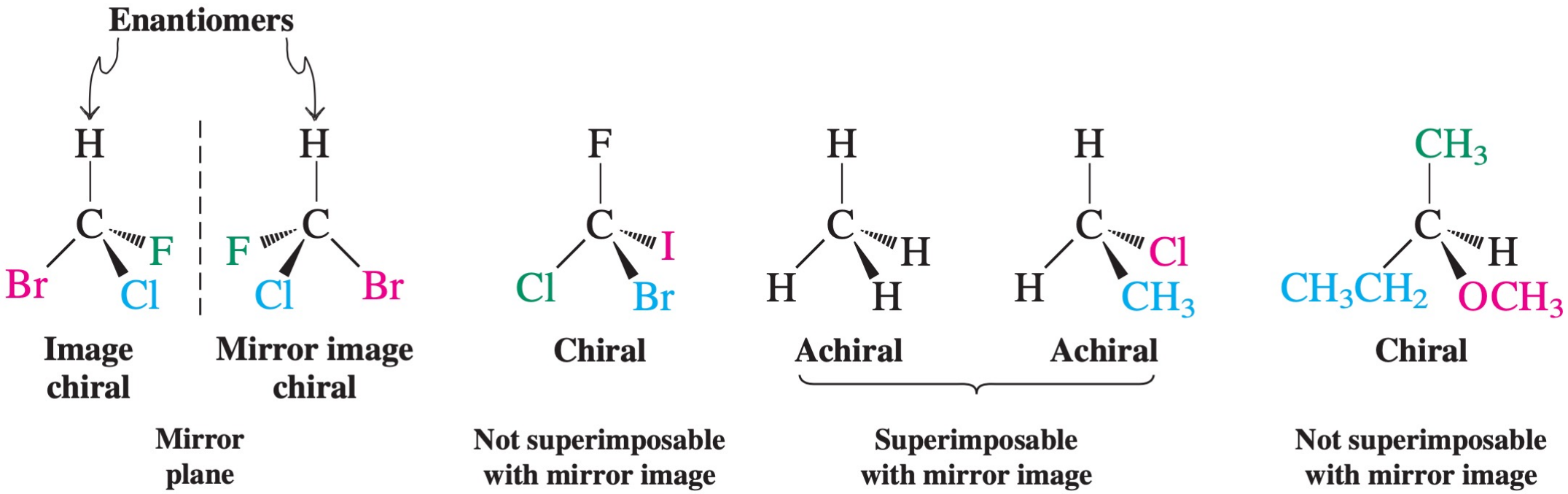
Enantiomères objets et images dans un miroir



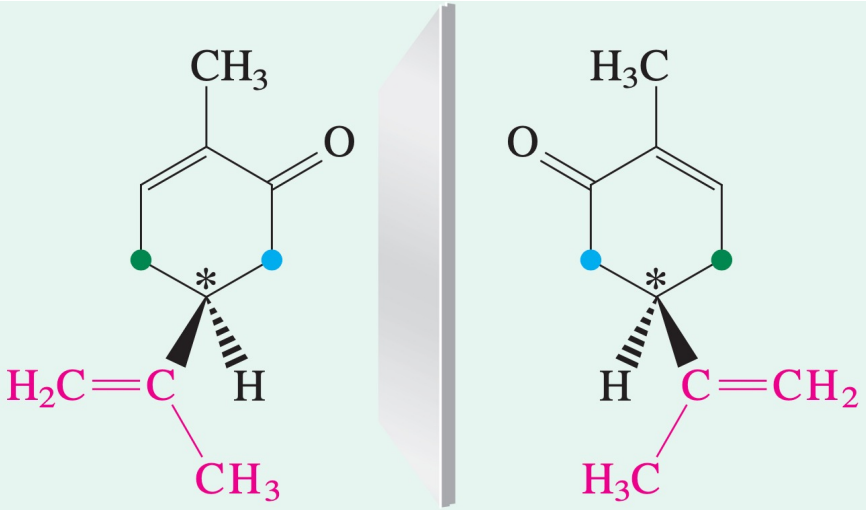


The two enantiomers of 2-bromobutane are nonsuperimposable

Chiral, pas chiral ?



