



CHIMIE ORGANIQUE

Stefan Matile (1-4, 10-13) – Sascha Hoogendoorn (5-9)
Sciences II, bureau 111/324
(SM 379 6519, SH 379 6085)

OBJECTIFS :

**Introduction aux concepts fondamentaux de la chimie organique,
aux classes de molécules organiques et leurs structures,
propriétés physiques, et réactions**

**Donner une (brève) vision de la chimie organique moderne comme
domaine centrale, créative et utile**

ENSEIGNEMENT : cours ex cathedra

(13 x 2 h janvier - avril)

mediaserver (live streaming)

REPETITOIRES (en groupes, 9 x 2 h, *super-important*)

AUTO-APPRENTISSAGE

EVALUATION : Questionnaire à choix multiple

STRUCTURE et BIBLIOGRAPHIE :

1. J. McMurry, Chimie organique, les grands principes, Dunod, Paris

2000 (ISBN : 2 10 004183 5)

(2003, ISBN : 2 10 007343 5)

2007, ISBN : 2 10 050547 0

2. Notes des exemples dans le cours

3. A propos de... (pas contenu dans l'examen)

REPETITOIRES

ASSISTANTS

Arthur Gaucherand

Alenka Marsalek

Laurane Michel

Julia Moreno

Clement Narbonne

Raphaël Paquis

Saidbakhrom Saidjalolov

Nicolas Sellet

Lundi - 13H15-15H00

Lundi, 9.2.26

Forum moodle

Semaine

18

19

20

21

22

23

24

25

25

Discussion

Exercice I

Exercice II

Exercice III

Exercice IV

Exercice V

Exercice VI

Exercice VII

Exercice VIII

Répétition Générale

(Mardi 10H15-12H00)

(<https://moodle.unige.ch/>)

REPETITOIRE 9.2.26, 13H15

ASSISTANTS

Laurane Michel

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Clement Narbonne

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Nicolas Sellet

FORMAT

Débutant 1

Débutant 2

Intermédiaire

Avancé

SALLE

SS 1-2

SS 4-5

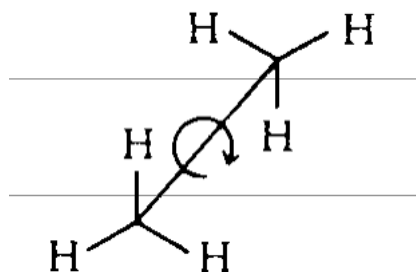
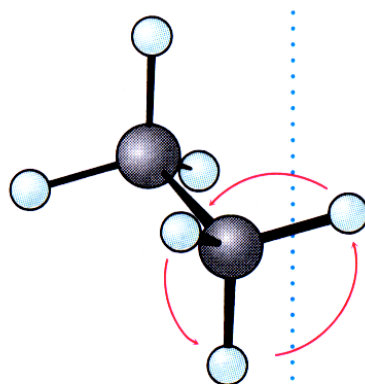
Franceschetti

SS 3

non pas enregistré

BIBLIOGRAPHIE :

McMurry



**H. Hart, J.-M. Conia,
Introduction à la chimie
organique Masson, Paris, 1997
(ISBN : 2-7296-0668-8)**

Le grand McMurry en anglais:

**[https://openstax.org/details/
books/organic-chemistry](https://openstax.org/details/books/organic-chemistry)**

Voir aussi :

**J Clayden, N Greeves, S Warren,
Chimie organique, De Boeck, Paris,
Ed 2, 2013 (ISBN 978-2-8041-7441-5)**

**KPC Vollhardt, NE Schore, Traité de
chimie organique, De Boeck, Paris,
1999 (ISBN : 2-8041-3153-X)**

**AW Johnson, Invitation à la chimie
organique, De Boeck, Paris, 2003
(ISBN : 2-7445-0138-7)**

McMurry :

Amazon.com, Dunod.com, librairie médicale

Internet Archive: <https://archive.org/details/chimieorganiquel0000mcmu>

Modèles :

**<http://www.maruzen.info/hgs/catalog/index.php>
#1003A, Organic Chemistry Basic Set, \$28.00**

http://sasm.fr/catalogue/modeles_squelettiques/modeles-moleculaires-squelettiques,C0150,.php, 29.05 €

CONTENU

McMurry

1. Généralités

(1, 2, 15)

2. Lipides - stéroïdes - alcanes -

(2 - 5, 16)

alcènes - arènes -

3. Glucides - stéréochimie -

(6, 14)

4. Alcools - éthers - phénols -

(8, 16)

hydroquinones - thiols - disulfures

5. Glucides - aldéhydes - cétones -

(9, 14)

imines -

6. Protéines - lipides -

(10, 11, 15, 16)

acides - esters - amides -

7. Acides nucléiques - amines -

(12, 16)

CHIMIE ORGANIQUE - CONTENU SPÉCIFIQUE

	A. COURS	B. AUTO-APPRENTISSAGE	C. Partie du livre à connaître (A+B)
1. Généralités (1, 2, 15)	2.6, 2.1, 1.3, (15.1), (15.3.1), (1.1), (1.2), (1.4), 1.6, (16.4)	1.1, 1.2, 1.4, 1.5, 2.6 Exercices I et 1.7,30,34; 2.15,16,34, 35,66; 15.8,17,18	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10 2.1, (2.2), (2.4), 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11 3.2, 3.3, 3.4, (3.9), 3.10 4.6, 4.9.1, 4.11 (5.1), 5.2 6.1, 6.2, (6.4), 6.6, 6.7, 6.8, 6.9, 6.11, (6.12) (7.4), (7.5), 7.10.1 8.2, (8.3), 8.4.2, 8.4.3, 8.5.2, 8.6.4, (8.9) 9.1, 9.5, 9.6, 9.7, 9.8, 9.9, 9.10 10.2, (10.3), (10.5), 10.6, (10.7), (10.8), (10.11), 10.12.1 (11.1), 11.4, 11.8, 11.9, 11.10, 11.11 12.2, 12.3, 12.4.2, 12.4.3, 12.6 14.2, 14.3, 14.4, 14.5, 14.6, 14.7.2/3, (14.8), (14.9), 14.10 15.1, (15.2), 15.5, (15.9) 15.10.1 (16.2), 16.3, (16.4), 16.5, 16.6, (16.7), (16.9), (16.13) (17.2.4), (17.4.2), (17.5)
2. Lipides – stéroïdes - alcanes - alcènes - arènes - (2 - 5, 16)	1.7, (2.2), (15.1), 2.5, (16.4), 2.7, 2.9, 2.8, 2.10, 2.11, 14.6, (16.5), 1.9, (15.9), (2.4), 1.8, 3.2, 3.3, 3.4, (16.2), 4.6, 4.9.1, 4.11, 5.2, (5.1), (15.5), (15.9)	2.2, 2.5, 2.9 Exercices II et 1.27,28,64; 2.5,8,23, 24,29,40,44,54,67,68,71; 3.8,19	
3. Glucides - stéréochimie - (6, 14)	(14.4), 14.2, 6.1, 6.2, 14.2, 14.3, (6.4), 6.6, (15.1), 6.7, 6.8, 6.11, 6.9, 14.3, 14.4, (15.9), (6.12)	Exercices III et 6.3,18,22,23,24,46,58,59,60; 14.3,23,24,25,32,39,40; 15.2,19,26	
4. Alcools - éthers - phénols - thiols (8, 15)	1.9, 1.4, 8.2, 1.10, (8.3), (15.1), (15.2), 8.4.2, 8.4.3 8.5.2, 9.3.1, 14.7.3, (16.5), 8.6.4, (8.9), (15.5)	Exercices IV et 8.6,41,42,54,62	
5. Glucides - aldéhydes - cétones - imines - (9, 14)	9.1, 9.5, 9.7, (3.9), (3.10), 14.4, 14.5, 14.6, 9.8, 9.9, 14.7.2, (14.8), (14.9), 9.9, 16.6, 10.6, (10.9), 9.6, (17.2.4), 9.10, 12.4.3, (17.5), (7.5.5),	Exercices V, VI et 9.14,15,16,44,45; 12.11,12; 14.19,34,43,44,48; 17.8,9	
6. Protéines - lipides - acides - esters - amides - (10, 11, 15, 16)	10.2, 1.10, (10.3), (10.8), 10.6, (10.11), 16.3, (10.5), 10.12.1, (16.13), 15.10.1, (11.1), 16.5, 11.4, 11.8, 11.9, 11.10, 11.11; (17.4.2)	Exercices VII, VIII et 10.5,20,21,28; 11.8,19,20,30,33,40,43	
7. Acides nucléiques - amines - (12, 16)	12.2, 12.3, 12.4.2, 8.8.2, (7.4), (7.5), 7.10.1, 12.6 (16.7), (16.9)	Exercices VIII et 12.1,5,6,16,19,28,37	

xx.x.y : seulement sujet y du chapitre xx.x

(xx.x) : seulement partie du chapitre xx.x

CHIMIE ORGANIQUE - CONTENU SPÉCIFIQUE

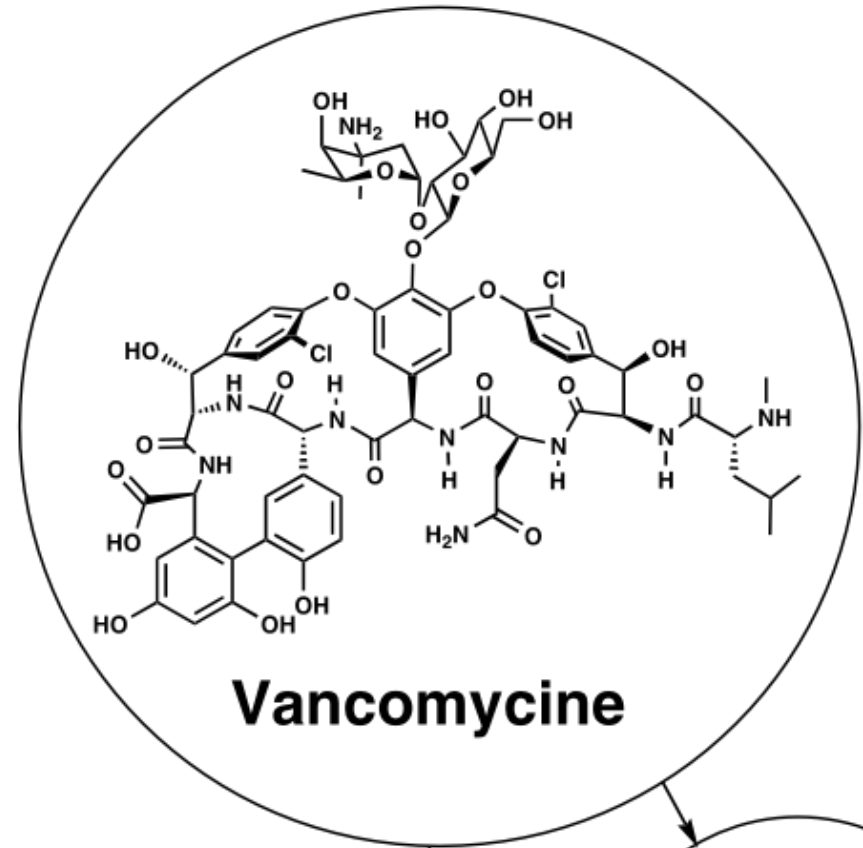
	A. COURS	B. AUTO-APPRENTISSAGE	C. Partie du livre à connaître (A+B)
1. Généralités (1, 2, 15)	2.6, 2.1, 1.3, (15.1), (15.4), (1.1), (1.2), (1.5), (16.4), 1.7	1.1, 1.2, 1.4, 1.5, 1.6, 2.6 Exercices I et 1.13,27,34; 2.14,15,27, 48,64; 15.9,52,53	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12
2. Lipides – stéroïdes - alcanes - alcènes - arènes - (2 - 5, 16)	1.8, (2.2), (15.1), 2.5, (16.4), 2.7, 2.9, 2.8, 2.10, 2.11, 14.7, (16.5), 1.11, (15.10), (2.4), 1.8, 1.9, 1.10, (4.13), 3.2, 3.3, 3.4, (16.2), 4.6, 4.10.1, 4.12, 5.3, (5.2), (15.10)	2.2, 2.5, 2.9 Exercices II et 1.62,67,68; 2.4,7,22, 23,33,37,40,56,57,61,65; 3.10,58	2.1, 2.2, (2.4), 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11 3.2, 3.3, 3.4, (3.10), (3.11) 4.6, 4.10.1, (4.12), (4.13) (5.2), 5.3
3. Glucides - stéréochimie - (6, 14)	(14.4), 14.2, 6.1, 6.2, 14.2, (6.4), 6.6, (15.1), 6.7, 6.8, 6.11, 6.12, 6.9, 14.3, 14.4, (15.10), (6.14)	Exercices III et 6.3,16,39,53,54,55,61, 62,63; 14.4,28,36,37,56,57,58; 15.2, 25,54	6.1, 6.2, (6.4), 6.6, 6.7, 6.8, 6.9, 6.11, (6.12), (6.14) (7.6), (7.7), 7.12
4. Alcools - éthers - phénols - thiols (8, 15)	1.11, 1.5, 8.2, 1.12, (8.3), (15.1), (15.2), (15.3), 8.5, 8.7.3, 9.4.1, 14.8.3, (16.5), 8.8.3, (8.12), 15.5	Exercices IV et 8.8,37,38,39,49	8.2, (8.3), 8.5, 8.7.3, 8.8.3, (8.12) (9.1), 9.2, 9.4.1, 9.6, 9.7, 9.8, 9.9.1, 9.11 10.2, (10.3), (10.5), (10.6), (10.9), (10.10) (11.1), 11.4, 11.7, 11.8, 11.9, 11.10
5. Glucides - aldéhydes - cétones - imines - (9, 14)	(9.1), 9.2, 9.6, 9.7, (3.10), (3.11), 14.5, 14.6, 14.7, (14.8), 9.8, (14.10), 8.5, 17.2.4, 9.9.1, 9.11.1, (17.5)	Exercices V, VI et 9.15,38,39; 14.20,31,39,40,45, 17.9	12.2, 12.3, 12.4.1, 12.6
6. Protéines - lipides - acides - esters - amides - (10, 11, 15, 16)	10.2, (10.3), (10.5), (10.6), (10.9), (16.2), 16.3, 10.6.1, (15.1), (10.9), (16.12), (10.10), (15.11), (11.1), 11.4, 11.7, 11.8, 11.9, 11.10, (17.4)	Exercices VII, VIII et 10.5,23,24,66; 11.9,32,41,42,49,50	14.2, 14.3, 14.4, 14.5, 14.6, 14.7, (14.8) 15.1, (15.2), (15.3), (15.4), 15.5, (15.10) (16.2), 16.3, (16.4), (16.5), (16.6), (16.7), (16.8), (16.12)
7. Acides nucléiques - amines - (12, 16)	12.2, 12.3, (16.7), 12.4.1, 8.11, (7.6), (7.7), 7.12, 12.6, (16.6)	Exercices VIII et 12.1,6,7,19,23,37,54	(17.2), (17.5)

xx.x.y : seulement sujet y du chapitre xx.x

(xx.x) : seulement partie du chapitre xx.x

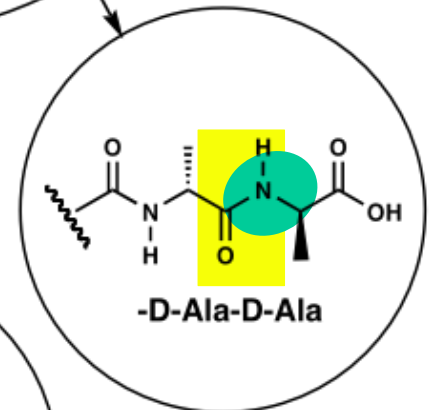
A propos de...

médecine et chimie organique

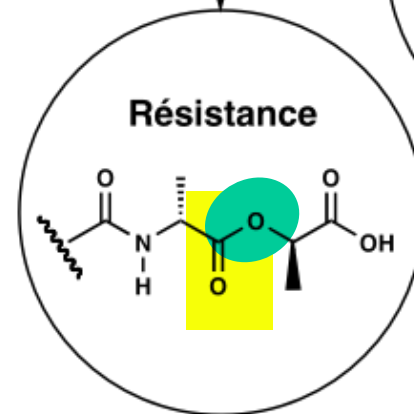


Vancomycine

DEFINITION
chimie organique, travaille sur
des molécules

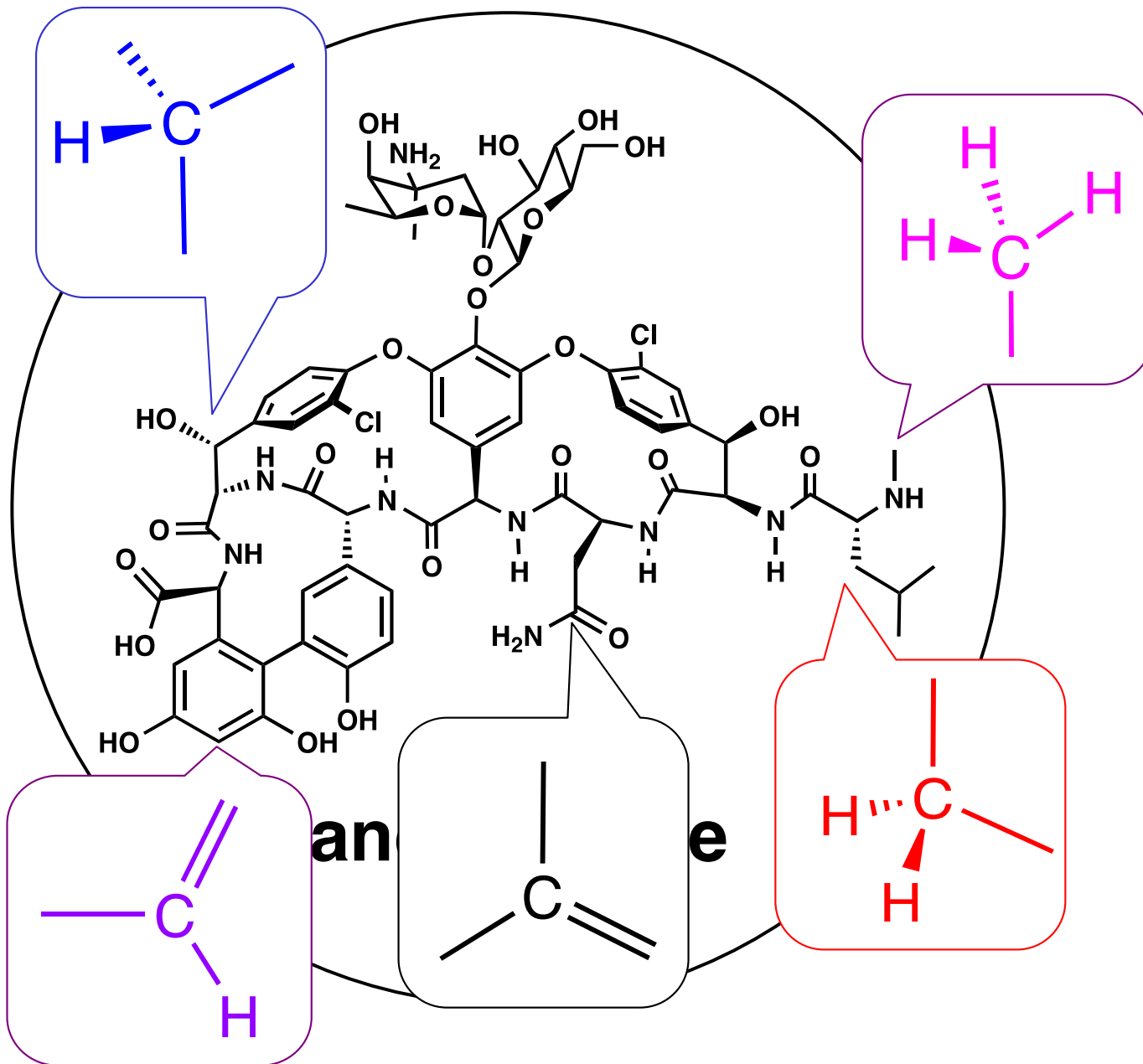


-D-Ala-D-Ala



Résistance

Molécules - groupes fonctionnels - la vancomycine (2.1, dessiner : 2.6, 1.3)



(antibiotique)

Produit naturel

(Métabolite

secondaire)