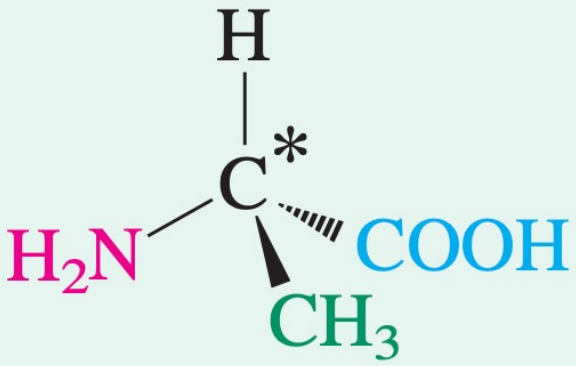
Nous sommes chiraux !



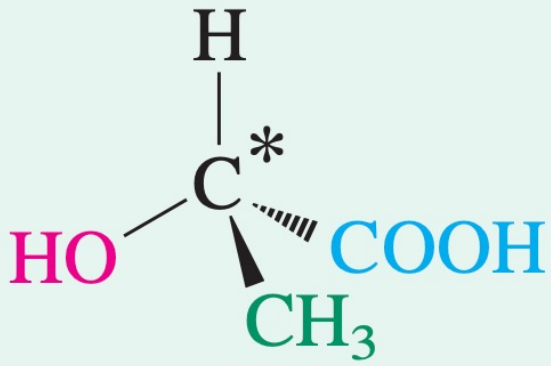
Caraway seeds

Spearmint

Différentes représentations de la chiralité



2-Aminopropanoic acid (Alanine)

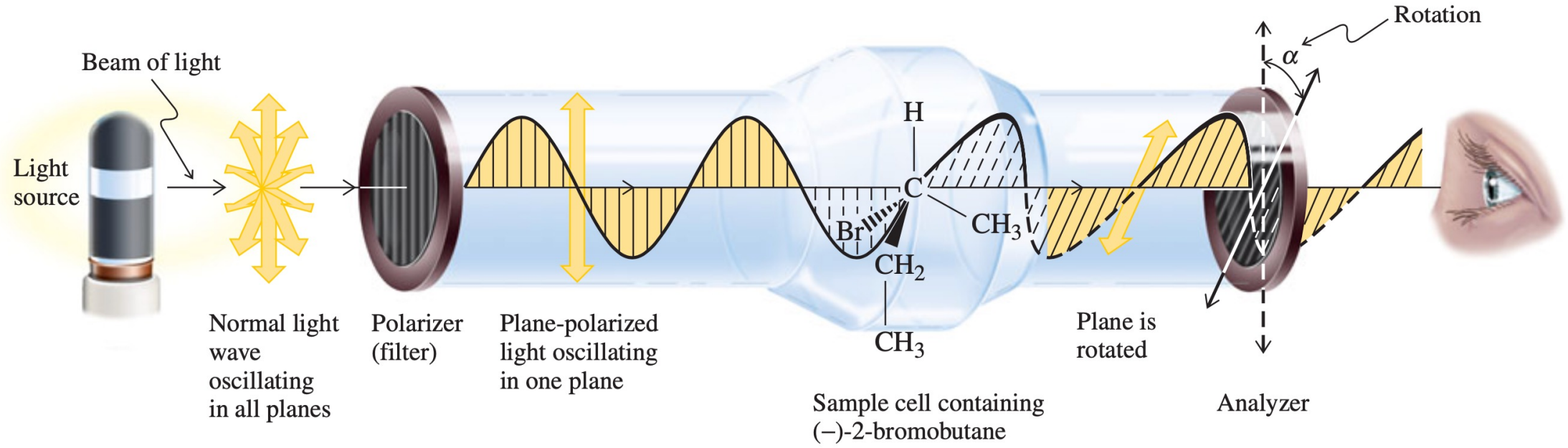


2-Hydroxypropanoic acid (Lactic acid)

Enantiomères

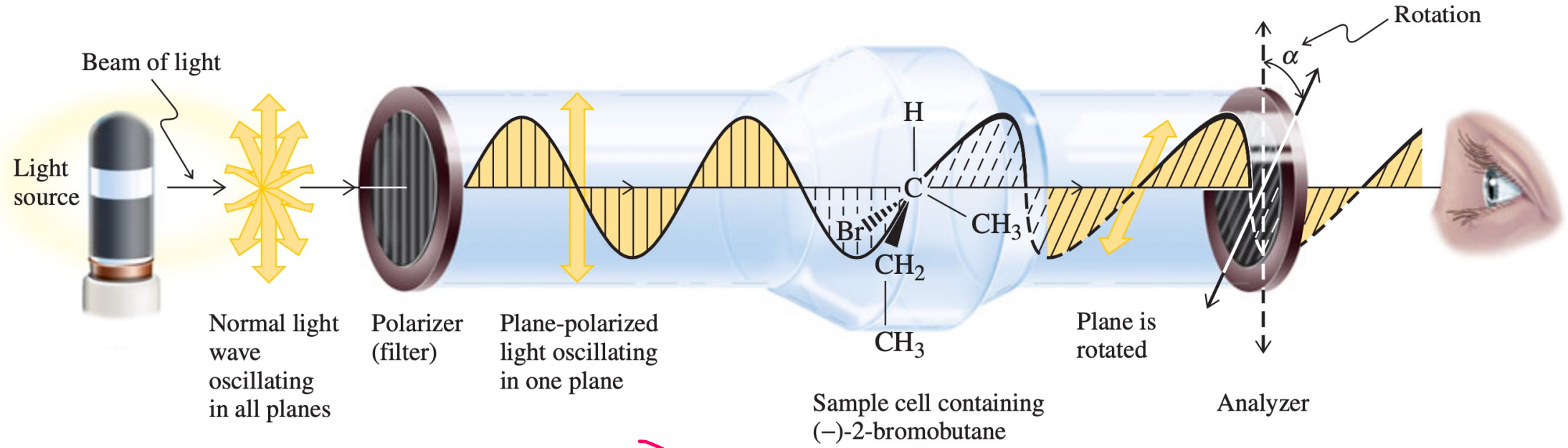
Houses of edible snails: the ratio of right-handed (on the left) to left-handed is 20,000:1.

Propriétés optiques des molécules chirales



Propriétés optiques des molécules chirales

POLARIMÈTRE



Specific Rotation*

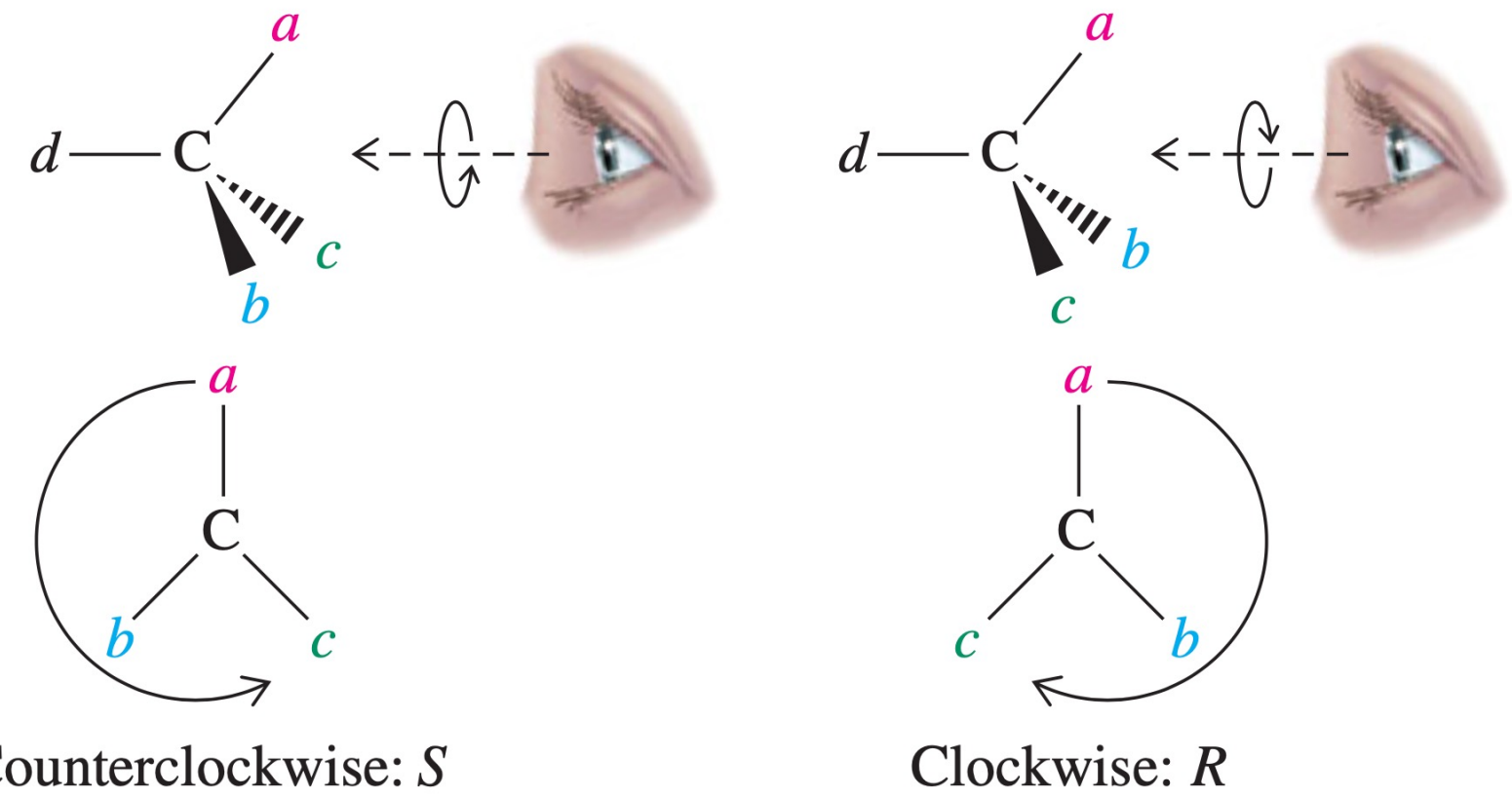
$$[\alpha]_{\lambda}^{t^\circ} = \frac{\alpha}{l \cdot c}$$