Les grandes familles

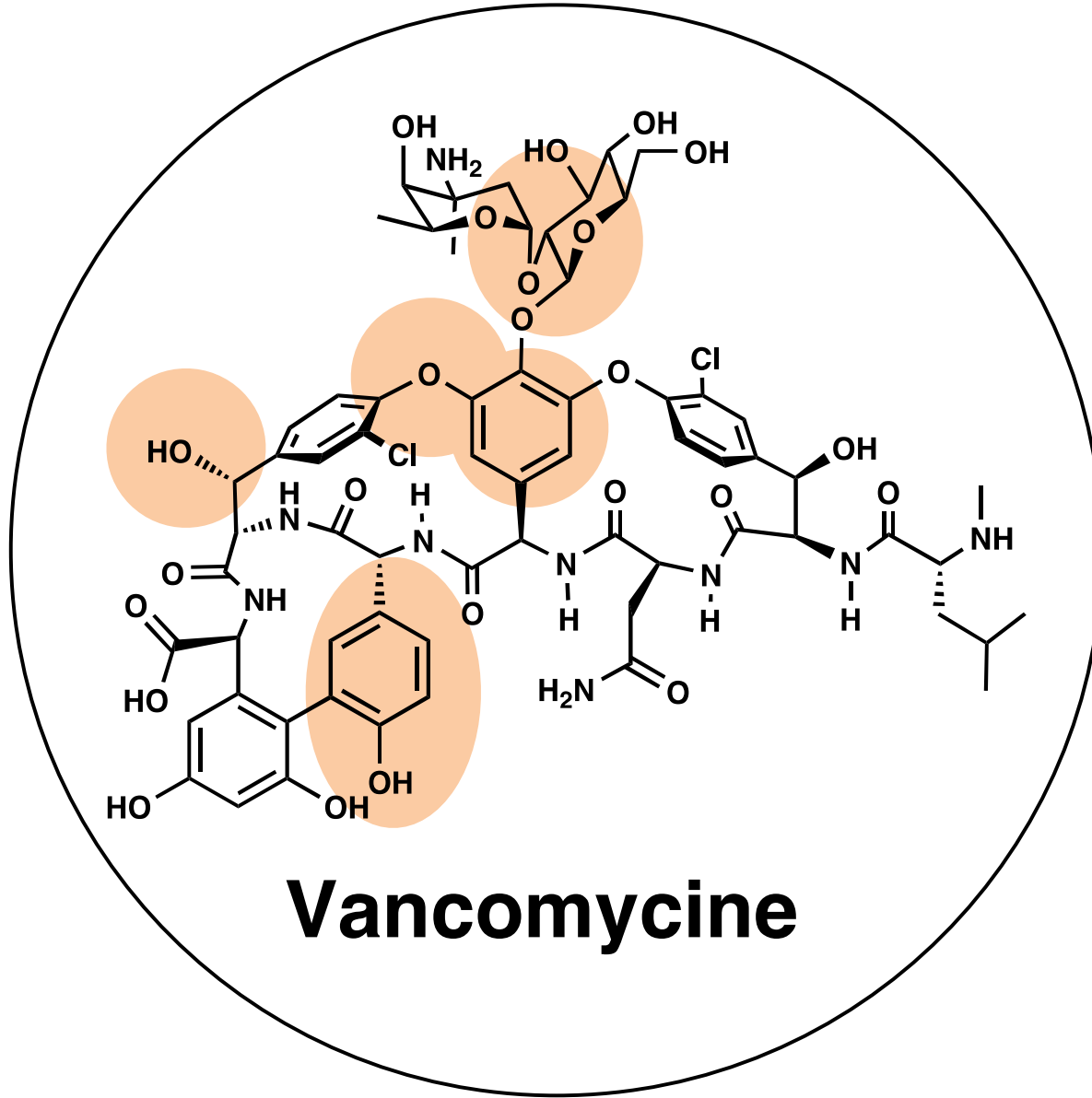
1. Produits naturels

2. Protéines

3. Nucléotides

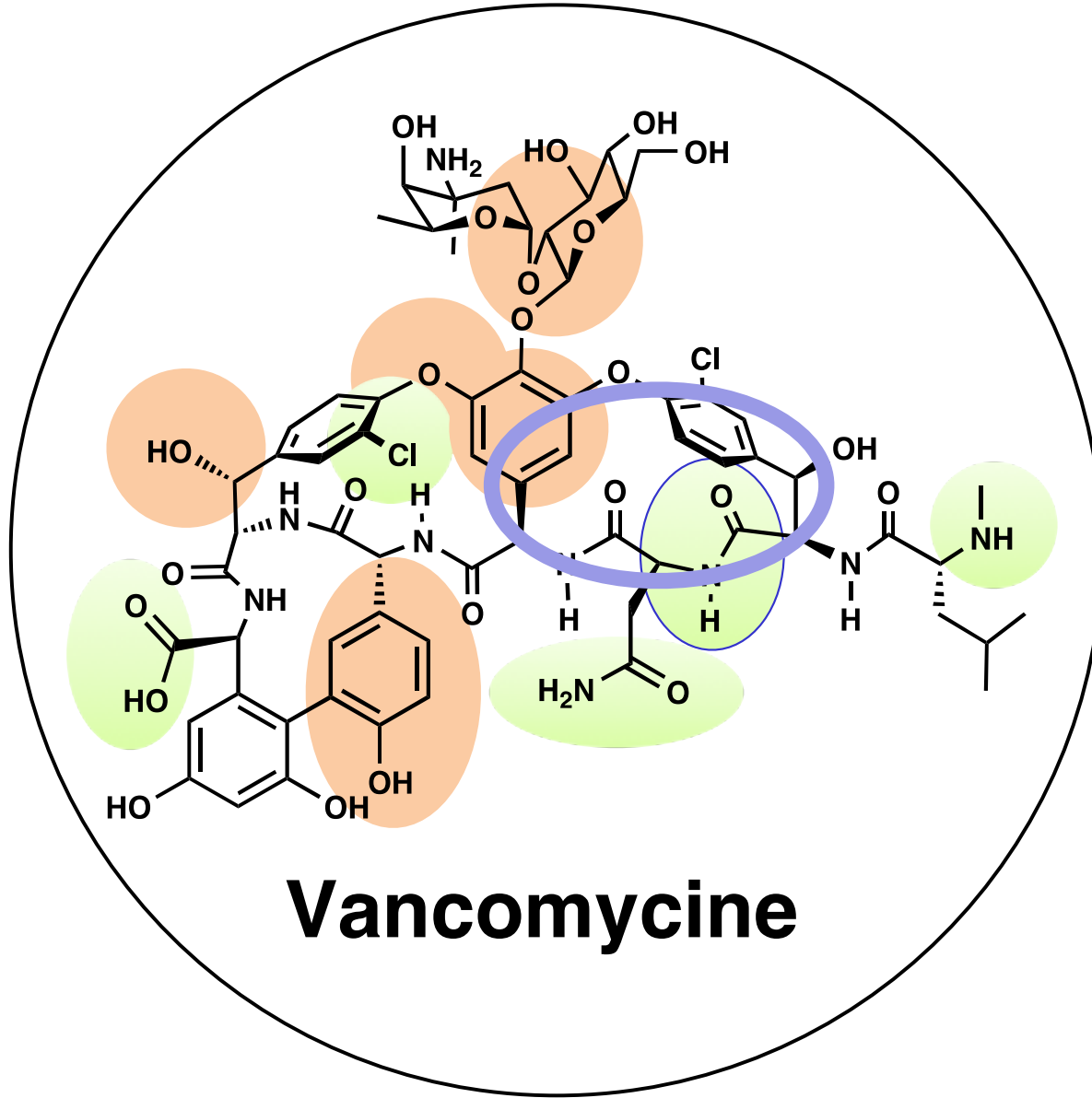
4. Glucides

5. Lipides



Vancomycine

- Alcène**
- Alcyne**
- Arène**
- Alcool**
- Phénol**
- Thiol**
- Éther**
- Sulfure**
- Disulfure**
- Aldéhyde**
- Cétone**
- Hémiacétal**
- Acétal**



Vancomycine

Acide carb.

Ester

Lactone

Amide

Lactame

Amine

Imine

Halogénure

Phosphate

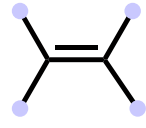
acyclique

carbocyclique

hétérocyclique



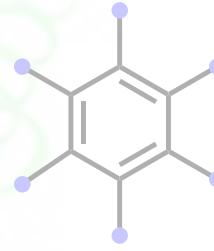
Alkane



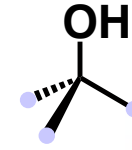
Alcène



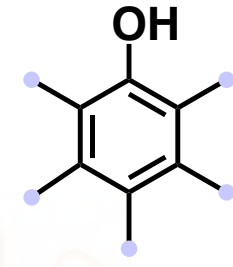
Alkyne



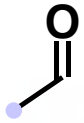
Arène



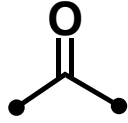
Alcool



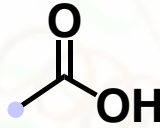
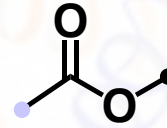
Phénol



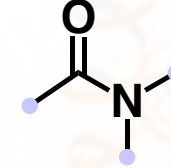
Aldéhyde



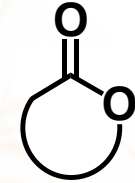
Cétone

Acide
carboxylique

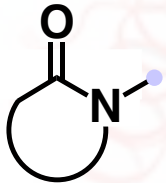
Ester



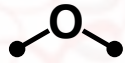
Amide



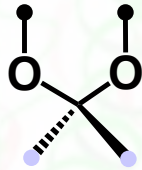
Lactone



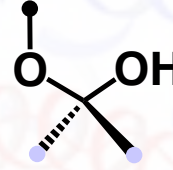
Lactame



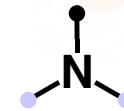
Éther



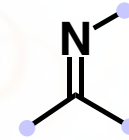
Acétal



Hémiacétal



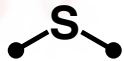
Amine



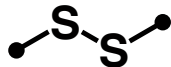
Imine



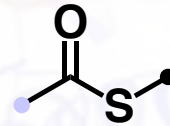
Thiol



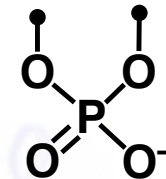
Sulfure



Disulfure



Thioester



Phosphodiester

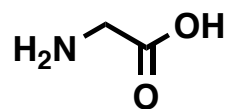


X = F, Cl, Br, I

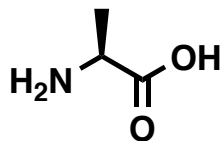
Halogénure

●● = Reste de la molécule ● = H possible

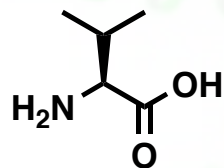
Les acides aminés (formes neutres)



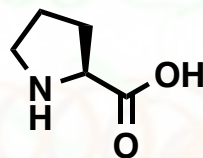
Glycine
(Gly, G)



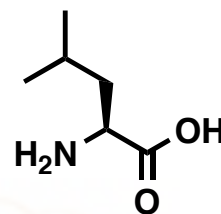
Alanine
(Ala, A)



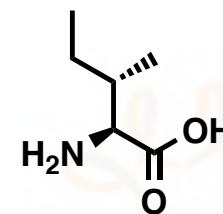
Valine
(Val, V)



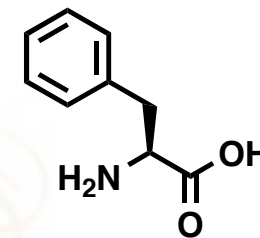
Proline
(Pro, P)



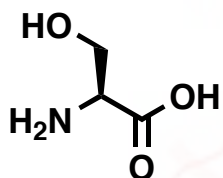
Leucine
(Leu, L)



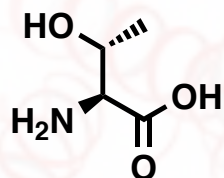
Isoleucine
(Ile, I)



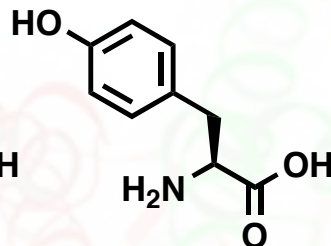
Phénylalanine
(Phe, F)



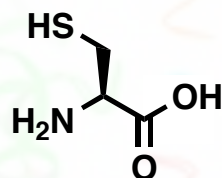
Sérine
(Ser, S)



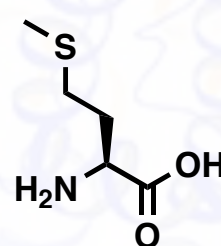
Thréonine
(Thr, T)



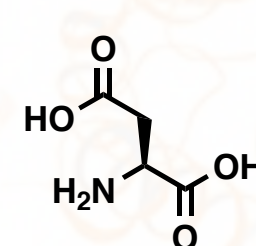
Tyrosine
(Tyr, Y)



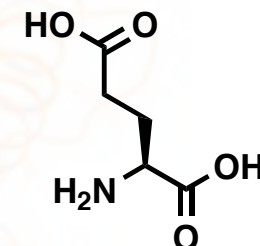
Cystéine
(Cys, C)



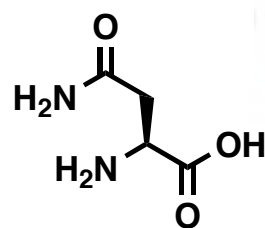
Méthionine
(Met, M)



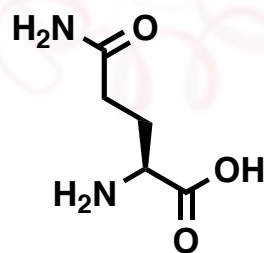
Acide aspartique
(Asp, D)



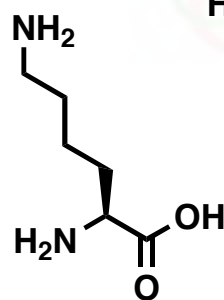
Acide glutamique
(Glu, E)



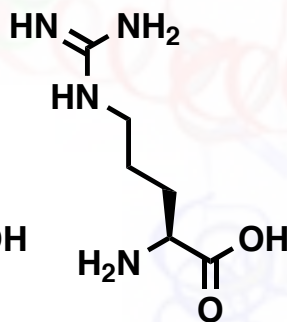
Asparagine
(Asn, N)



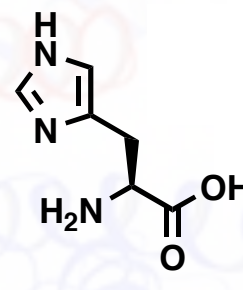
Glutamine
(Gln, Q)



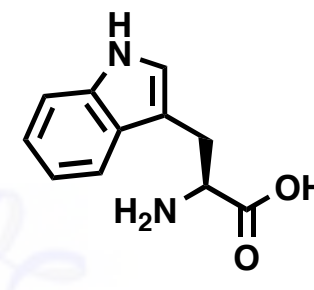
Lysine
(Lys, K)



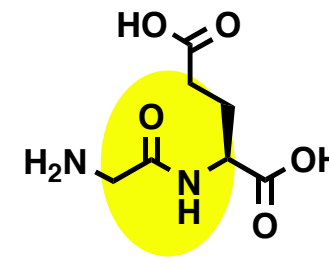
Arginine
(Arg, R)



Histidine
(His, H)



Tryptophane
(Trp, W)



Asparagine
(Asn, N)

Alcène

Alcyne

Arène

Alcool

Phénol

Thiol

Éther

Sulfure

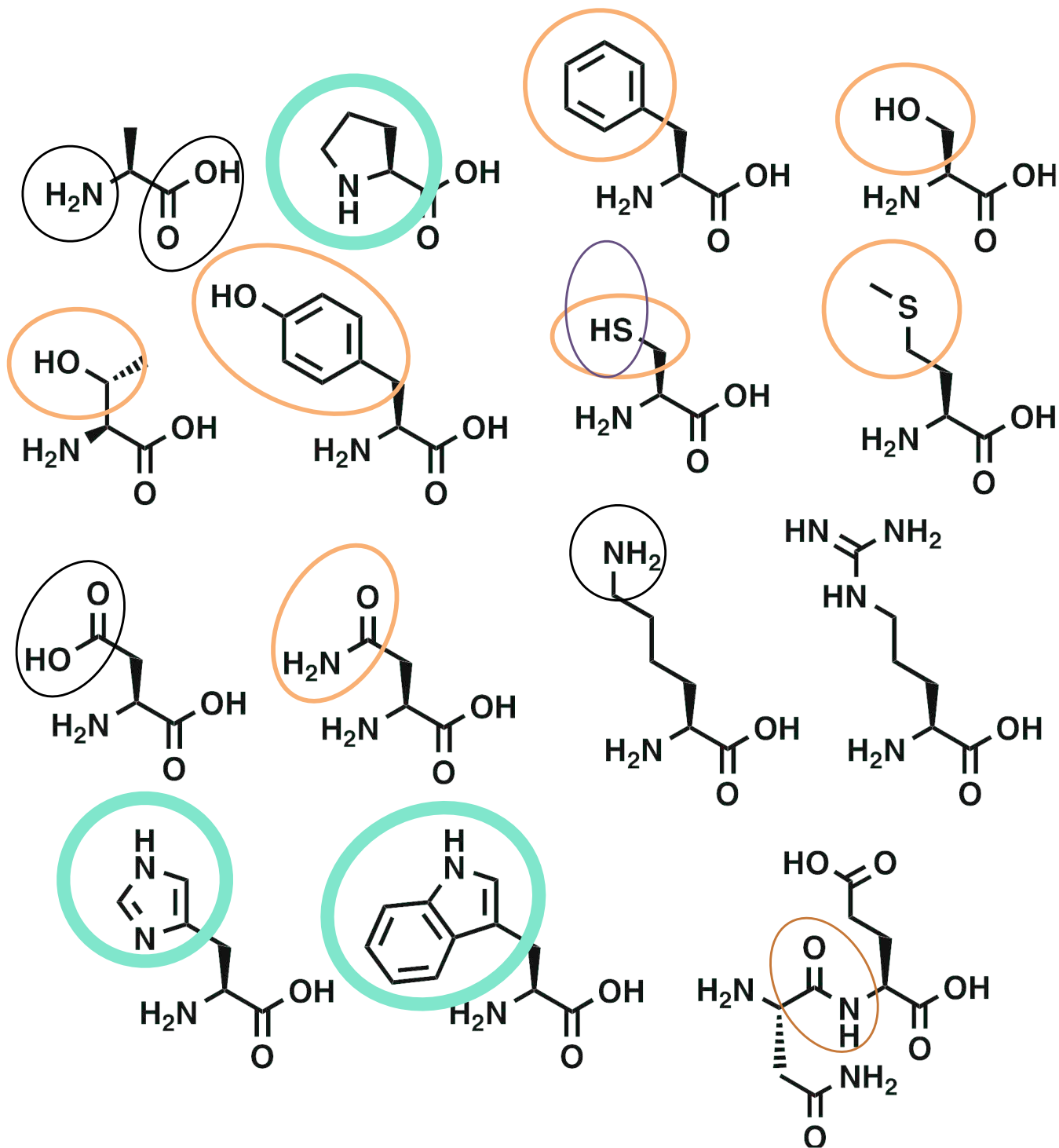
Disulfure

Aldéhyde

Cétone

Hémiacétal

Acétal



Acide carb.

Ester

Lactone

Amide

Lactame

Amine

Imine

Halogénure

Phosphate

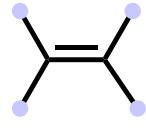
acyclique

carbocyclique

hétérocyclique



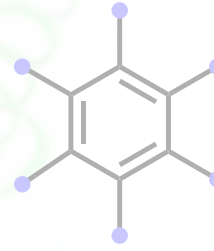
Alkane



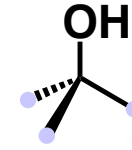
Alcène



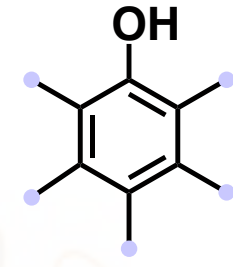
Alkyne



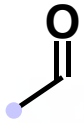
Arène



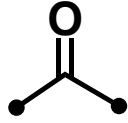
Alcool



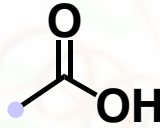
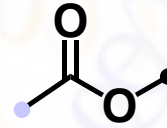
Phénol



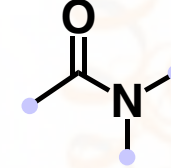
Aldéhyde



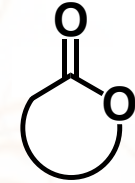
Cétone

Acide
carboxylique

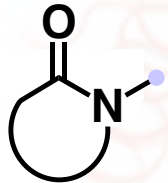
Ester



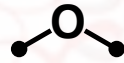
Amide



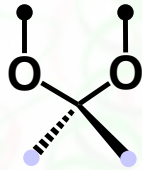
Lactone



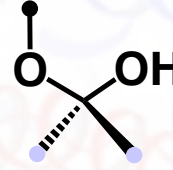
Lactame



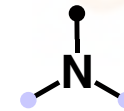
Éther



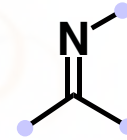
Acétal



Hémiacétal



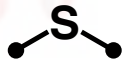
Amine



Imine



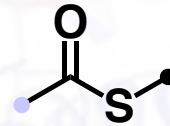
Thiol



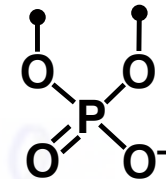
Sulfure



Disulfure



Thioester



Phosphodiester

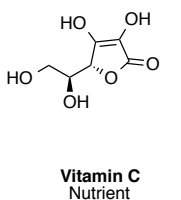
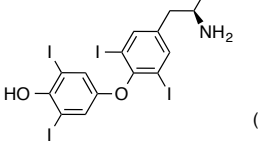
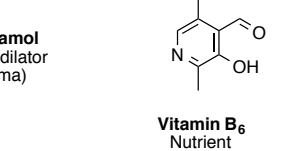
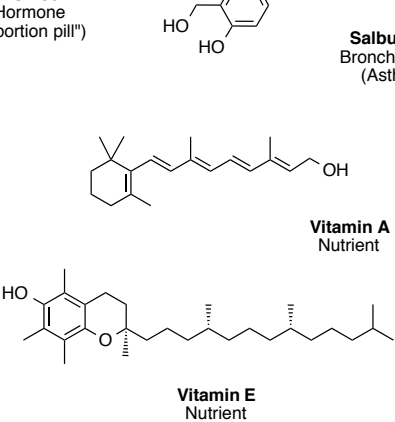
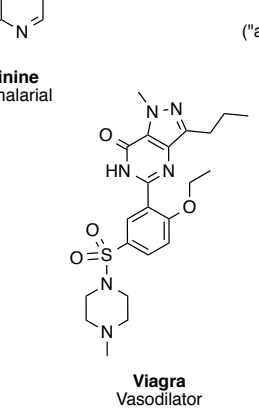
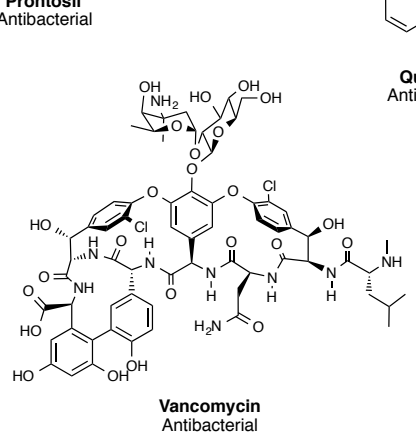
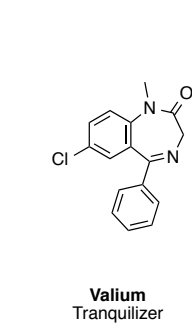
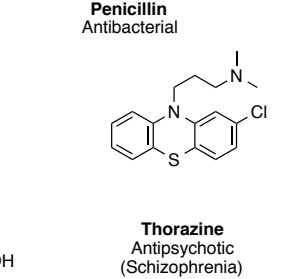
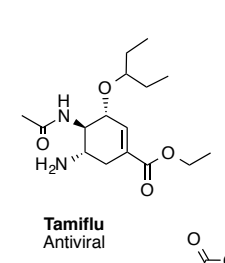
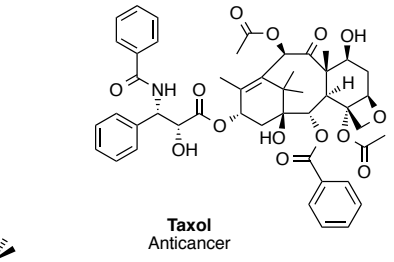
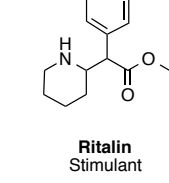
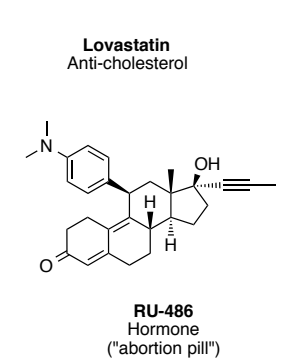
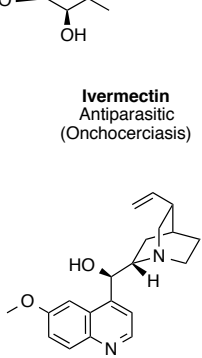
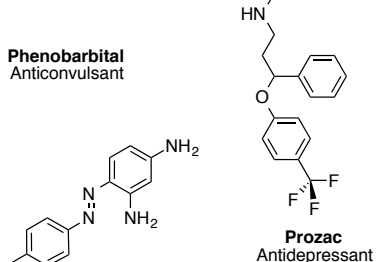
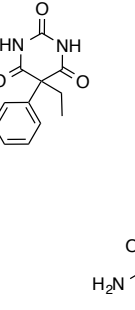
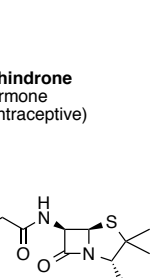
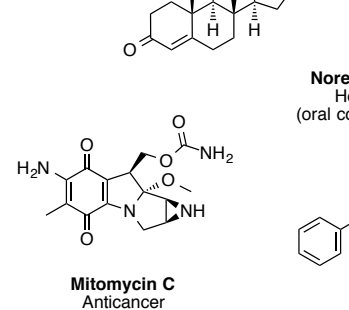
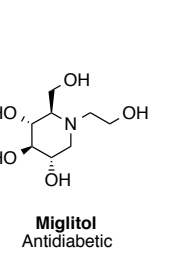
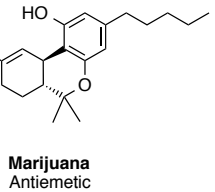
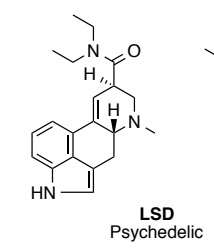
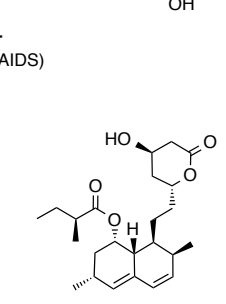
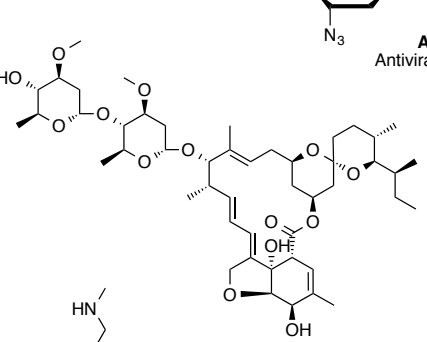
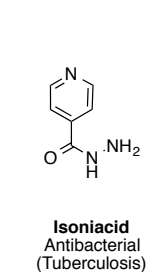
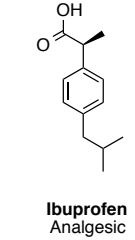
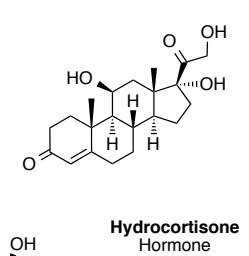
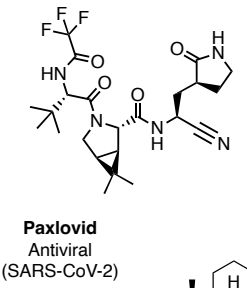
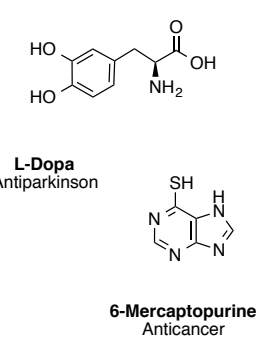
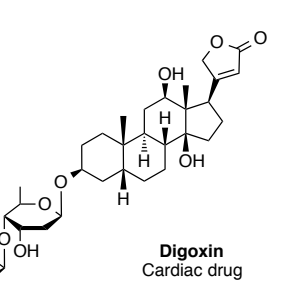
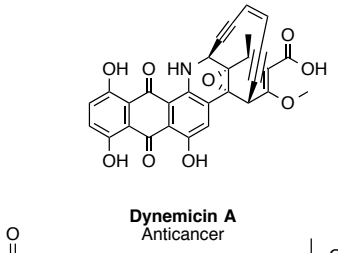
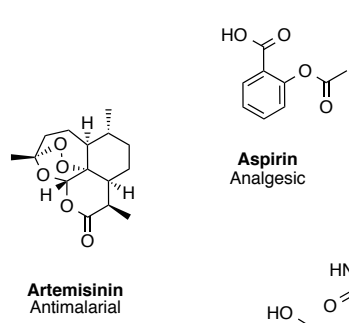
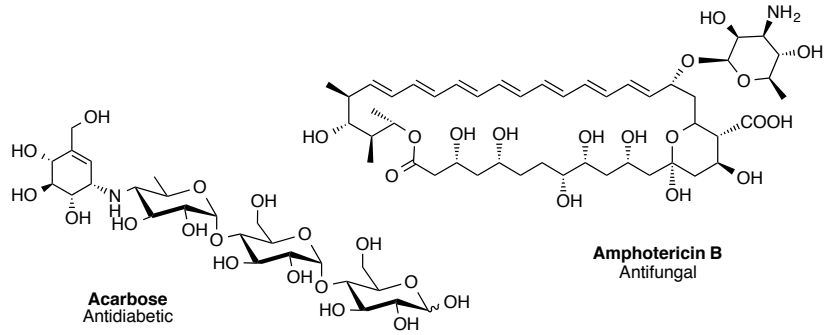


X = F, Cl, Br, I

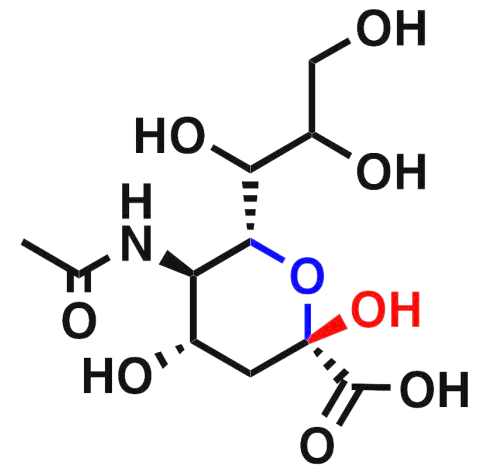
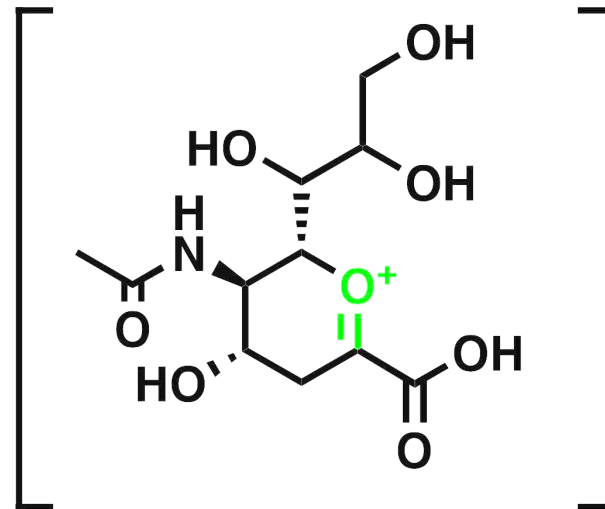
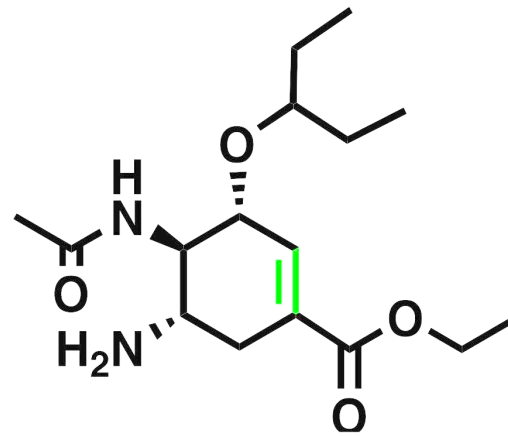
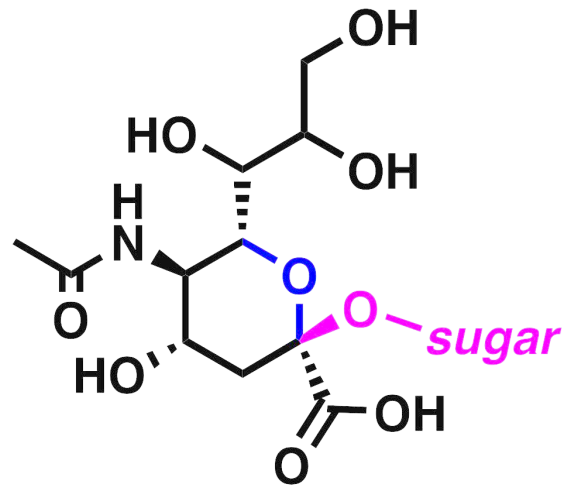
Halogénure

●● = Reste de la molécule ● = H possible

Molécules qui ont changé notre monde...



Tamiflu



NANA
(N-acetylneuraminic acid, sialic acid)

Molécules - atomes le tableau périodique - la vancomycine

formule moléculaire : $C_{66}H_{75}Cl_2N_9O_{24}$

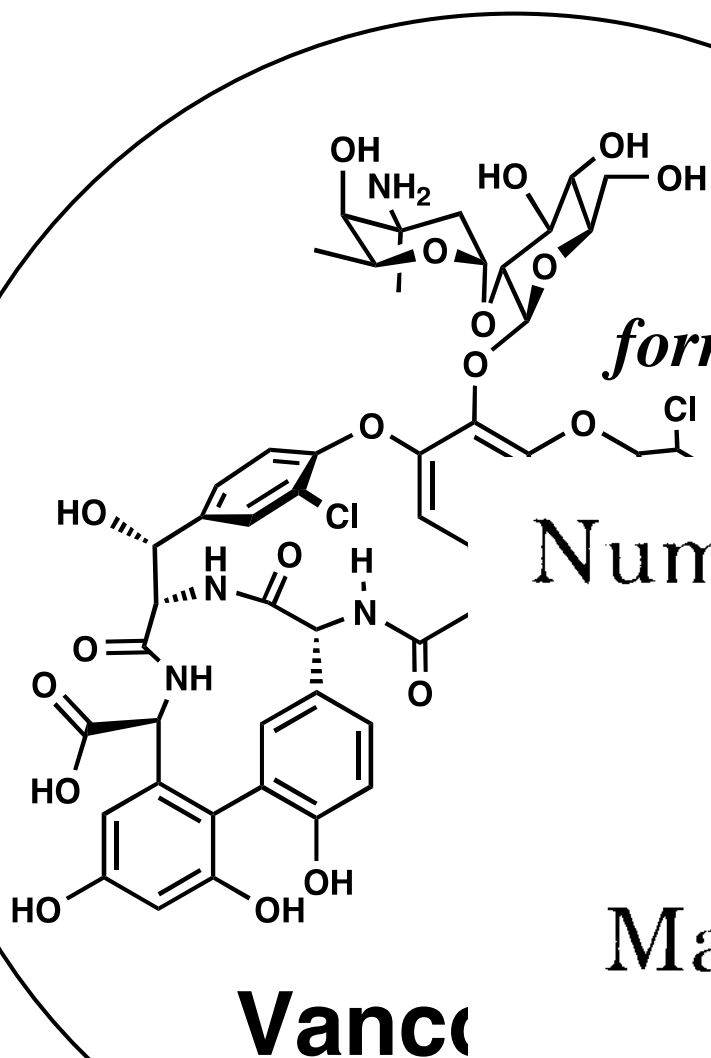
Numéro atomique —

Nom —

Symbole —

Masse atomique —

6
Carbone
C
12,011

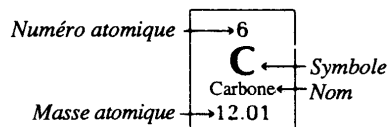


masse moléculaire : 1449,3

groupes

Tableau périodique des éléments

I A																				VIII A							
1 H Hydrogène 1.008																				2 He Hélium 4.00							
II A																		III A	IV A	V A	VI A	VII A					
3 Li Lithium 6.94		4 Be Béryllium 9.01																		5 B Bore 10.81	6 C Carbone 12.01	7 N Azote 14.01	8 O Oxygène 16.00	9 F Fluor 19.00	10 Ne Néon 20.18		
11 Na Sodium 22.99		12 Mg Magnésium 24.30																		13 Al Aluminium 26.98	14 Si Silicium 28.09	15 P Phosphore 30.97	16 S Soufre 32.06	17 Cl Chlore 35.45	18 Ar Argon 39.95		
		III B	IV B	V B	VI B	VII B	VIII B			I B	II B																
19 K Potassium 39.10		20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titane 47.90	23 V Vanadium 50.94	24 Cr Chrome 52.00	25 Mn Manganèse 54.94	26 Fe Fer 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.70	29 Cu Cuivre 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Sélénium 78.96	35 Br Brome 79.90	36 Kr Krypton 83.80									
37 Rb Rubidium 85.47		38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdène 95.94	43 Tc Technétium 98.91	44 Ru Ruthénium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.4	47 Ag Argent 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Étain 118.69	51 Sb Antimoine 121.75	52 Te Tellure 127.60	53 I Iode 126.90	54 Xe Xénon 131.30									
55 Cs Césium 132.91		56 Ba Baryum 137.33	57* La Lanthane 138.91	72 Hf Hafnium 178.49	73 Ta Tantale 180.95	74 W Tungstène 183.85	75 Re Rhénium 186.21	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platine 195.09	79 Au Or 196.97	80 Hg Mercure 200.59	81 Tl Thallium 204.37	82 Pb Plomb 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astate (210)	86 Rn Radon (222)									
87 Fr Francium (223)		88 Ra Radium 226.03	89† Ac Actinium 227.03	104 § (261)	105 § (262)	106 § (263)	107 § (262)	108 § (265)	109 § (267)																		



périodes

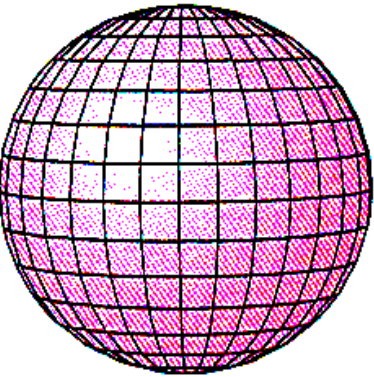
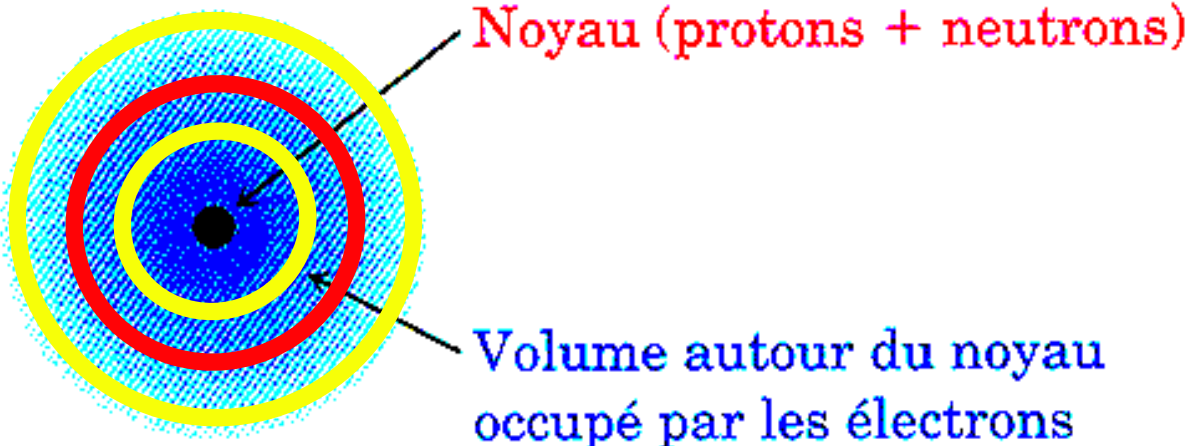
Lanthanides

58 Ce Cérium 140.12	59 Pr Praséodyme 140.91	60 Nd Néodyme 144.24	61 Pm Prométhium (145)	62 Sm Samarium 150.4	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutéium 174.97
90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium (244)	95 Am Américium (243)	96 Cm Curium (247)	97 Bk Berkélium (249)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendélévium (258)	102 No Nobélium (259)	103 Lr Lawrencium (260)

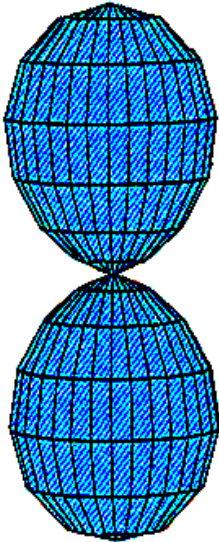
Actinides

isotopes

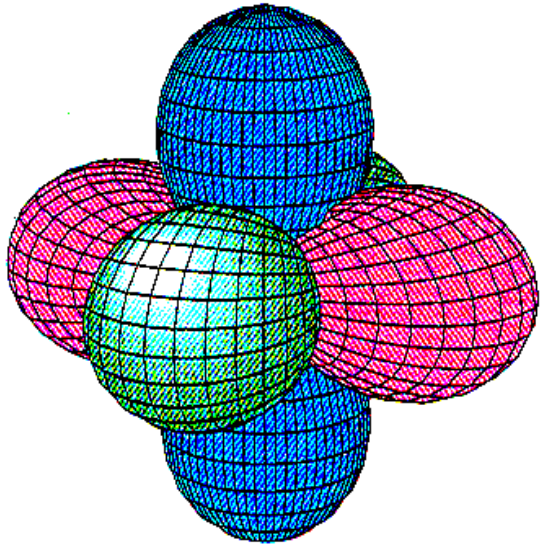
Structure atomique



Une orbitale *s*



Une orbitale *p*



Trois orbitales *2p*

Répartition des électrons

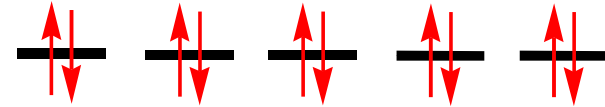


3^e couche
(18 électrons maximum)

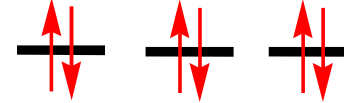
2^e couche
(8 électrons maximum)

1^{re} couche
(2 électrons maximum)

3 *d*



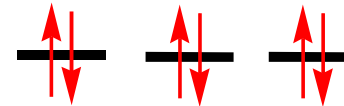
3 *p*



3 *s*



2 *p*



2 *s*



1 *s*

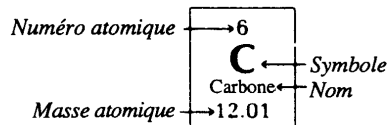


configuration électronique - couches de valence

groupes

Tableau périodique des éléments

I A																				VIII A							
1 H Hydrogène 1.008																				2 He Hélium 4.00							
II A																		III A	IV A	V A	VI A	VII A					
3 Li Lithium 6.94		4 Be Béryllium 9.01																		5 B Bore 10.81	6 C Carbone 12.01	7 N Azote 14.01	8 O Oxygène 16.00	9 F Fluor 19.00	10 Ne Néon 20.18		
11 Na Sodium 22.99		12 Mg Magnésium 24.30																		13 Al Aluminium 26.98	14 Si Silicium 28.09	15 P Phosphore 30.97	16 S Soufre 32.06	17 Cl Chlore 35.45	18 Ar Argon 39.95		
		III B	IV B	V B	VI B	VII B	VIII B			I B	II B																
19 K Potassium 39.10		20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titane 47.90	23 V Vanadium 50.94	24 Cr Chrome 52.00	25 Mn Manganèse 54.94	26 Fe Fer 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.70	29 Cu Cuivre 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Sélénium 78.96	35 Br Brome 79.90	36 Kr Krypton 83.80									
37 Rb Rubidium 85.47		38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdène 95.94	43 Tc Technétium 98.91	44 Ru Ruthénium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.4	47 Ag Argent 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Étain 118.69	51 Sb Antimoine 121.75	52 Te Tellure 127.60	53 I Iode 126.90	54 Xe Xénon 131.30									
55 Cs Césium 132.91		56 Ba Baryum 137.33	57* La Lanthane 138.91	72 Hf Hafnium 178.49	73 Ta Tantale 180.95	74 W Tungstène 183.85	75 Re Rhénium 186.21	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platine 195.09	79 Au Or 196.97	80 Hg Mercure 200.59	81 Tl Thallium 204.37	82 Pb Plomb 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astate (210)	86 Rn Radon (222)									
87 Fr Francium (223)		88 Ra Radium 226.03	89† Ac Actinium 227.03	104 § (261)	105 § (262)	106 § (263)	107 § (262)	108 § (265)	109 § (267)																		



périodes

Lanthanides

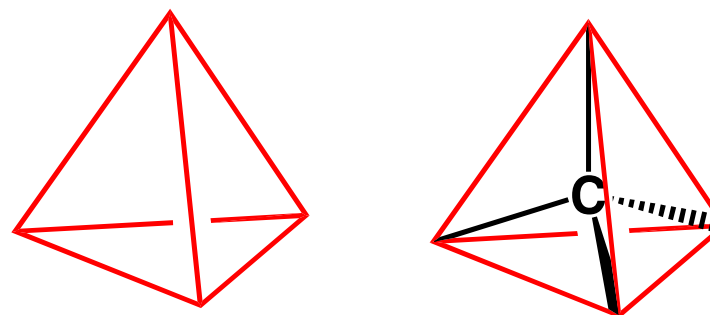
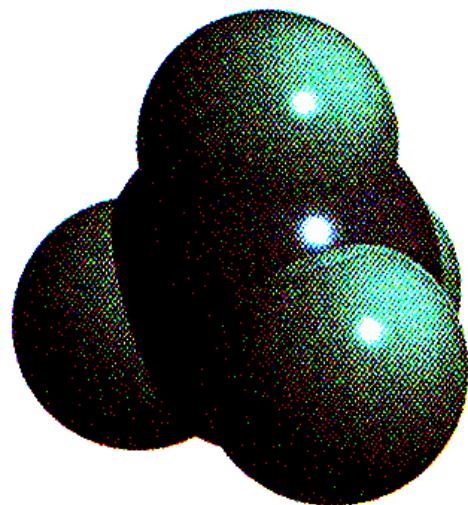
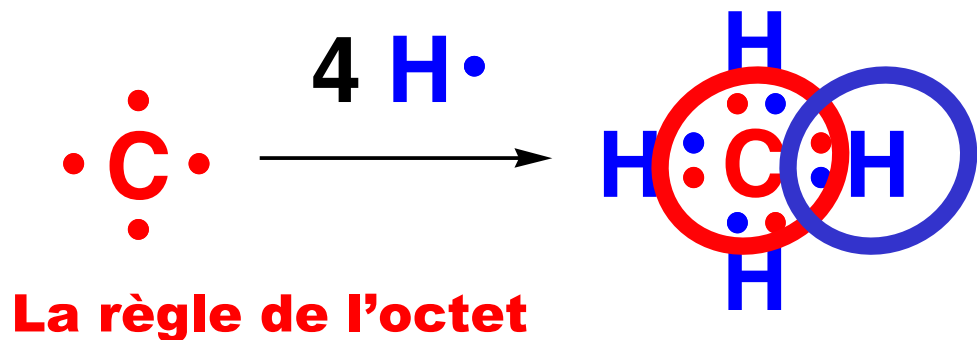
58 Ce Cérium 140.12	59 Pr Praséodyme 140.91	60 Nd Néodyme 144.24	61 Pm Prométhium (145)	62 Sm Samarium 150.4	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutéium 174.97
90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium (244)	95 Am Américium (243)	96 Cm Curium (247)	97 Bk Berkélium (249)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendélévium (258)	102 No Nobélium (259)	103 Lr Lawrencium (260)