température — Degrés — Pouvoir optique rotatoire spécifique

longueur onde — dm — g/mL

ex $[\alpha]_D^{25}$ raie D du Na (589 nm)

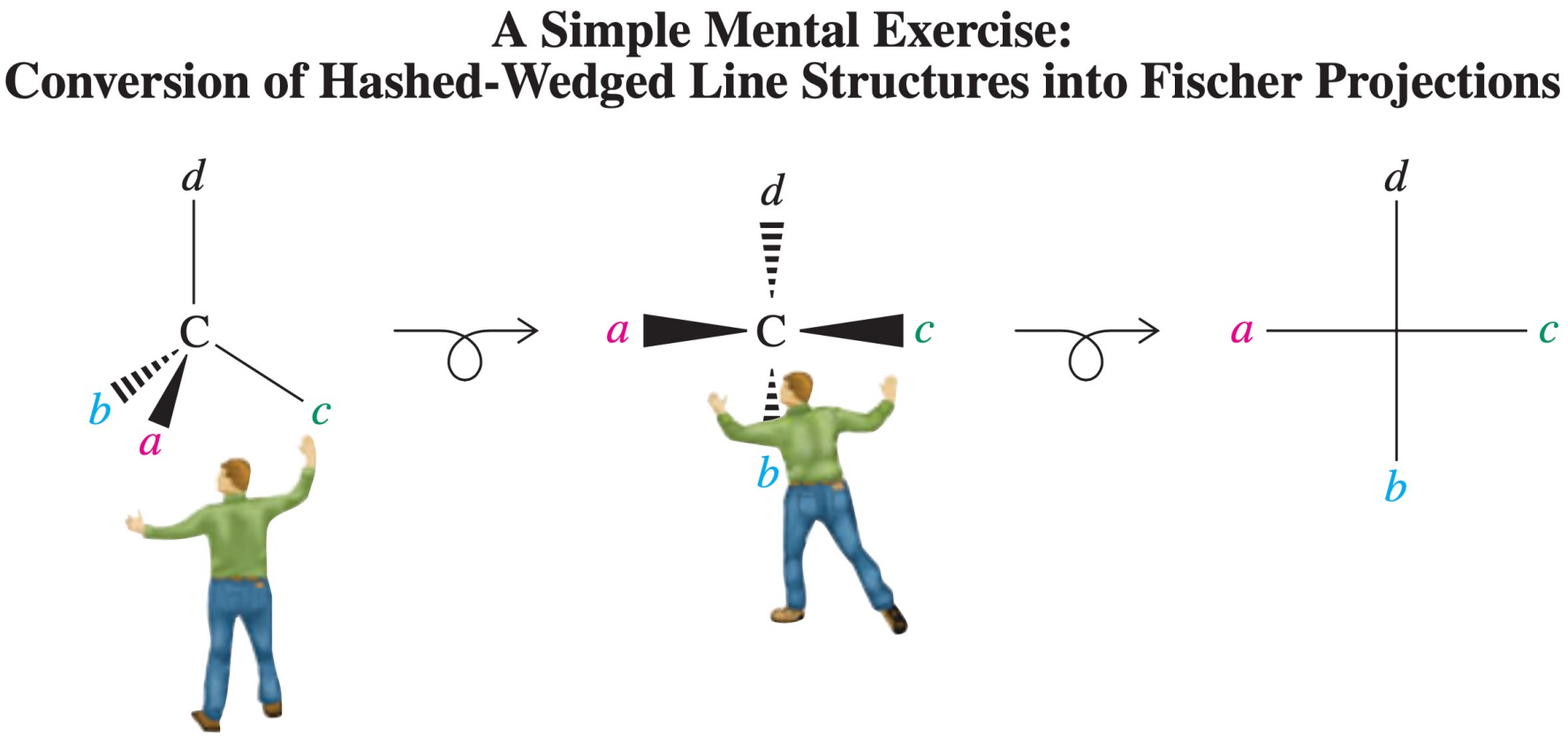
Nomenclature de la chiralité moléculaire