Actinides

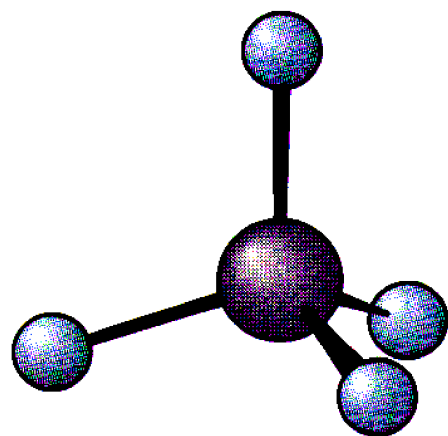
isotopes

Liaisons covalentes

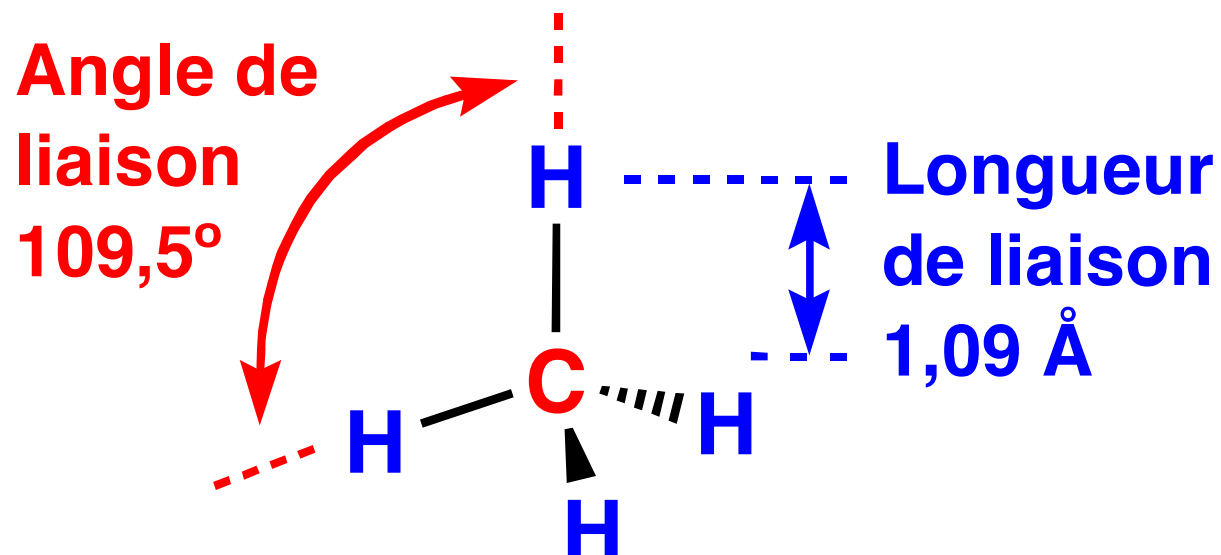
Méthane

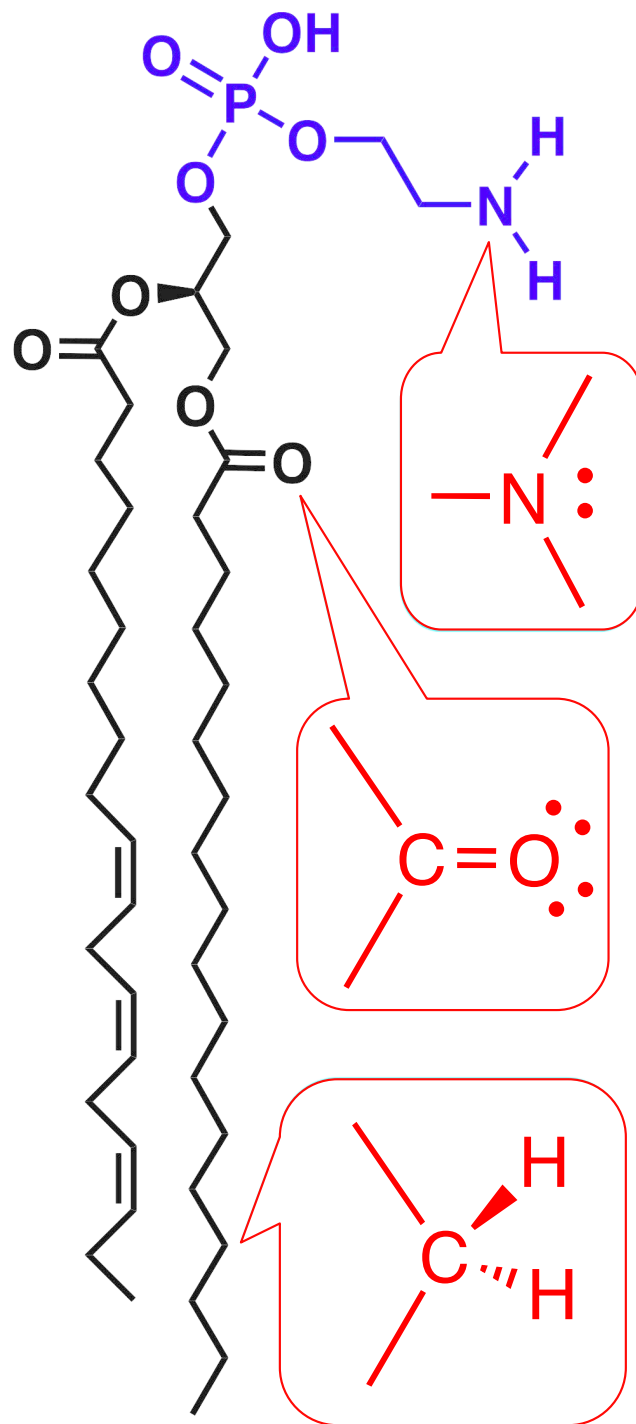
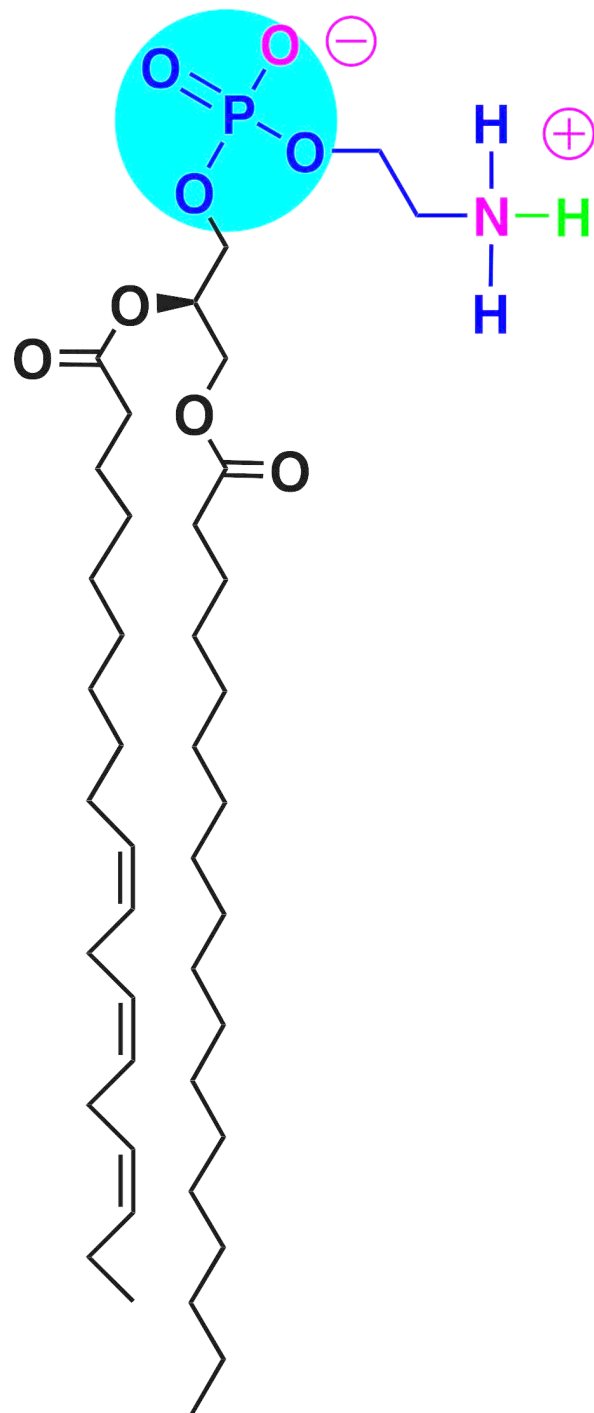


Un tétraèdre



Vue spatiale

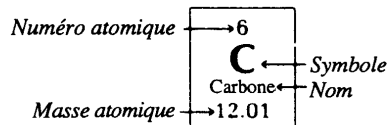




groupes

Tableau périodique des éléments

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périodes

Lanthanides

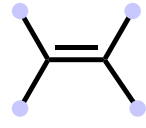
58 Ce Cérium 140.12	59 Pr Praséodyme 140.91	60 Nd Néodyme 144.24	61 Pm Prométhium (145)	62 Sm Samarium 150.4	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutéium 174.97
90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium (244)	95 Am Américium (243)	96 Cm Curium (247)	97 Bk Berkélium (249)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendélévium (258)	102 No Nobélium (259)	103 Lr Lawrencium (260)

Actinides

isotopes



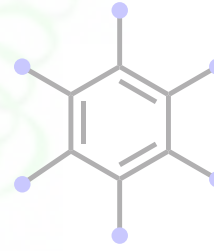
Alkane



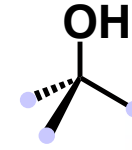
Alcène



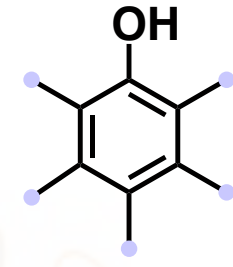
Alkyne



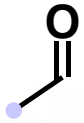
Arène



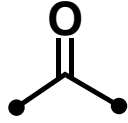
Alcool



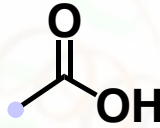
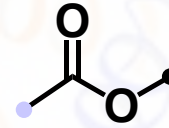
Phénol



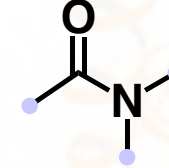
Aldéhyde



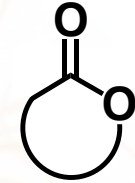
Cétone

Acide
carboxylique

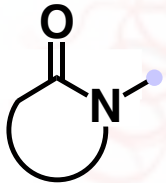
Ester



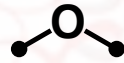
Amide



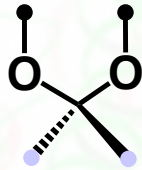
Lactone



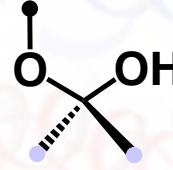
Lactame



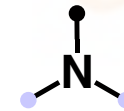
Éther



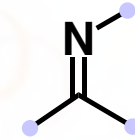
Acétal



Hémiacétal



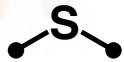
Amine



Imine



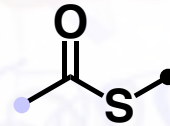
Thiol



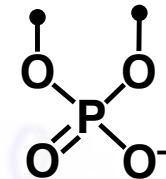
Sulfure



Disulfure



Thioester



Phosphodiester

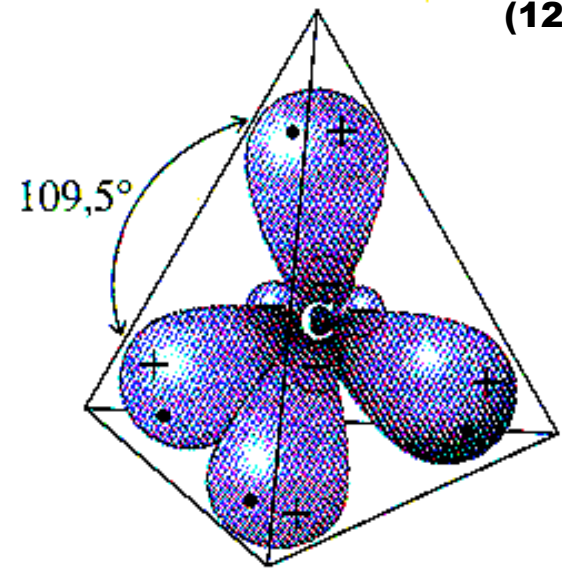
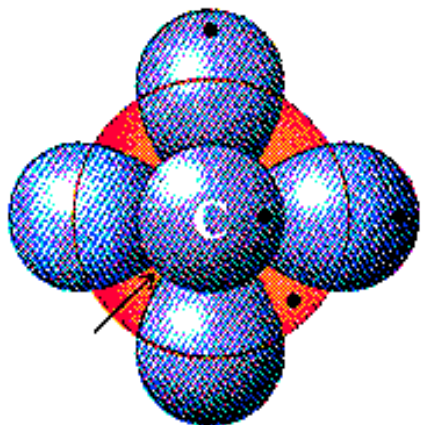


X = F, Cl, Br, I

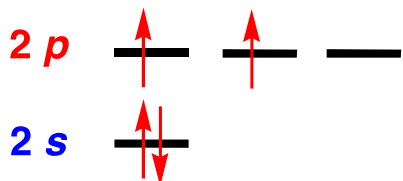
Halogénure

●● = Reste de la molécule ● = H possible

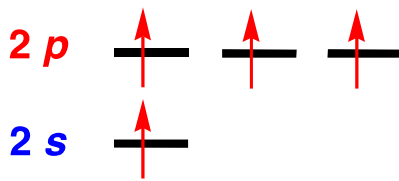
Hybridation du carbone



Energie



Orbitales atomiques du carbone



Un électron 2s est promu dans une orbitale 2p

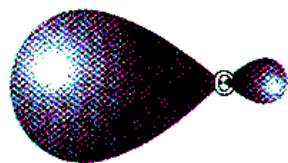


Les orbitales s et p se combinent pour former quatre orbitales hybrides sp^3 équivalentes



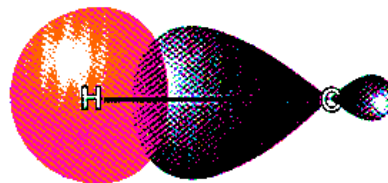
Une orbitale s

+

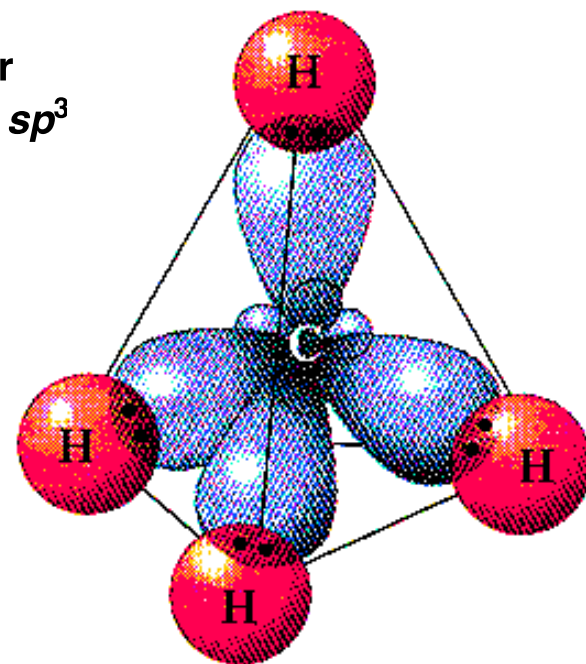


Une orbitale sp^3

recouvrement
(dégagement d'énergie)



Une liaison σ ($s-sp^3$)





Résumé 1

- **Molécules - groupes fonctionnels - atomes -**
- **Atomes : Le tableau périodique - périodes - groupes - isotopes - configuration électronique - couches de valence -**
- **Groupes fonctionnels : Molécules en médecine - acides aminés - produits naturels - lipides -**
- **Molécules : La règle de l'octet - liaisons covalentes - hybridation - formule moléculaire - masse moléculaire -**

La règle de l'octet

A

Couche électronique externe d'un atome

B

Mélange des orbitales atomiques de la même couche électronique de manière à former de nouvelles orbitales qui permettent de mieux décrire les liaisons entre atomes

C

Formule indiquant la nature et le nombre de chacun des atomes d'une molécule

D

Distribution des électrons d'un atome dans les orbitales atomiques

E

Tendance des atomes avec un numéro atomique ≥ 4 à se combiner de façon à avoir huit électrons dans leur couche de valence



CONTENU

McMurry

1. Généralités

(1, 2, 15)

**2. Lipides - stéroïdes - alcanes -
alcènes - arènes -**

(2 - 5, 16)

3. Glucides - stéréochimie -

(6, 14)

4. Alcools - éthers - phénols -

(8, 16)

hydroquinones - thiols - disulfures

5. Glucides - aldéhydes - cétones -

(9, 14)

imines -

6. Protéines - lipides -

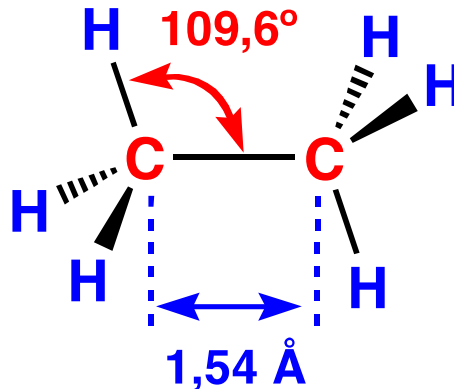
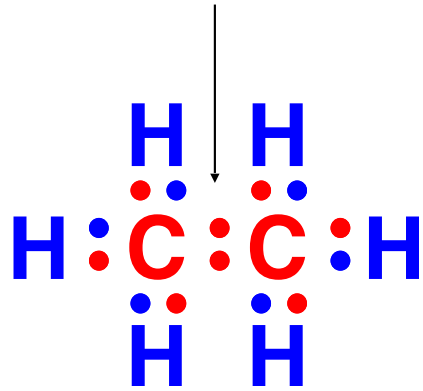
(10, 11, 15, 16)

acides - esters - amides -

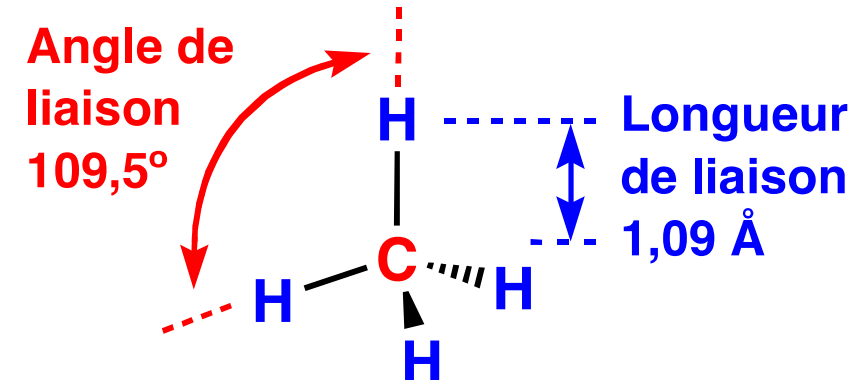
7. Acides nucléiques - amines -

(12, 16)

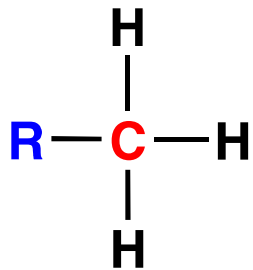
Liaison σ du type $sp^3 - sp^3$



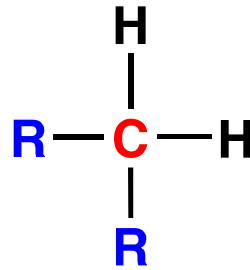
Alcanes



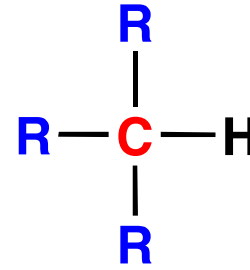
- alcanes saturés, hydrocarbures
- composés aliphatiques



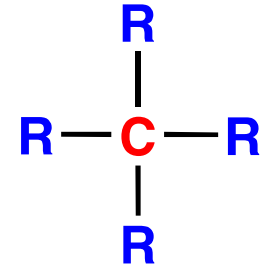
Carbone *primaire* (1°)
lié à un seul
autre carbone



Carbone *secondaire* (2°)
lié à deux
autres carbones



Carbone *tertiaire* (3°)
lié à trois
autres carbones

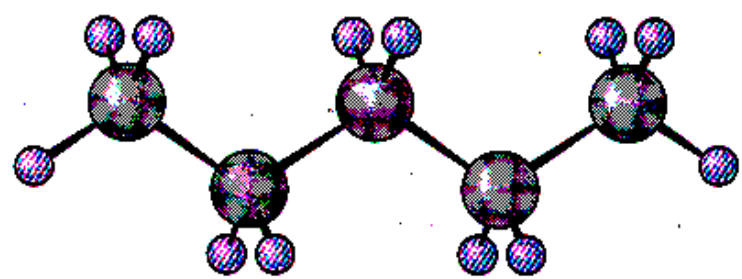


Carbone *quaternaire* (4°)
lié à quatre
autres carbones

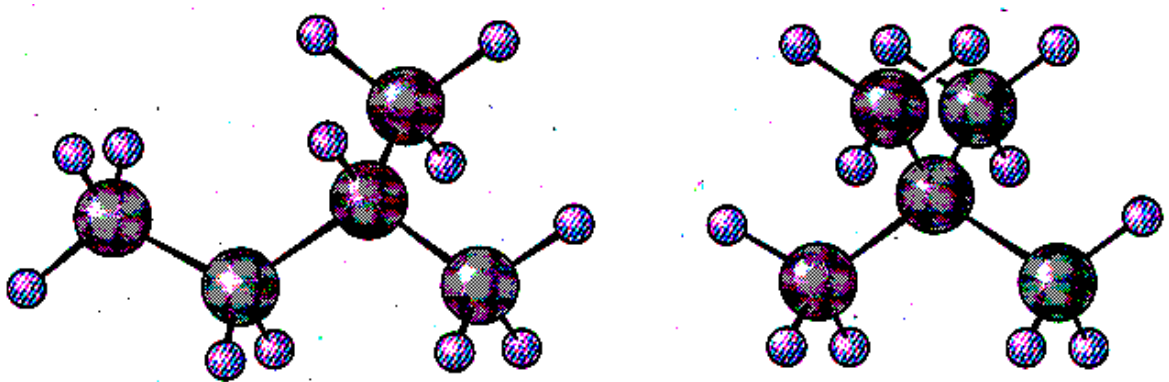
R = Reste de la molécule

Isomères de constitution

Formule	Nombre d'isomères	Formule	Nombre d'isomères
C_6H_{14}	5	$C_{10}H_{22}$	75
C_7H_{16}	9	$C_{15}H_{32}$	4 347
C_8H_{18}	18	$C_{20}H_{42}$	366 319
C_9H_{20}	35	$C_{30}H_{62}$	4 111 846 763

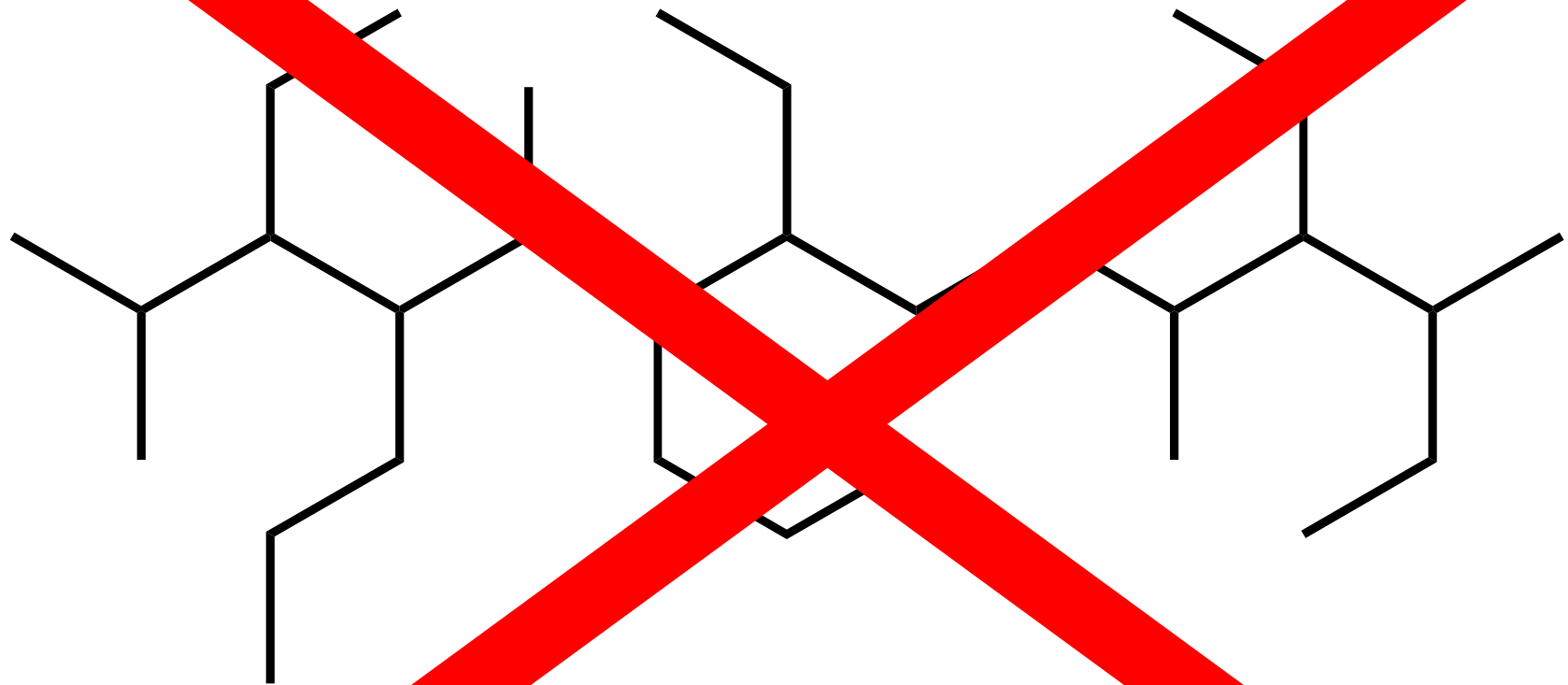


C_5H_{12}



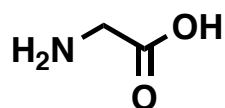
- alcanes linéaires
(normaux)

- alcanes ramifiés
- points d'ébullition

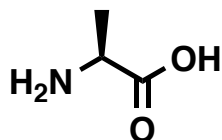


3,7,11-triethyl-2,5,10,12-
tetramethyl-4,6-dipropyloctadecane

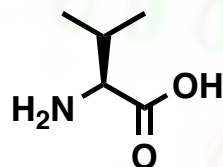
Substituants alkyles (C_nH_{2n+1})



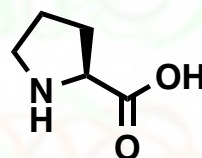
Glycine
(Gly, G)



Alanine
(Ala, A)



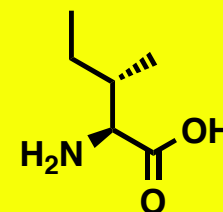
Valine
(Val, V)



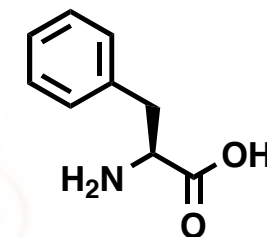
Proline
(Pro, P)



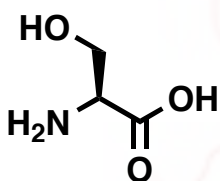
Leucine
(Leu, L)



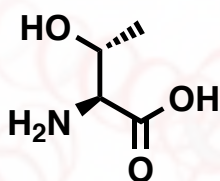
Isoleucine
(Ile, I)



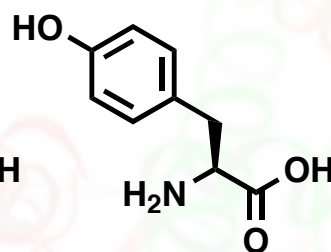
Phénylalanine
(Phe, F)



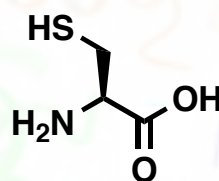
Sérine
(Ser, S)



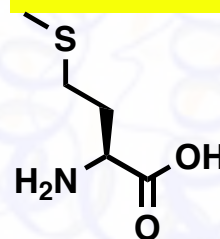
Thréonine
(Thr, T)



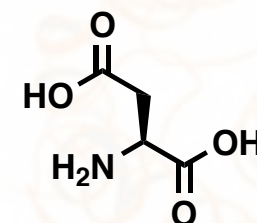
Tyrosine
(Tyr, Y)



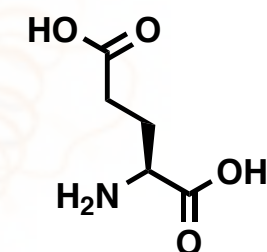
Cystéine
(Cys, C)



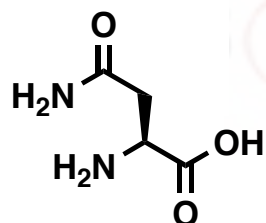
Méthionine
(Met, M)



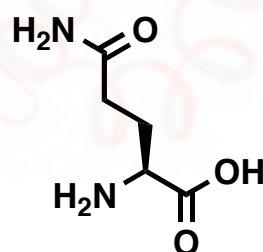
Acide aspartique
(Asp, D)



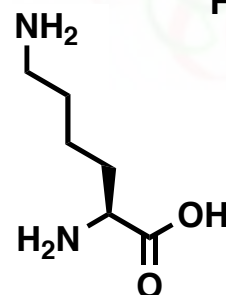
Acide glutamique
(Glu, E)



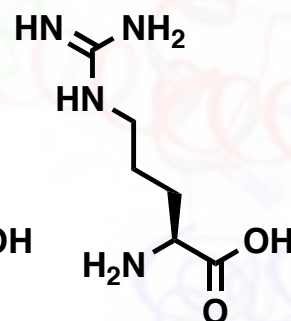
Asparagine
(Asn, N)



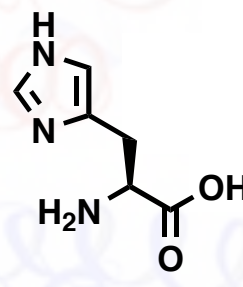
Glutamine
(Gln, Q)



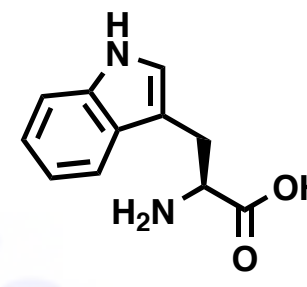
Lysine
(Lys, K)



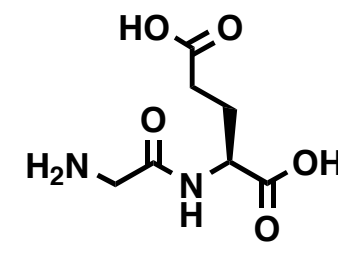
Arginine
(Arg, R)



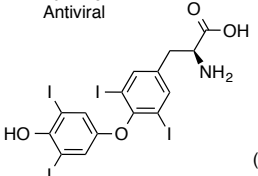
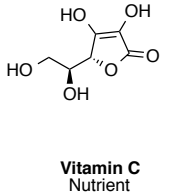
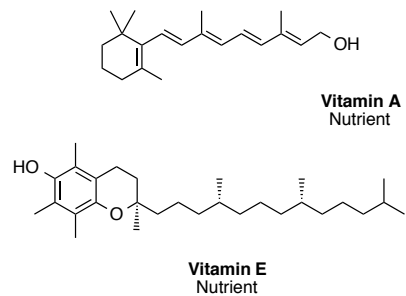
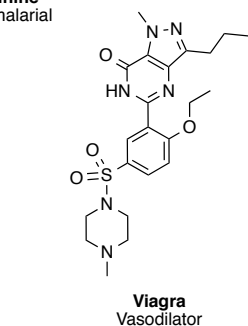
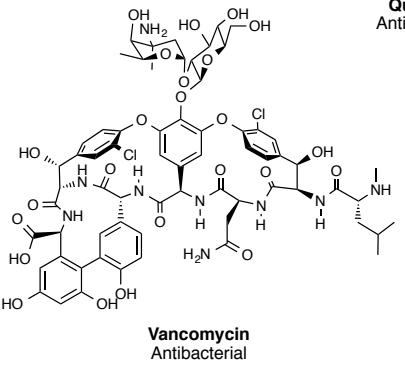
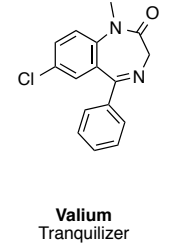
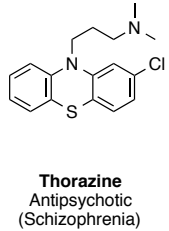
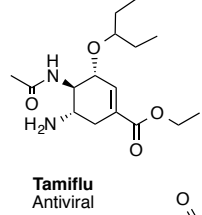
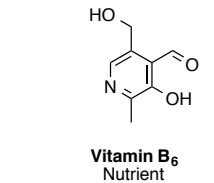
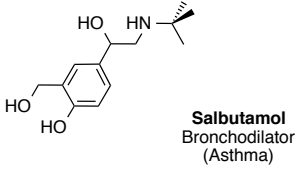
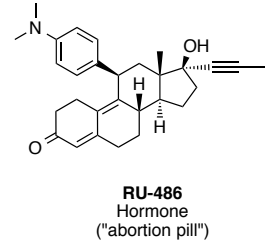
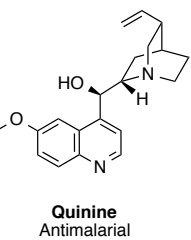
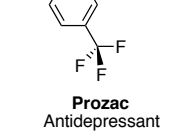
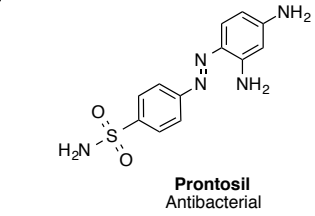
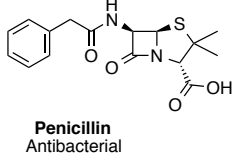
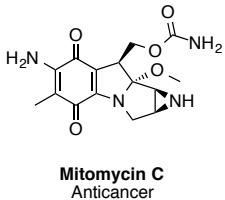
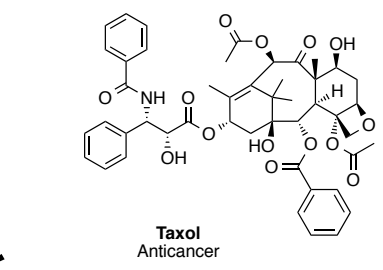
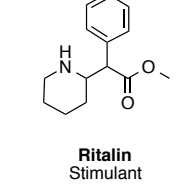
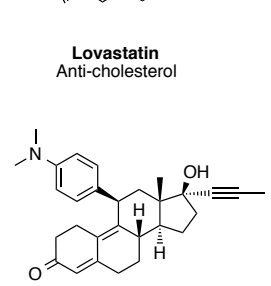
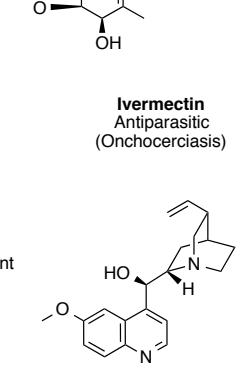
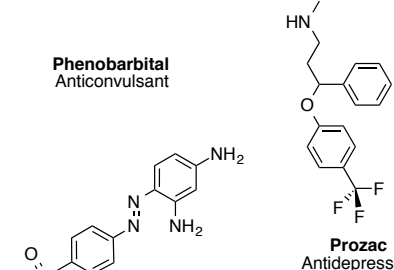
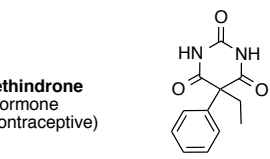
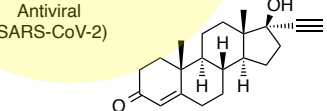
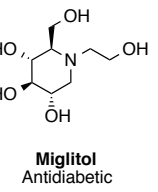
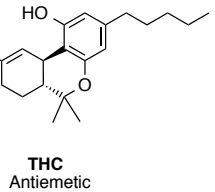
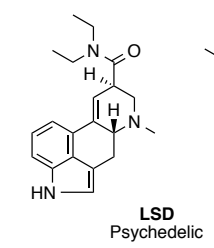
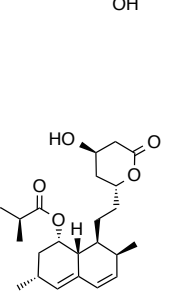
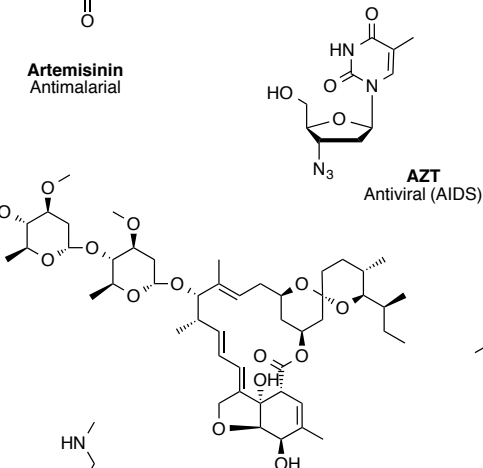
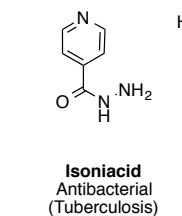
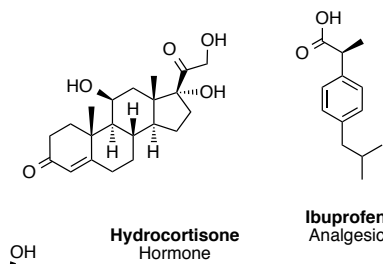
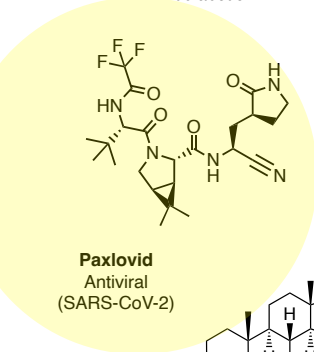
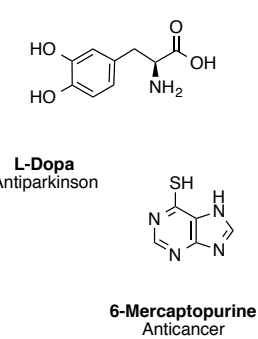
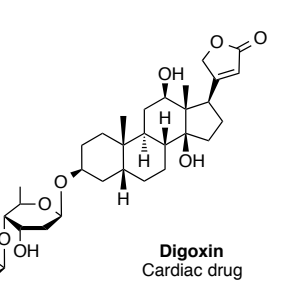
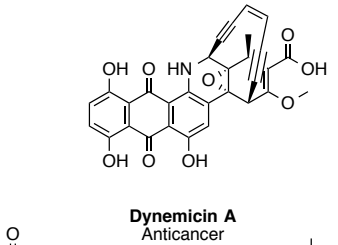
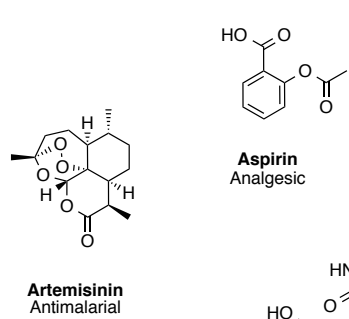
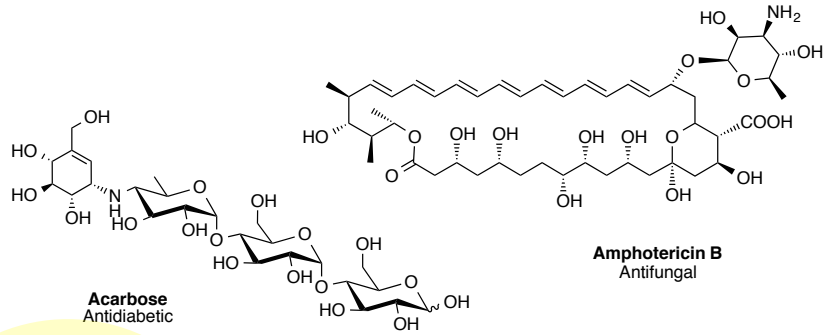
Histidine
(His, H)



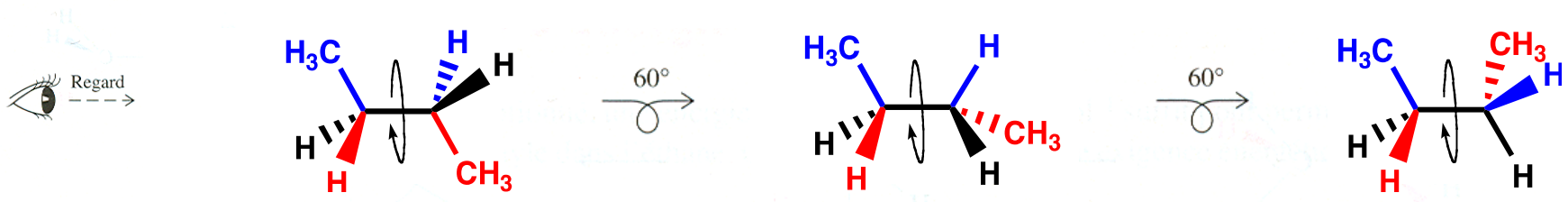
Tryptophane
(Trp, W)



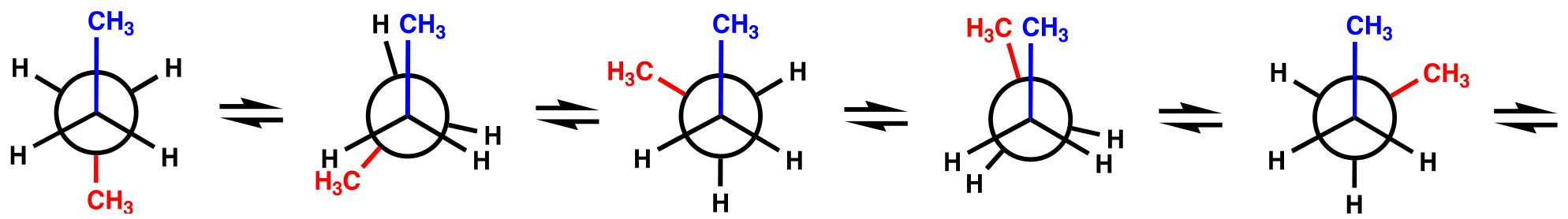
Molécules qui ont changé notre monde...



Isomères conformationnels (conformères)



Projection de Newman



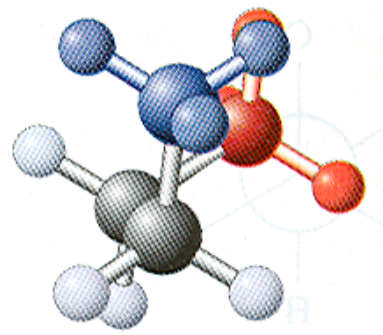
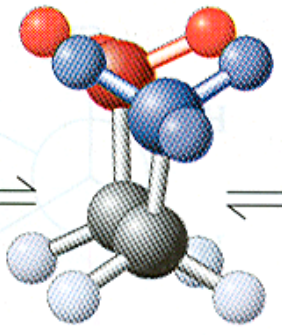
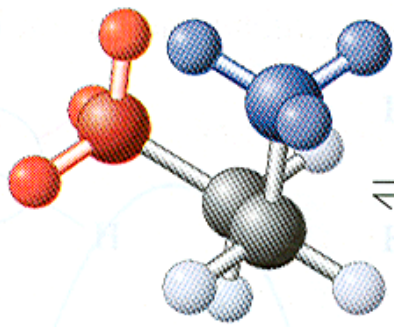
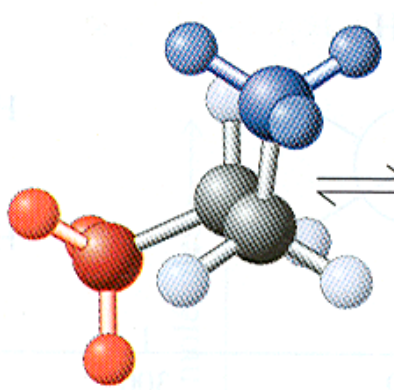
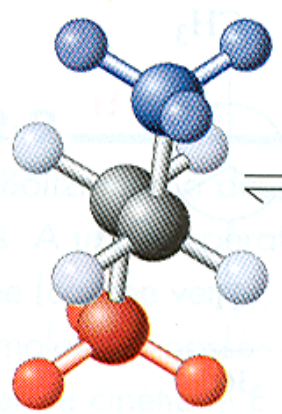
décalée

(éclipsée)

décalée

(éclipsée)

décalée

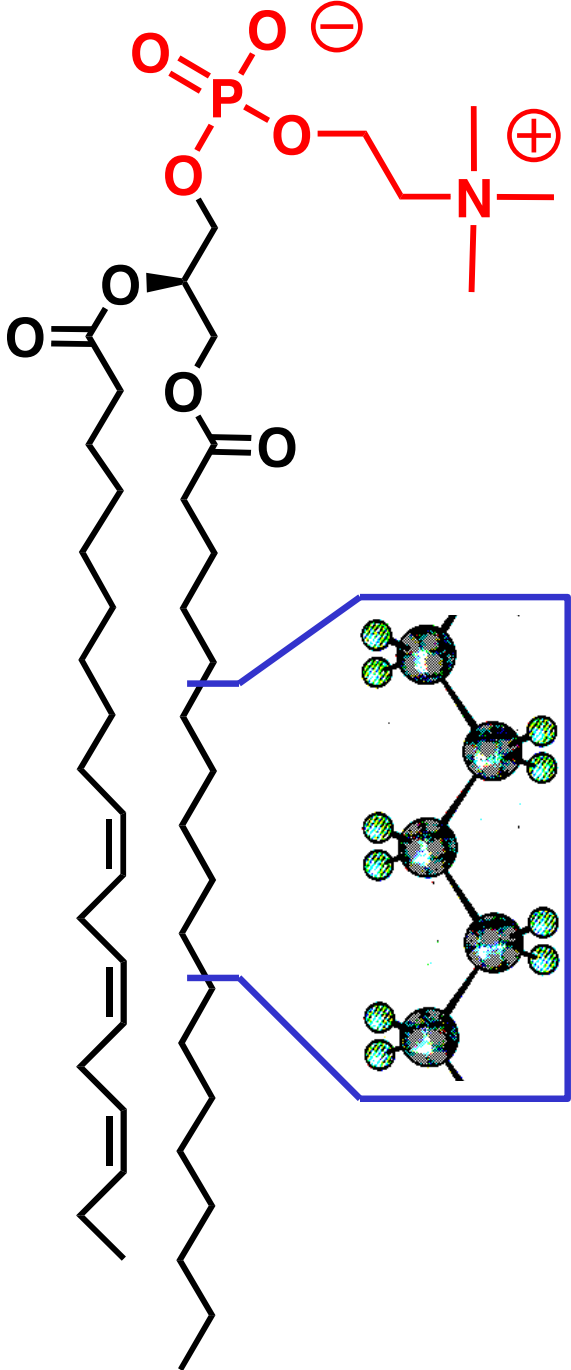
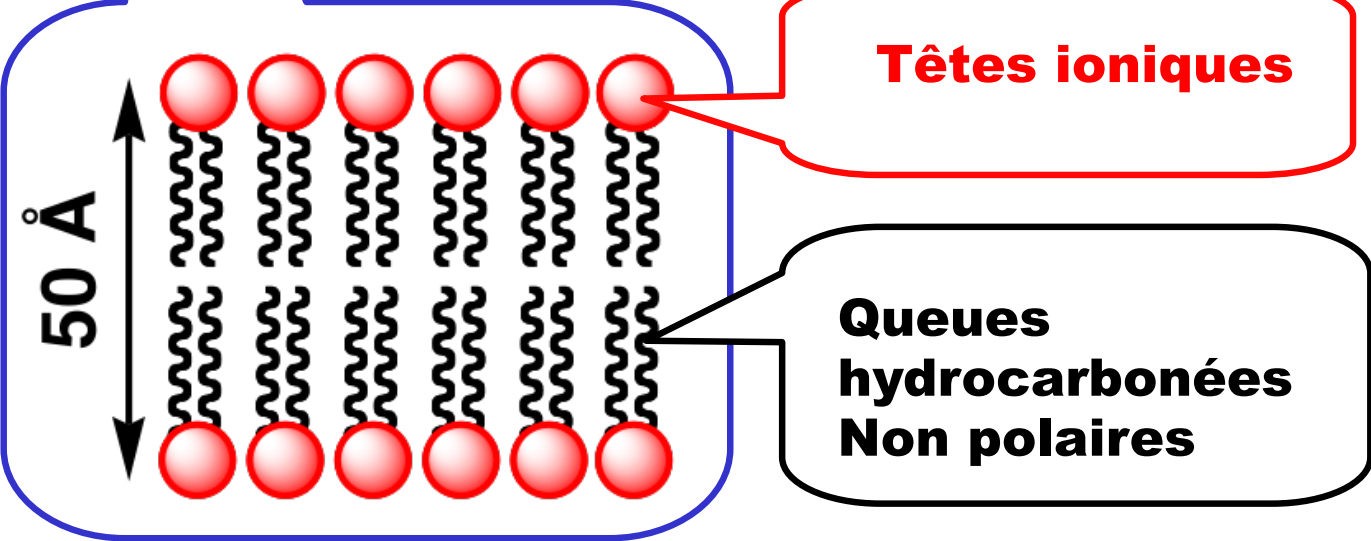
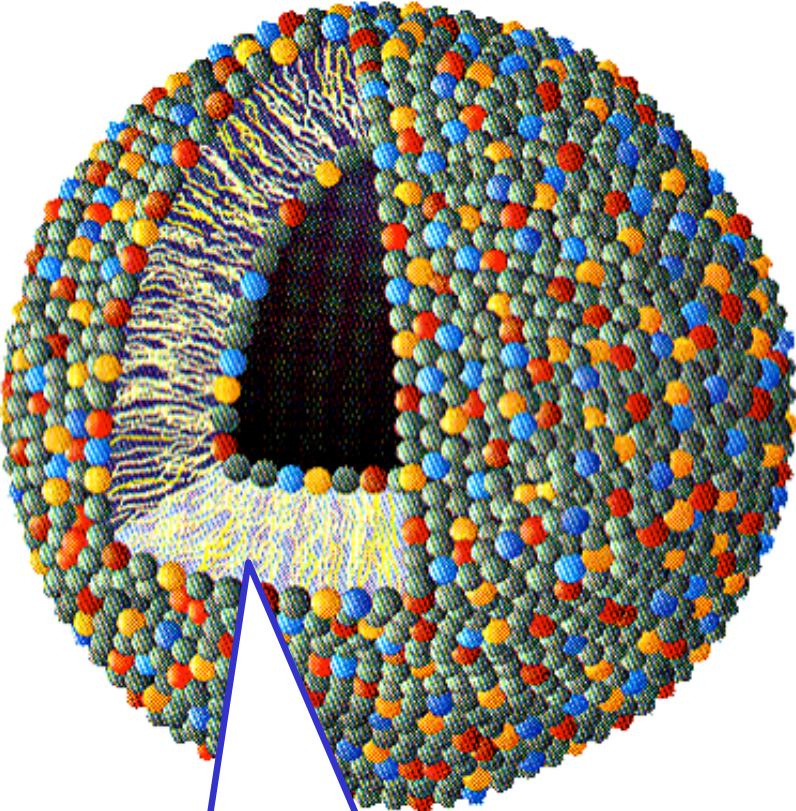


anti

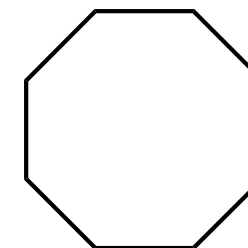
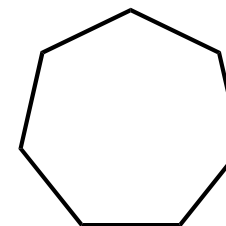
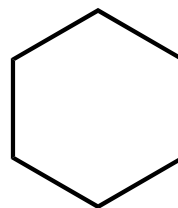
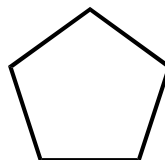
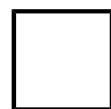
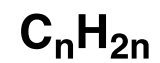
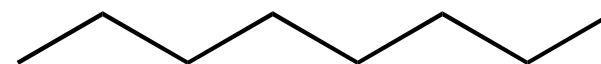
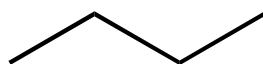
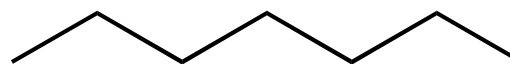
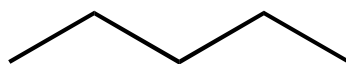
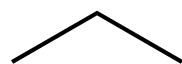
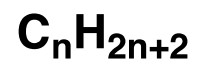
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(gauche)