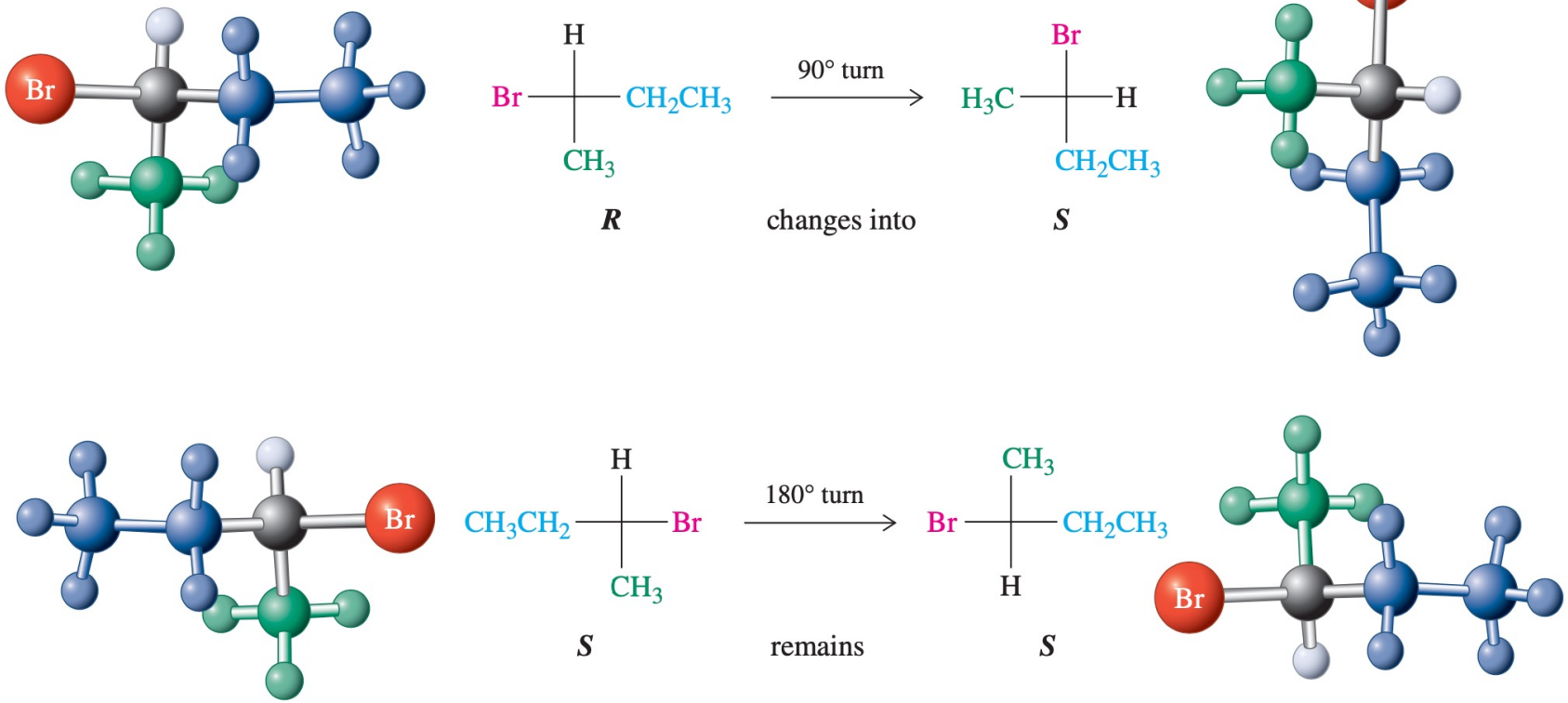
Vocabulaire de la chiralité moléculaire

- Deux énantiomères (RR, SS)(SR, RS) ont des [α] de signes opposés
- Un mélange 1:1 de deux énantiomères ([α] = 0) est appelé un mélange ***racémique***
- Un mélange avec un [α] non nul est dit « ***optiquement actif*** »
- Si [α] > 0 = (+) ***dextrogyre***, si [α] < 0 = (-) ***lévogyre***
- Deux composés avec plusieurs centres de chiralités ont aussi des ***diastéréoisomères*** *(RS, RR)* qui diffèrent en propriétés chimiques