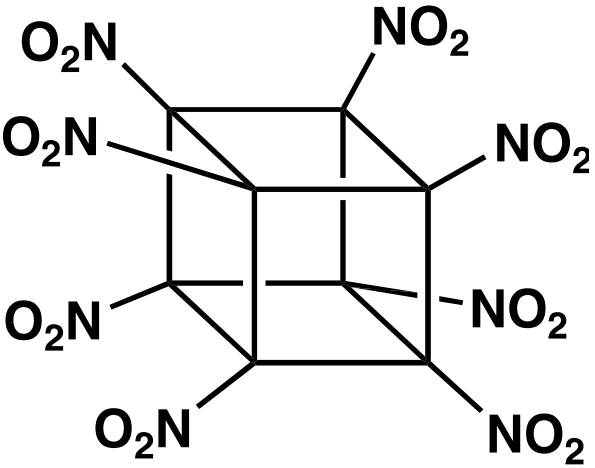
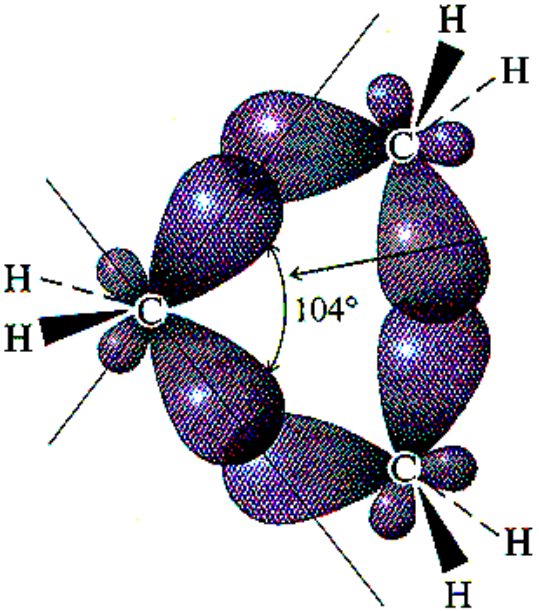
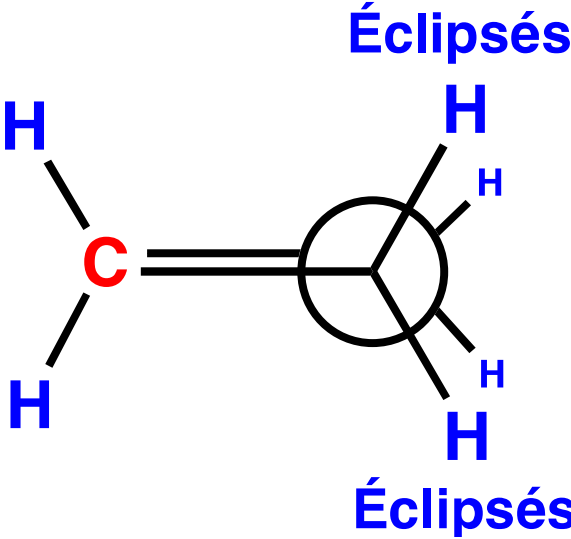
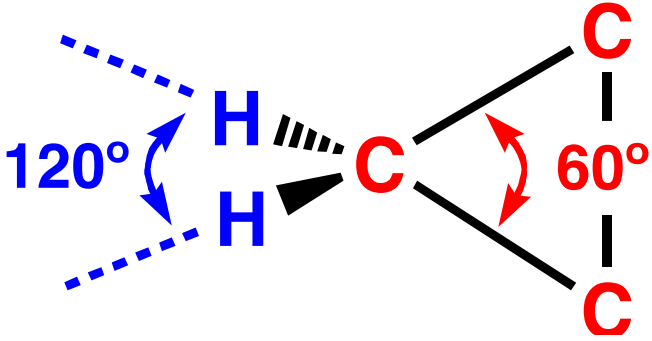
Acides gras saturés - phospholipides - biomembranes



Cycloalkanes

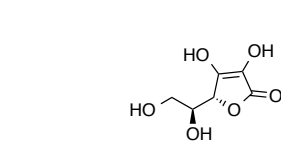
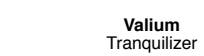
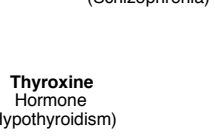
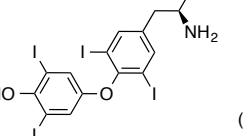
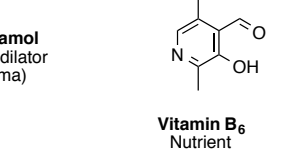
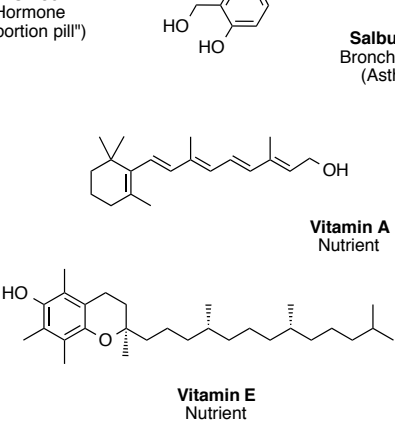
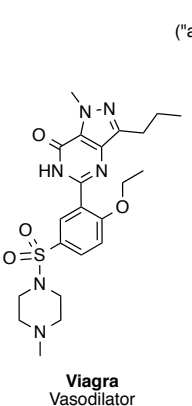
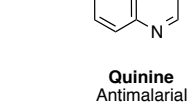
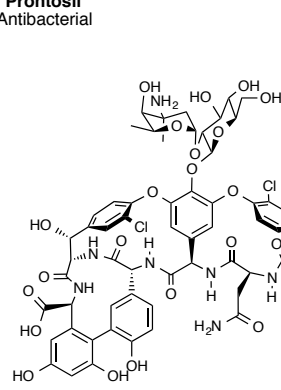
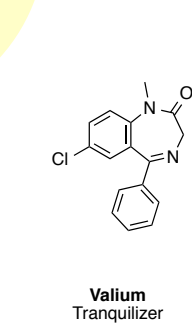
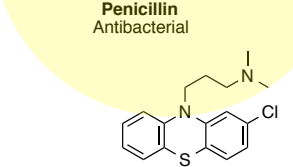
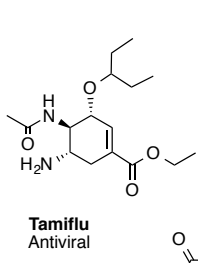
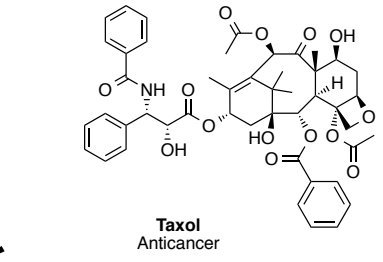
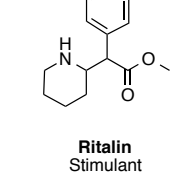
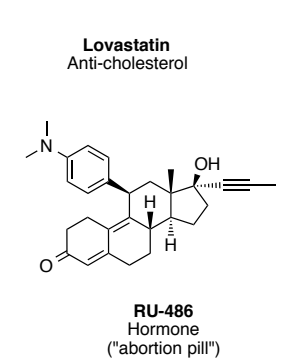
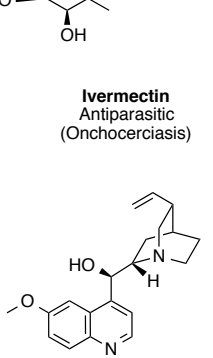
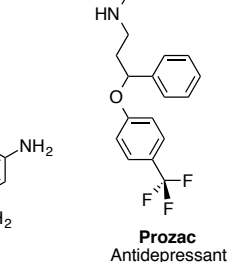
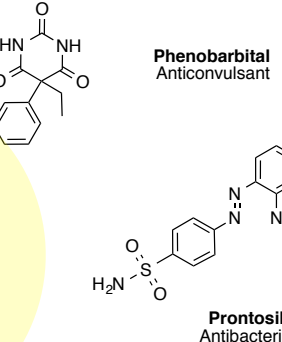
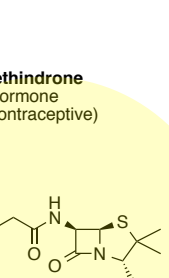
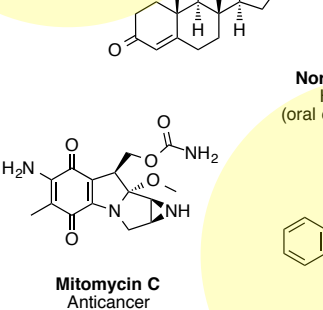
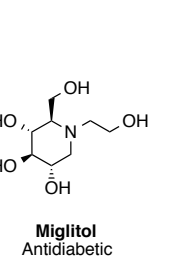
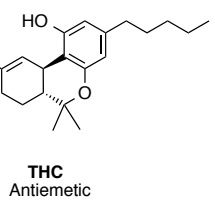
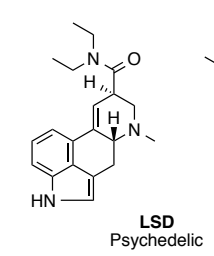
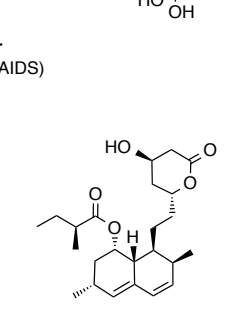
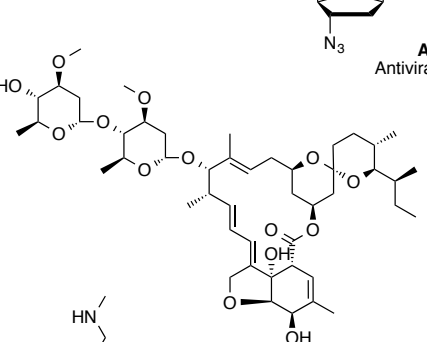
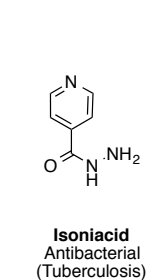
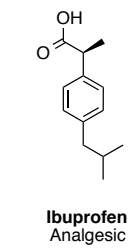
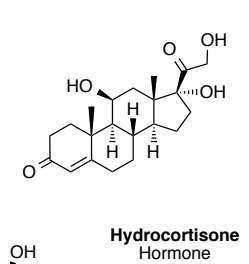
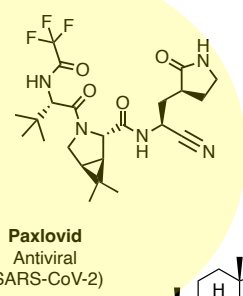
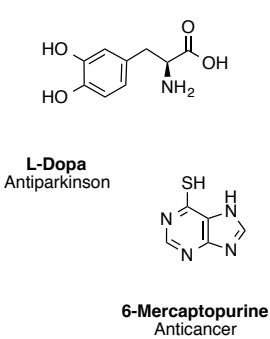
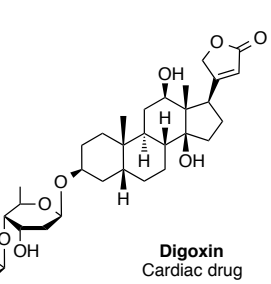
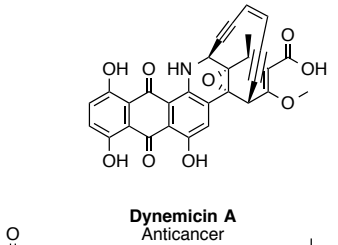
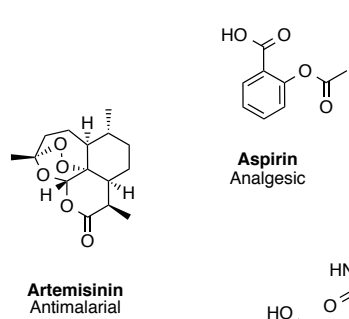
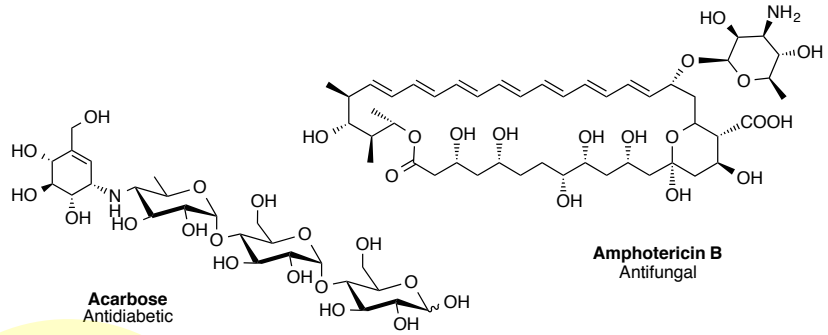


Tension de cycle

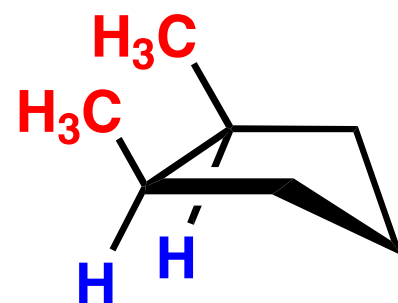
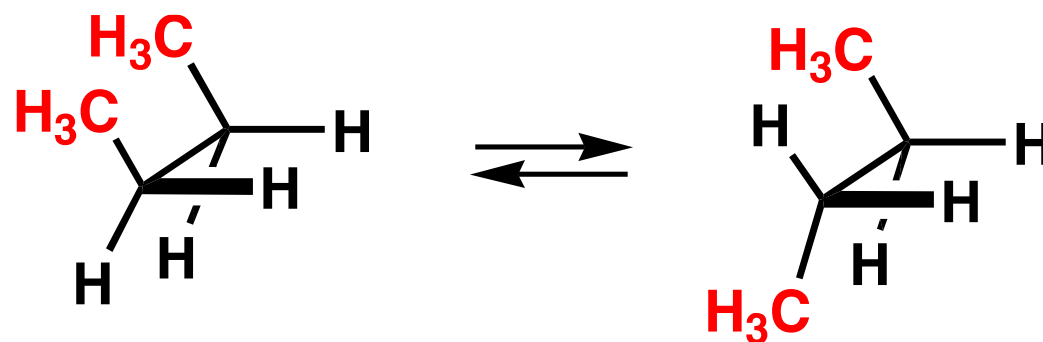
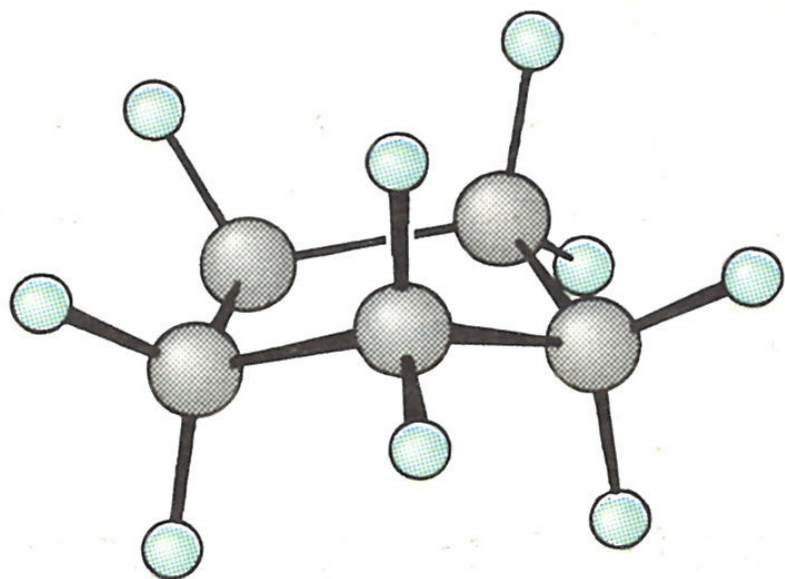


Octanitrocubane

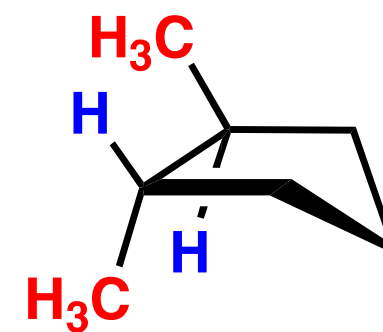
Molécules qui ont changé notre monde...



Stéréoisomères / Cyclopentane



cis
Eb 99 °C



trans
Eb 92 °C

Conformation décalée

A

isomères dont les atomes sont liés dans le même ordre, mais dont l'arrangement tridimensionnel est différent

B

une manière de représenter l'arrangement spatial d'une molécule en regardant le long d'une liaison

C

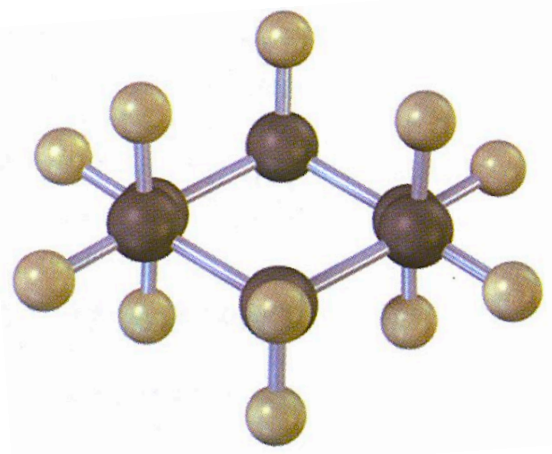
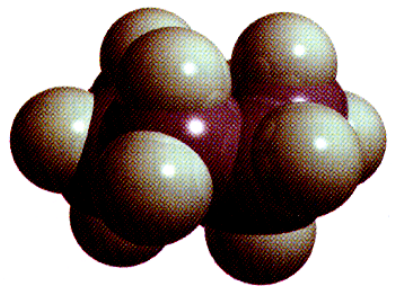
arrangement tridimensionnel des atomes autour d'une liaison, dans lequel les liaisons sur un atome coupent en deux les angles de liaison du second atome, lorsqu'elles sont vues en projection de Newman

D

molécules avec même formule moléculaire, mais d'arrangements des atomes différents

E

molécules qui ne diffèrent que par la rotation autour des liaisons simples



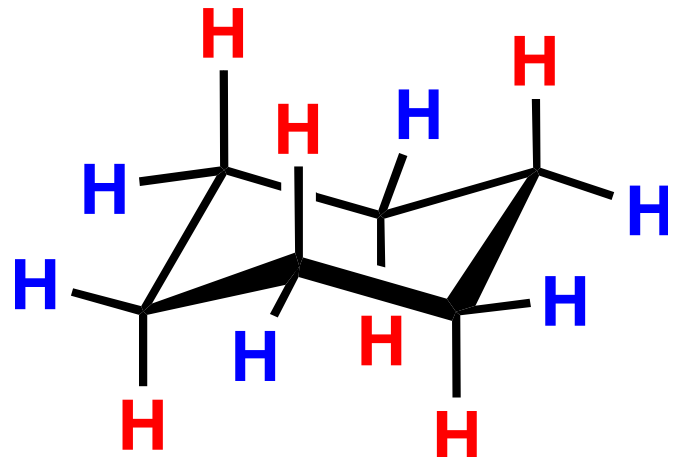
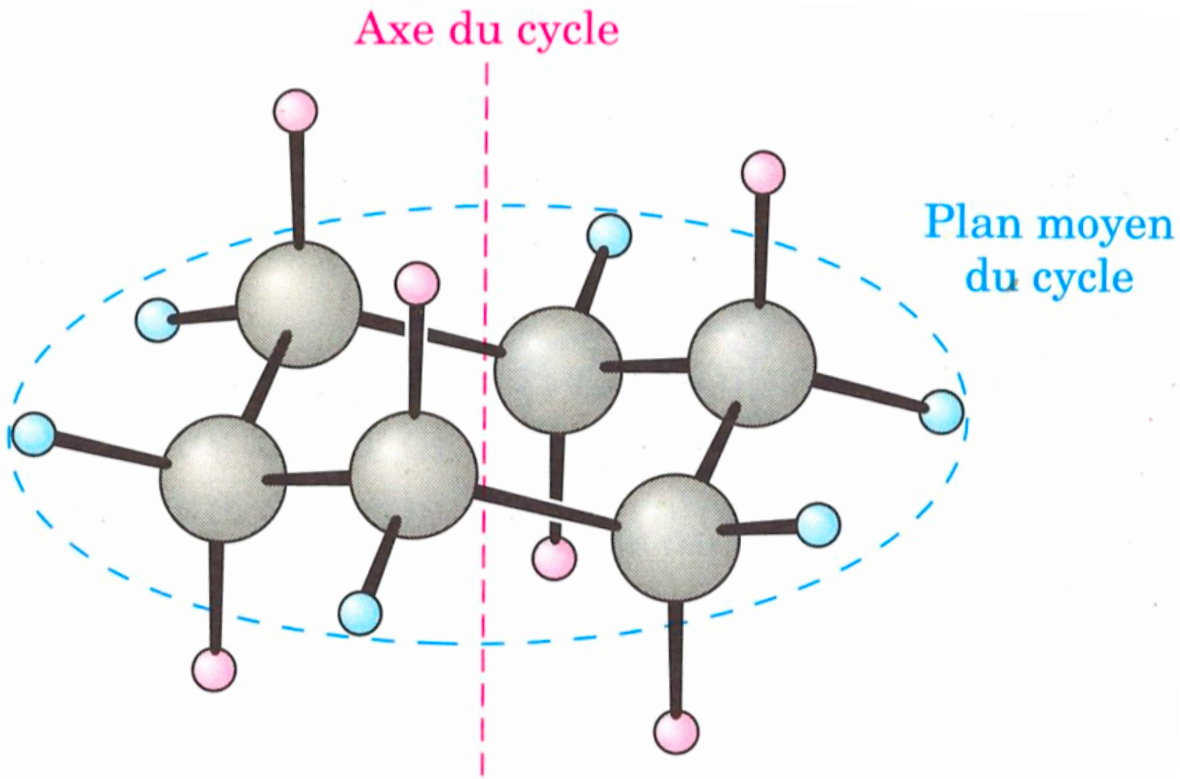
Cyclohexane