Une représentation mentale

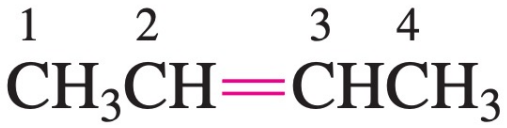


Une représentation mentale

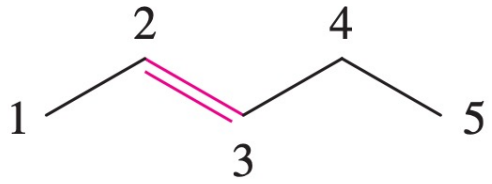


Isomères géométriques plans

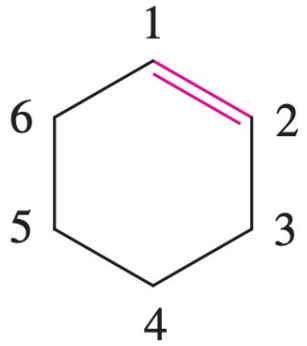
1-Butene
(A terminal alkene;
not 3-butene)



2-Butene
(An internal alkene
and a double-bond
isomer of 1-butene)

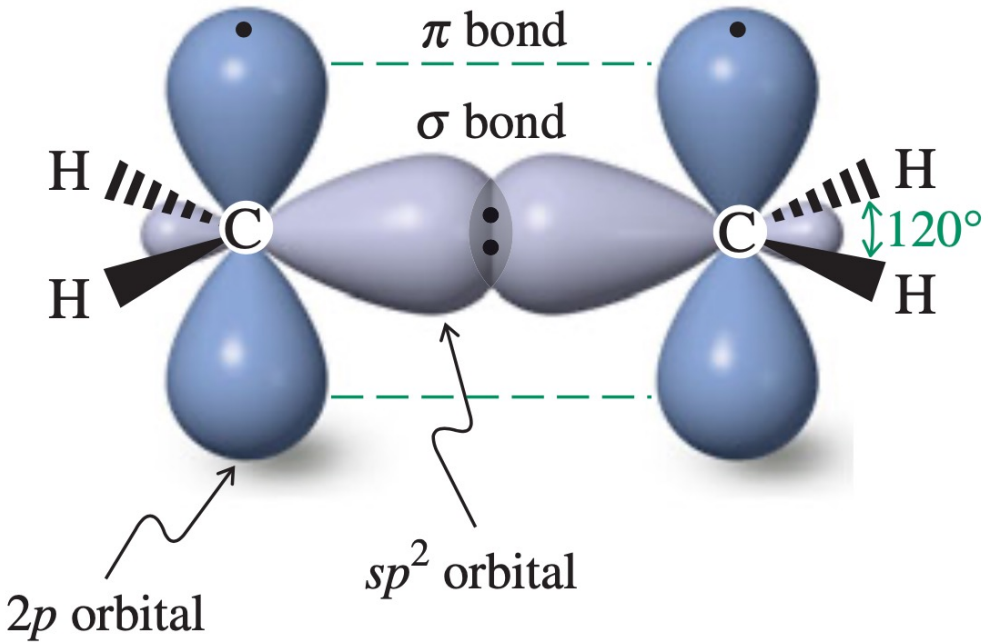


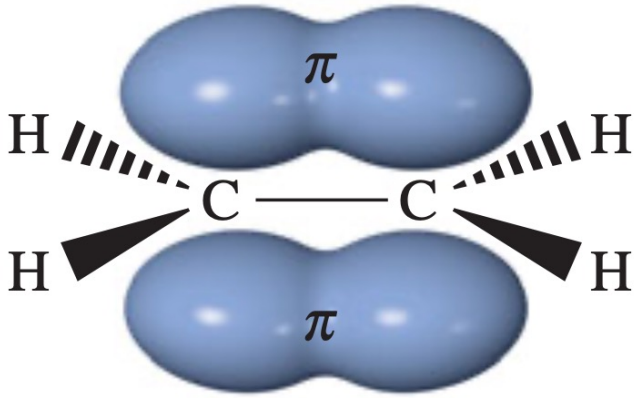
2-Pentene
(Not 3-pentene)



Cyclohexene

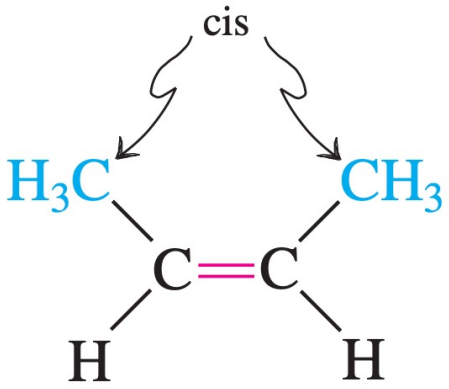
Systèmes trigonaux plans





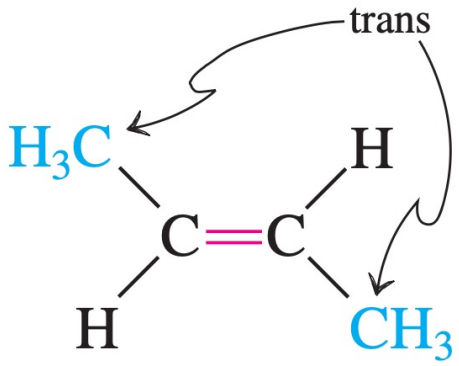
Cis-trans

Same side of double bond

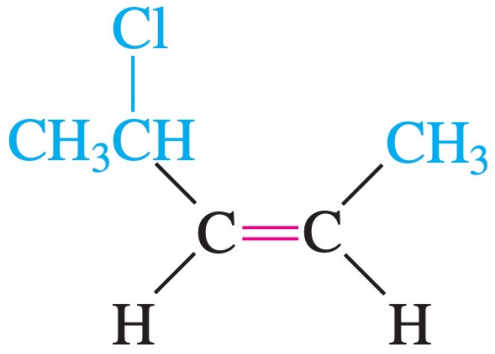


***cis*-2-Butene**

Opposite sides of double bond

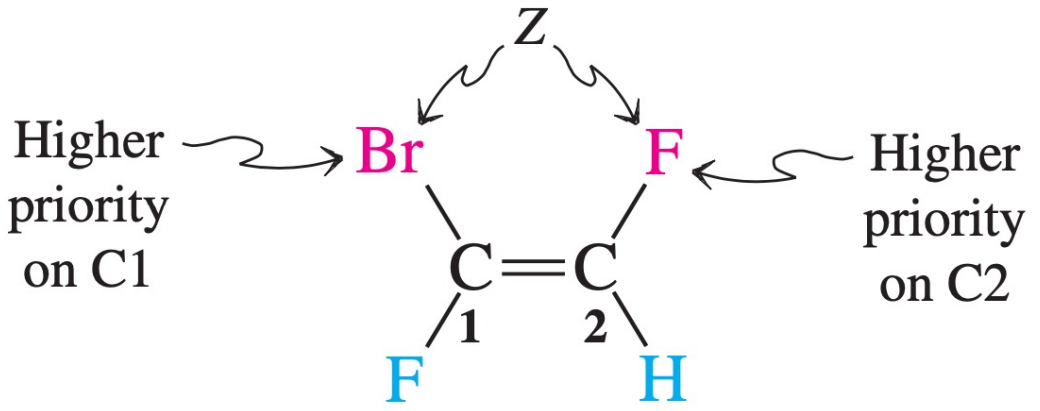


***trans*-2-Butene**

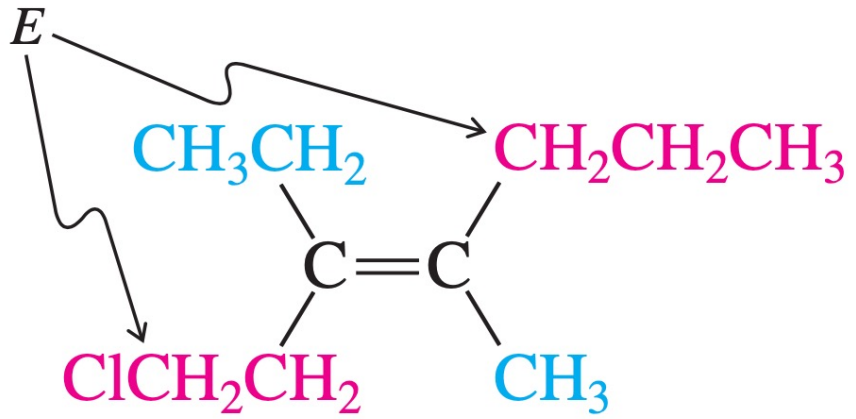


***cis*-4-Chloro-2-pentene**

Entgegen (opposé) Zusammen (ensembles)