Hexagone

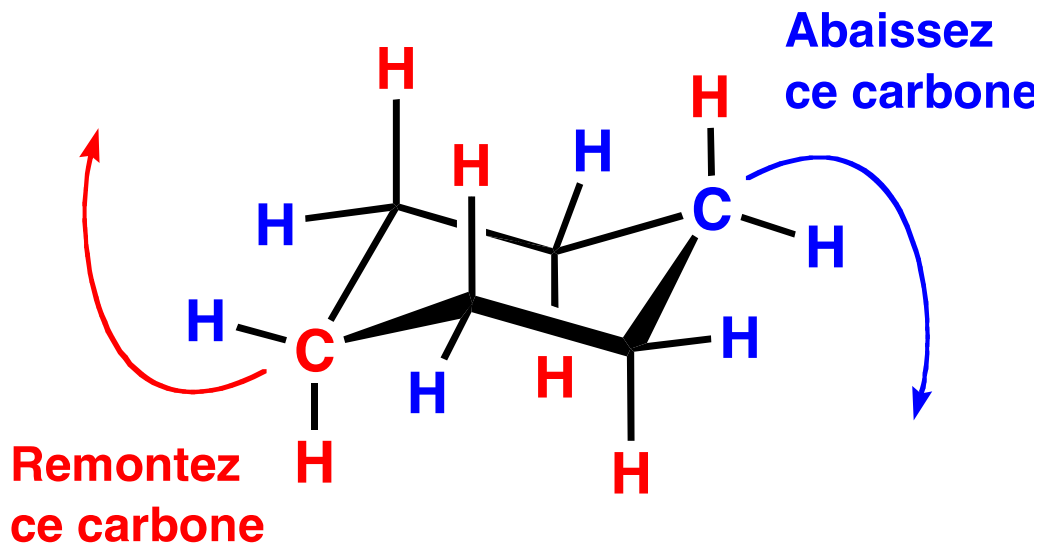
Liaisons équatoriales

Liaisons axiales

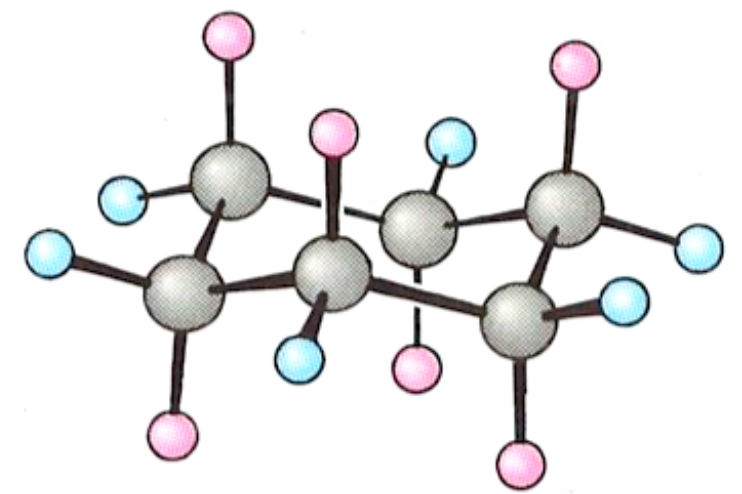
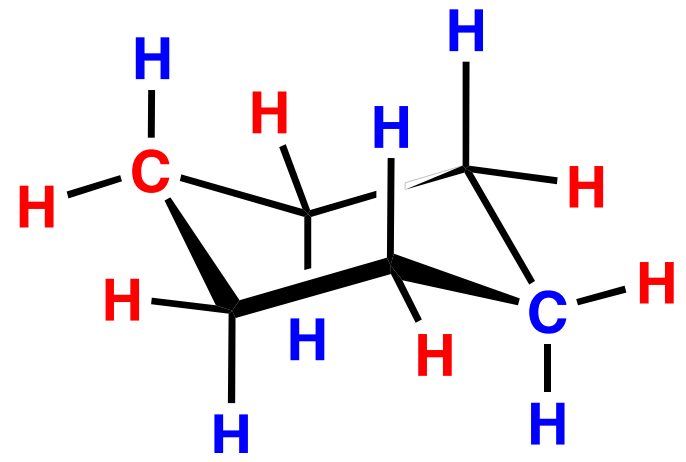
Conformation chaise



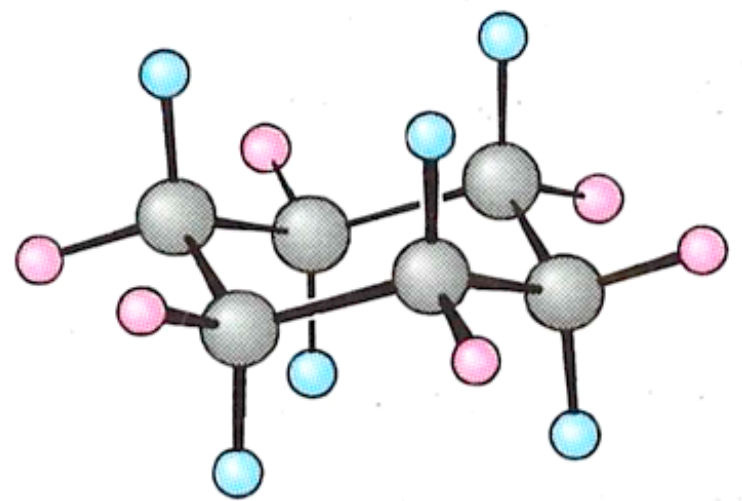
Conformations du cyclohexane



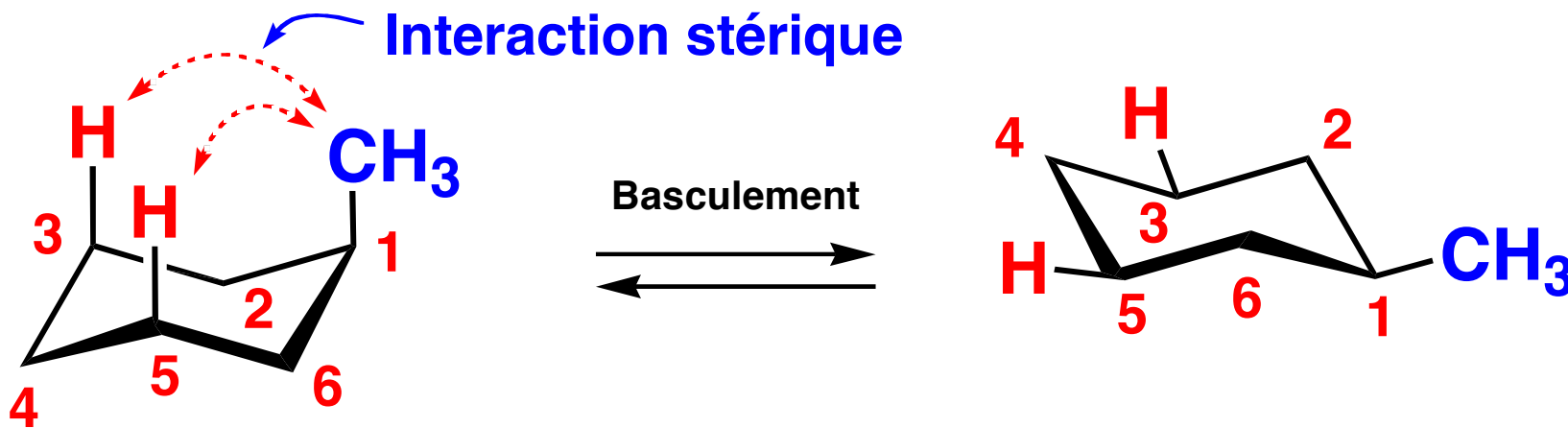
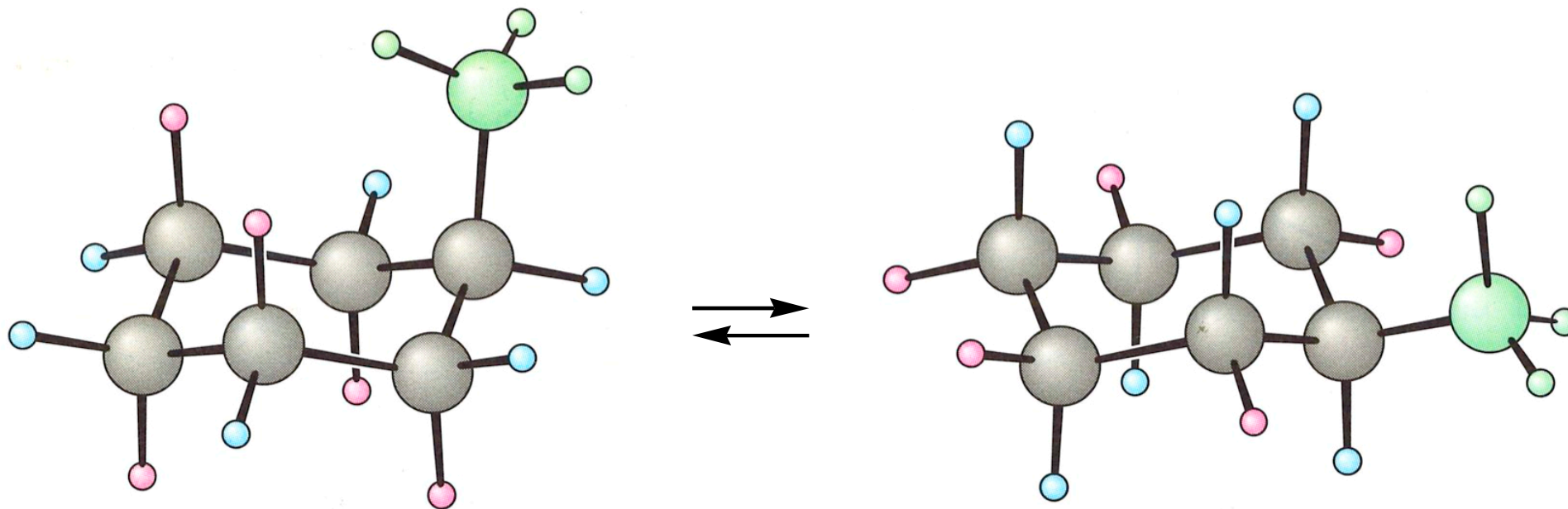
Basculement



Basculement



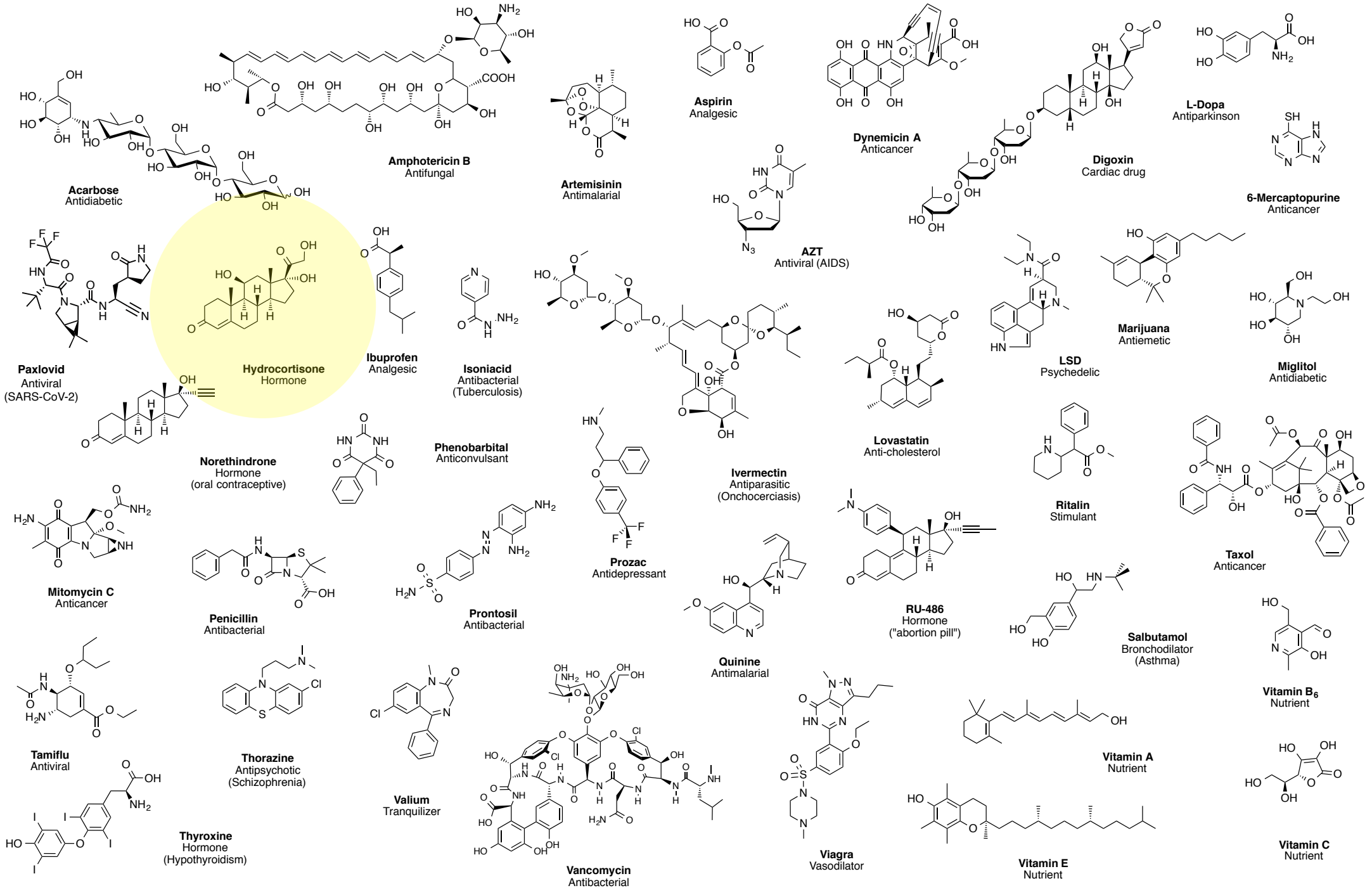
Conformations du cyclohexane



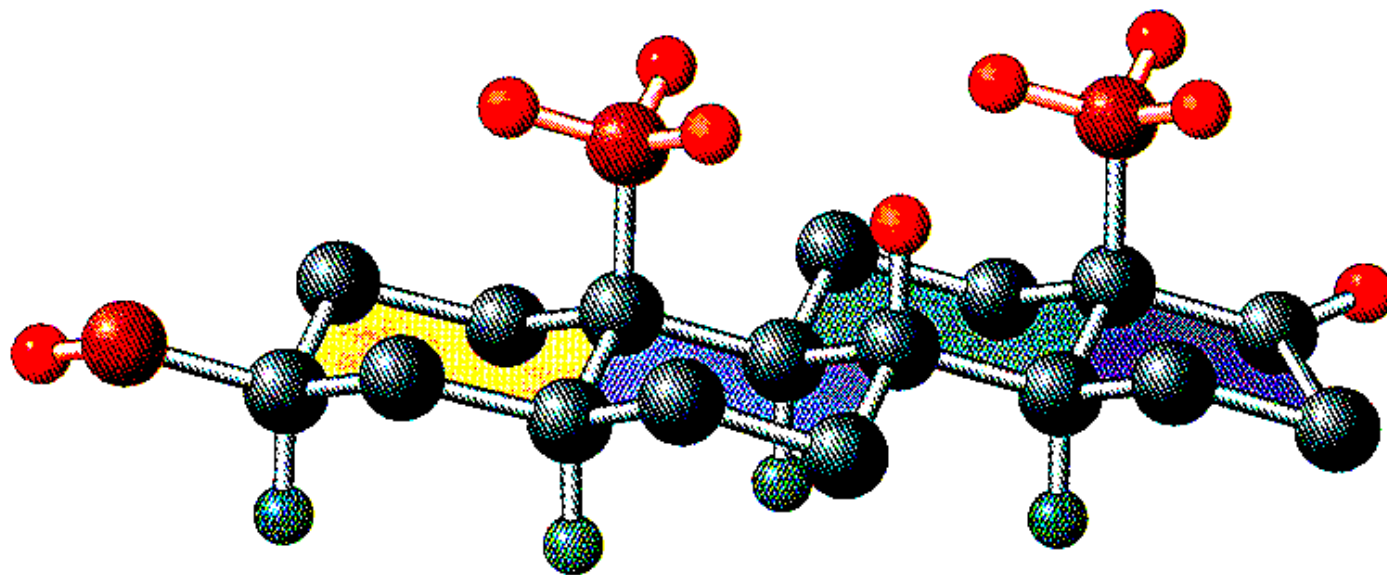
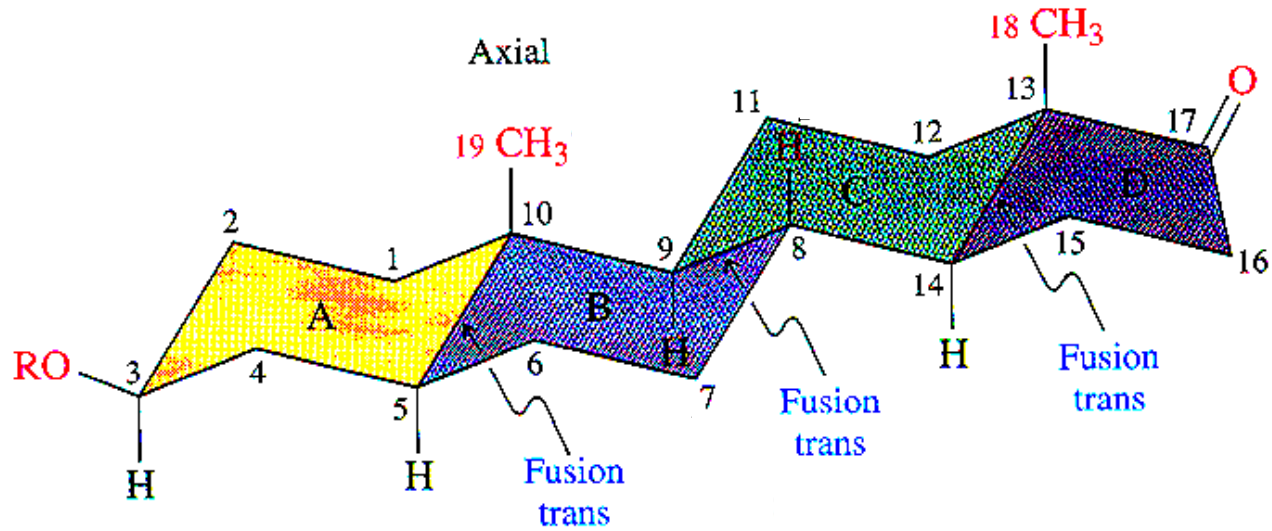
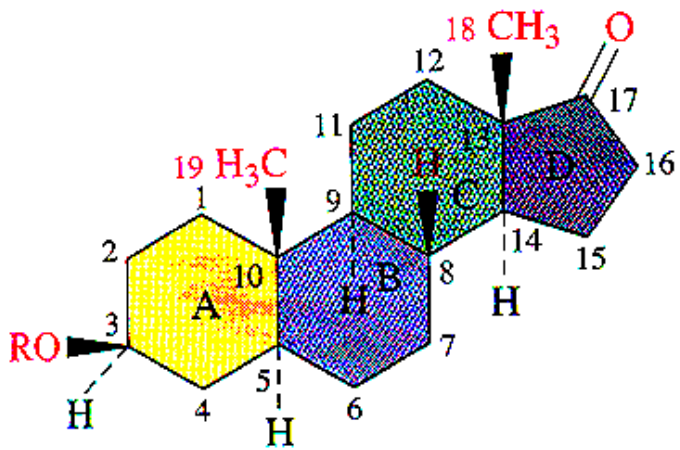
Interaction 1,3-diaxiale :

Contrainte stérique

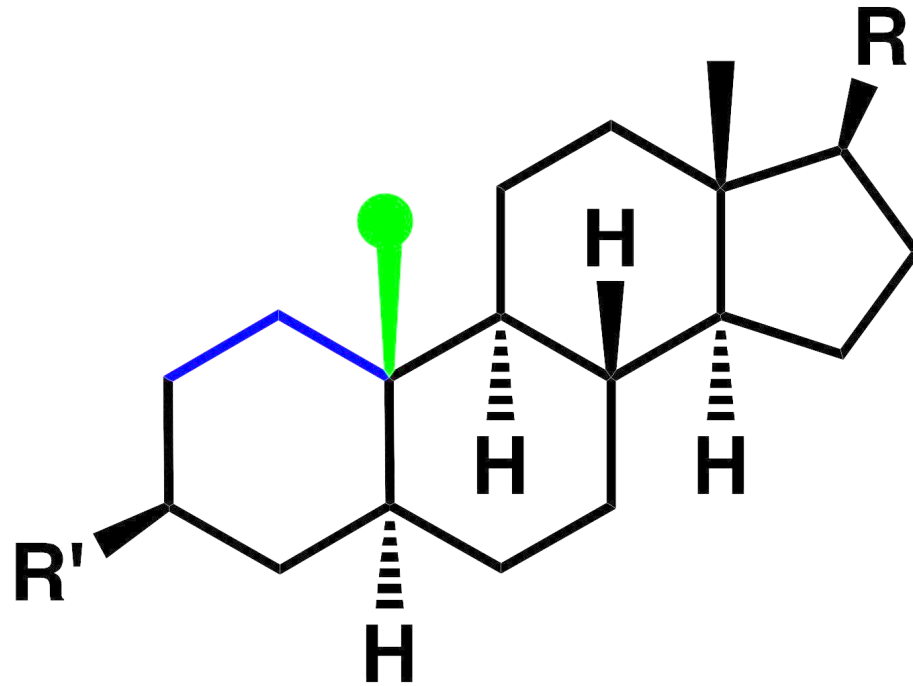
Molécules qui ont changé notre monde...



Stéroïdes



Interactions 1,3-diaxiales ?