(*Z*)-1-Bromo-1,2-difluoroethene



(*E*)-1-Chloro-3-ethyl-4-methyl-3-heptene

Les concepts importants

Faculté des Sciences

- Des ***isomères*** ont la ***même formule brute*** mais des ***formules développée différentes***.
- Les isomères de constitutions (structuraux) diffèrent dans l'ordre dans lequel les atomes individuels sont connectés.
- Les ***stéréoisomères*** ont la même connectivité mais diffèrent dans la disposition 3D des atomes.
- Les ***énantiomères*** sont objet et image dans un miroir.
- Un objet qui n'est pas superposable à son image miroir est ***chiral***.
- Un C portant ***quatre substituants différents*** (carbone asymétrique) est ***stéréocentre***.
- Un composé contenant un stéréocentre est chiral et existe sous la forme d'une paire d'énantiomères. Un mélange 1: 1 d'énantiomères est un ***racémate*** (***mélange racémique***).

Les concepts importants

- Les molécules chirales ne peuvent pas avoir de plan de symétrie (plan miroir). Si une molécule a un plan miroir, alors c'est ***achiral***.
- Les ***diastéréoisomères*** sont des stéréoisomères qui ne sont pas objet et image miroir. Les isomères *cis* et *trans* de composés cycliques sont des exemples de diastéréoisomères.
- ***Deux stéréocentres*** dans une molécule donnent jusqu'à ***quatre stéréoisomères***

Les concepts importants

- La plupart des propriétés physiques des énantiomères sont les mêmes. Une exception majeure est leur interaction avec la lumière polarisée. Un énantiomère fera tourner le plan de polarisation dans le sens des aiguilles d'une montre (***dextrogyre***), l'autre dans le sens inverse (***lévogyre***). Ce phénomène est appelé ***activité optique***.

Les concepts importants

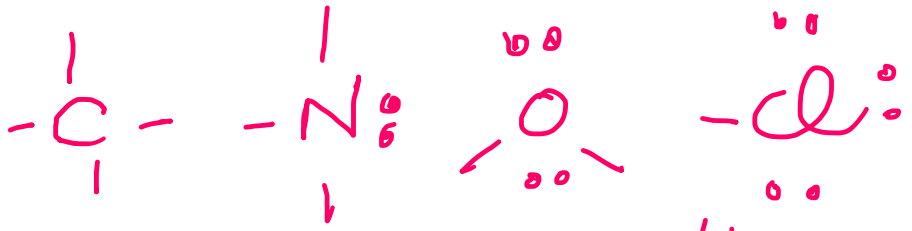
Faculté des Sciences

- Les ***projections de Fischer*** fournissent des figures au dessin rapide de molécules avec des stéréocentres.

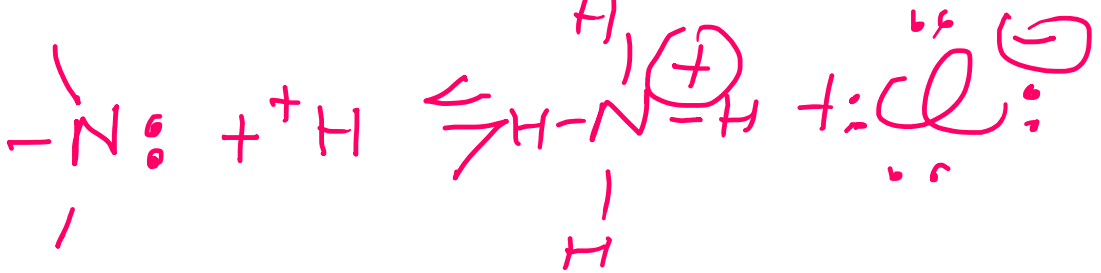
Conclusions générales

Faculté des Sciences

- Atomistique simple



- Propriétés acides-bases



- Structures et fonctions en chimie organique

Alcane C_nH_{2n+2}, Alcool, acide ...

- Différents cas d'isomérismes

constitution, stéréoisomères.