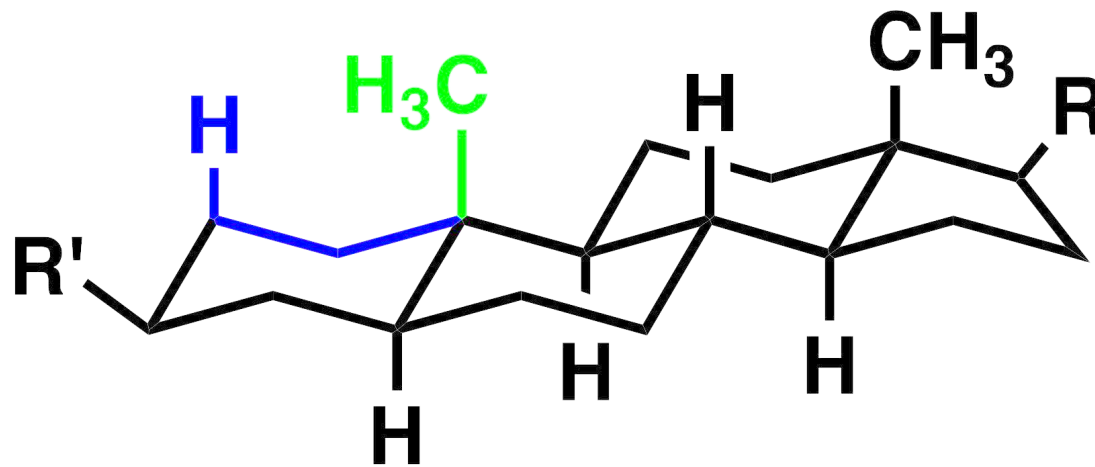


A 1

B 2

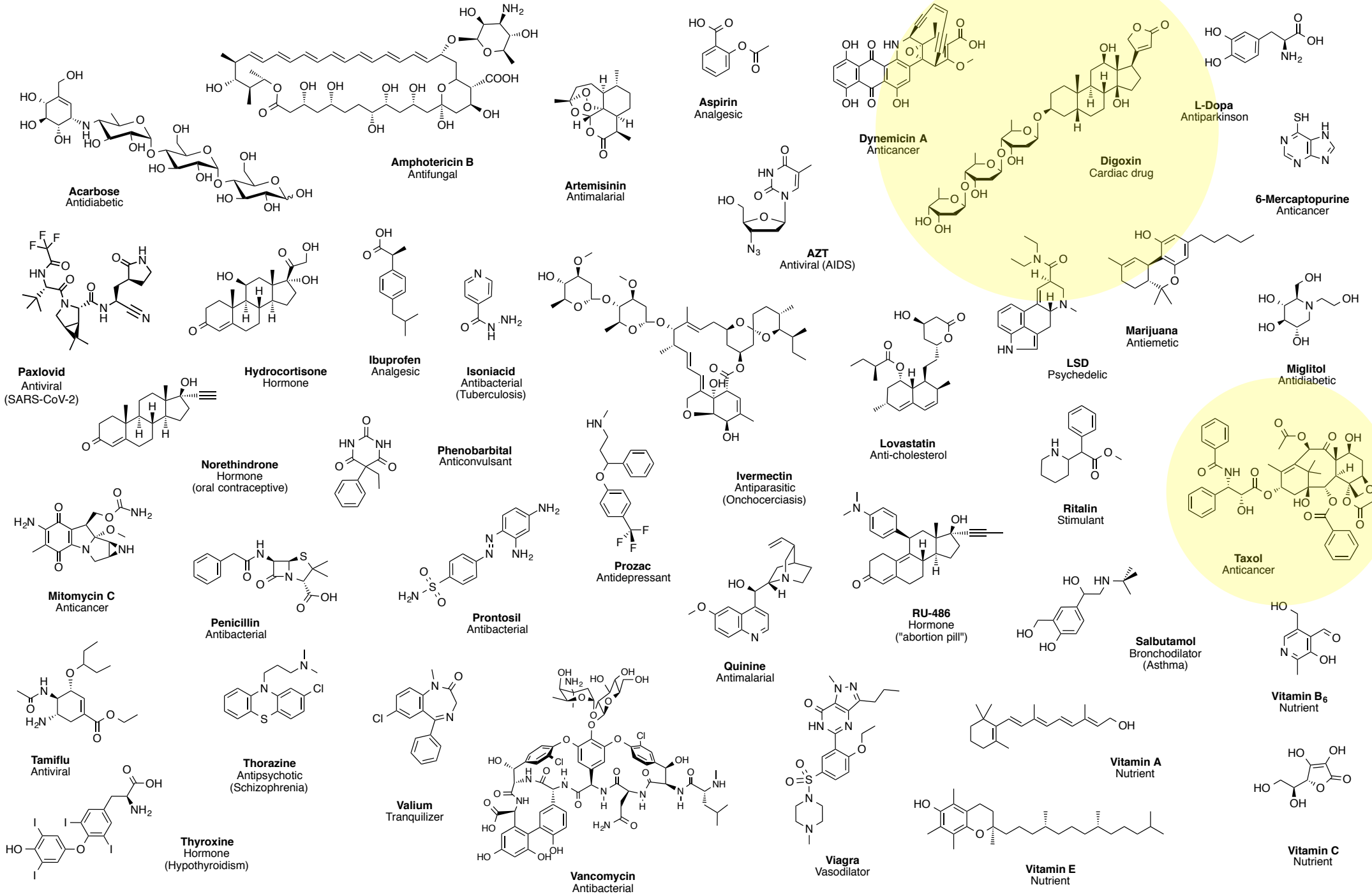
C 3

D 5

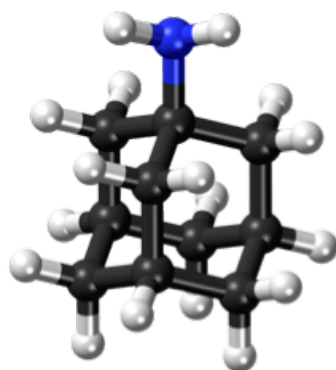
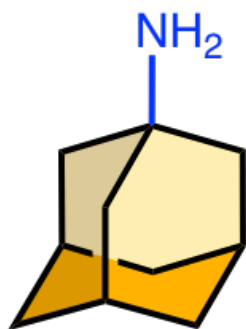
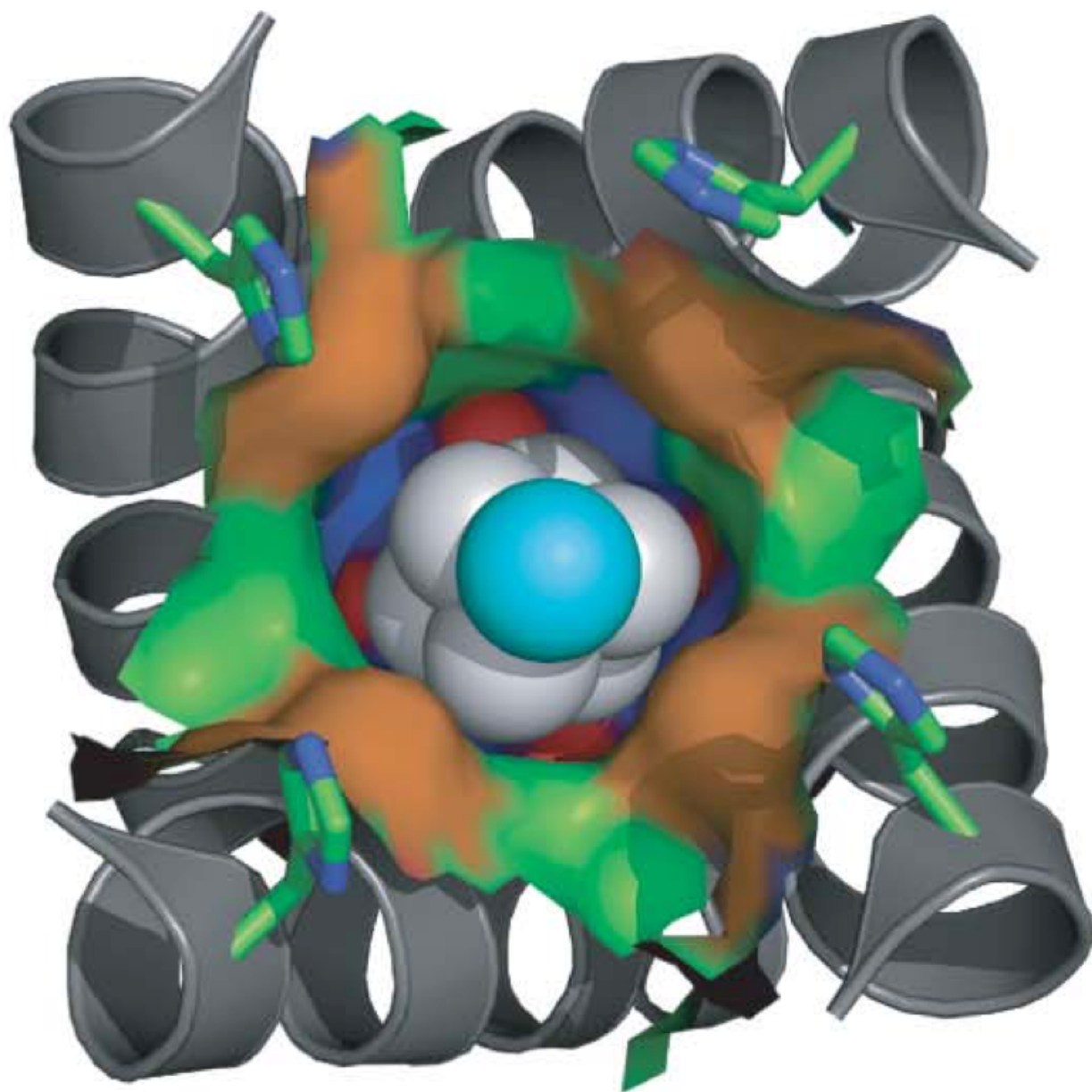
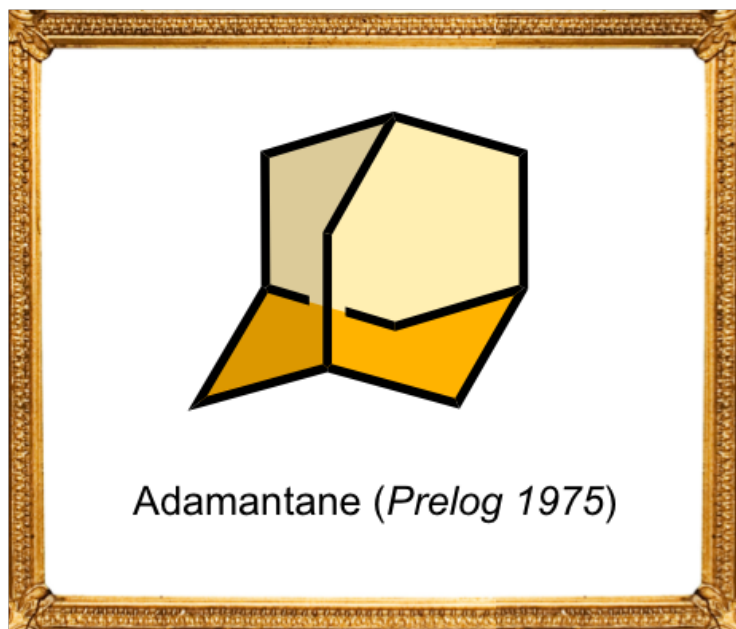


E 6

Molécules qui ont changé notre monde...



Gallery of Swiss Classics



Adamantadine
(antiviral, anti-Parkinson)



Liaison axiale

A

Conformation tridimensionnelle d'un cycle avec 6 atomes sp^3 qui présente moins de tension d'angle et d'éclipse

B

Forme tridimensionnelle exacte d'une molécule à un instant donné, en admettant que la rotation autour des liaisons simples est bloquée

C

Mouvement moléculaire transformant une conformation chaise en l'autre, interconvertissant ainsi les liaisons axiales et équatoriales

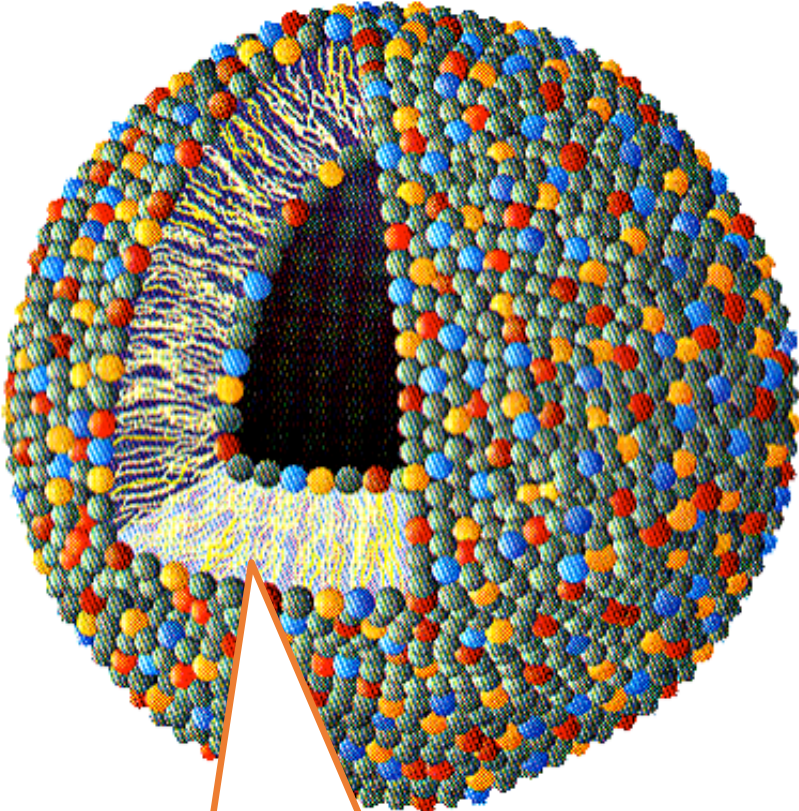
D

Interaction spatiale entre deux substituants axiaux, séparés par trois atomes dans une conformation chaise

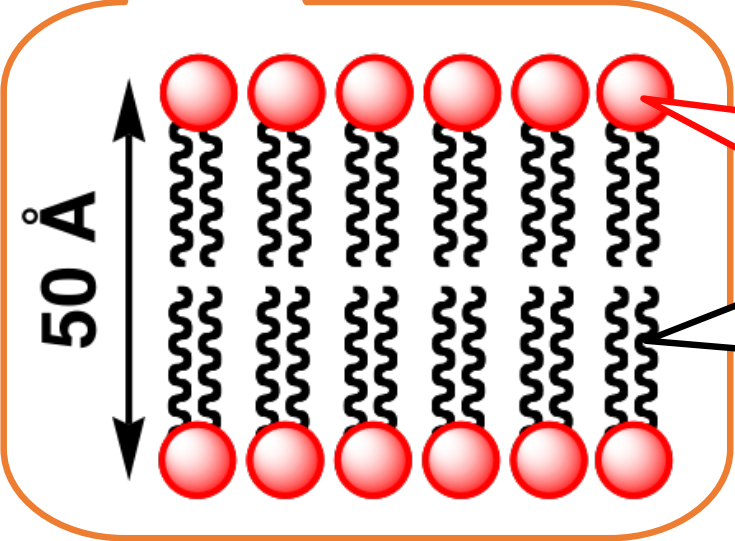
E

Liaison de la conformation chaise qui est perpendiculaire au plan moyen du cycle

Acides gras saturés - phospholipides - biomembranes

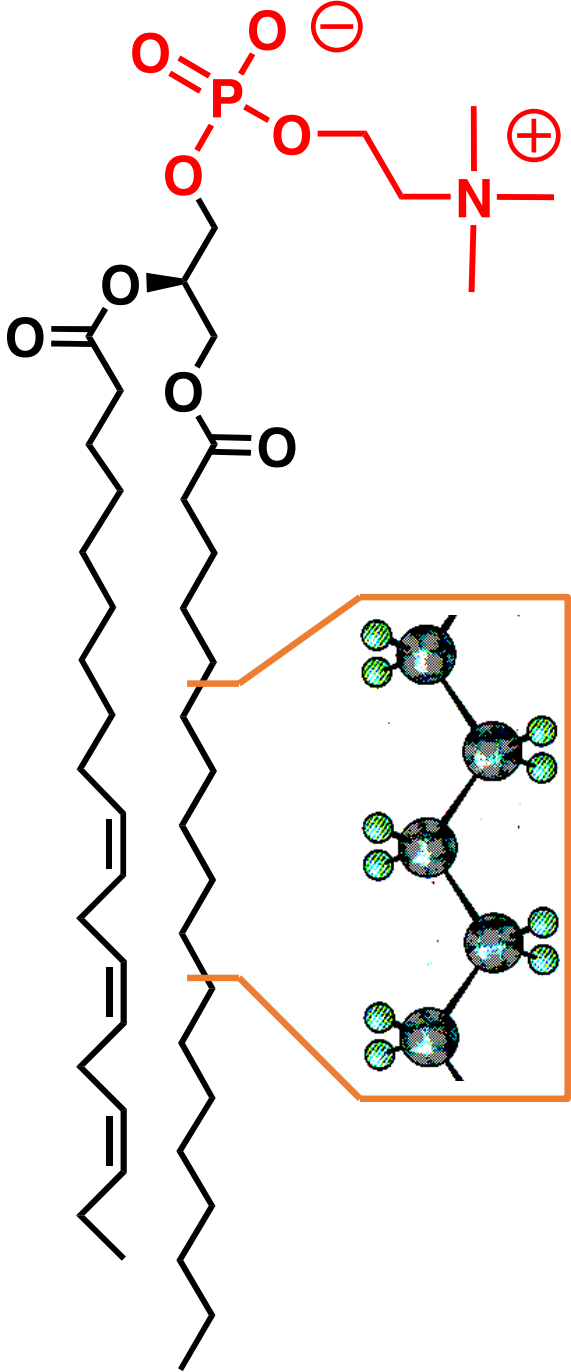


Amphiphiles

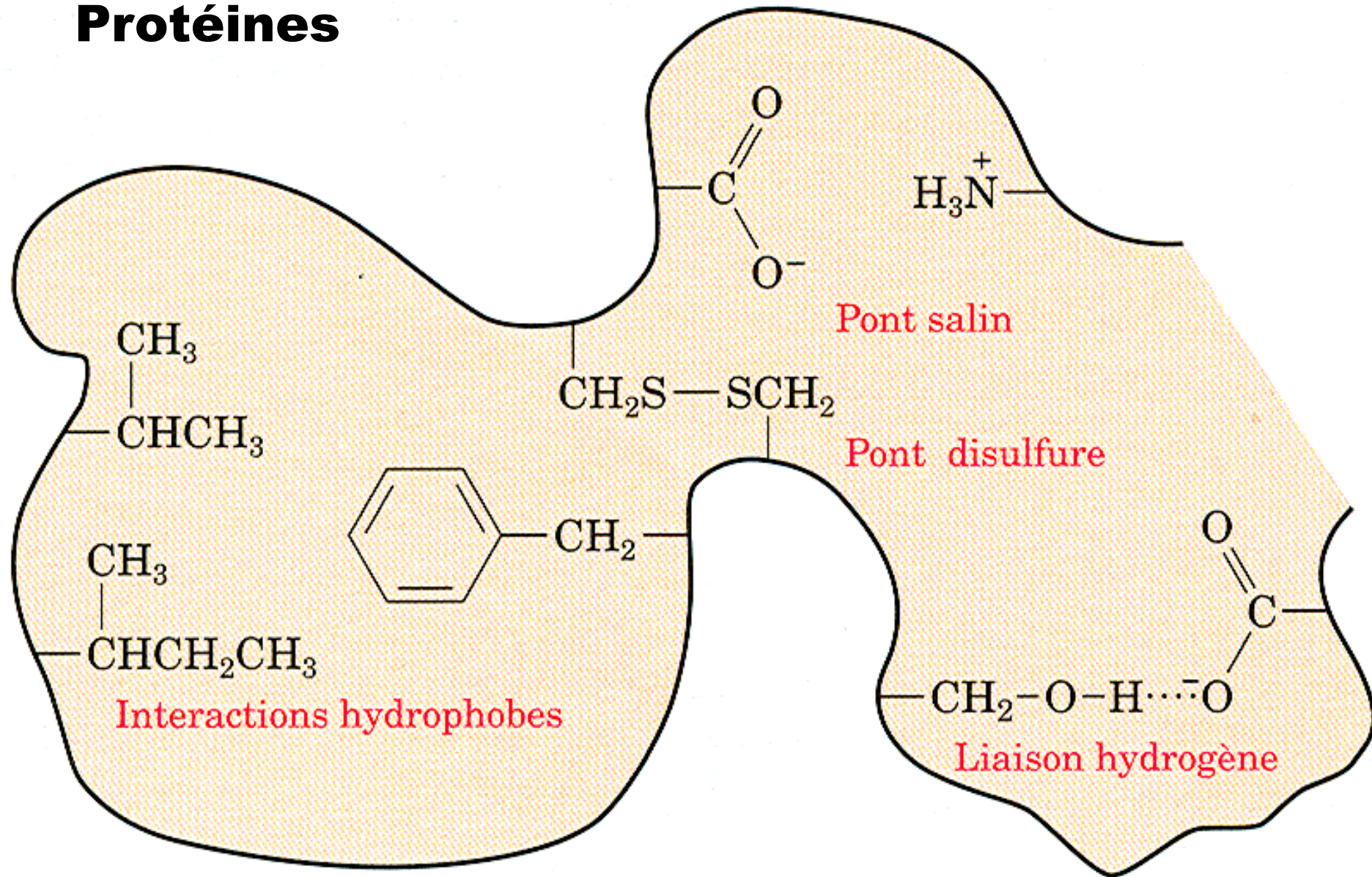


**Têtes
hydrophiles**

**Queues
hydrophobes**



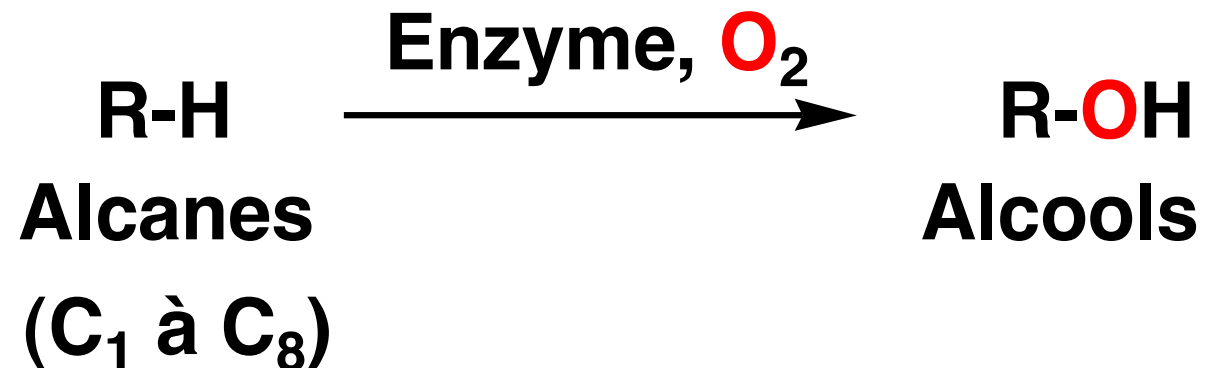
Protéines





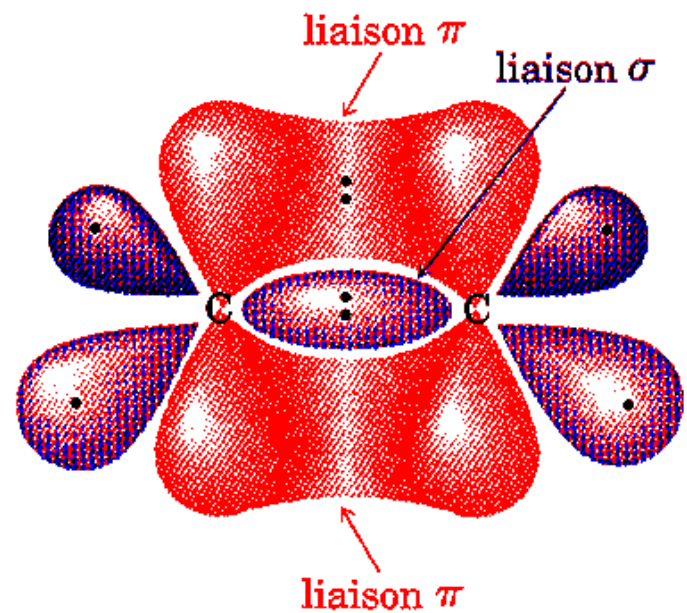
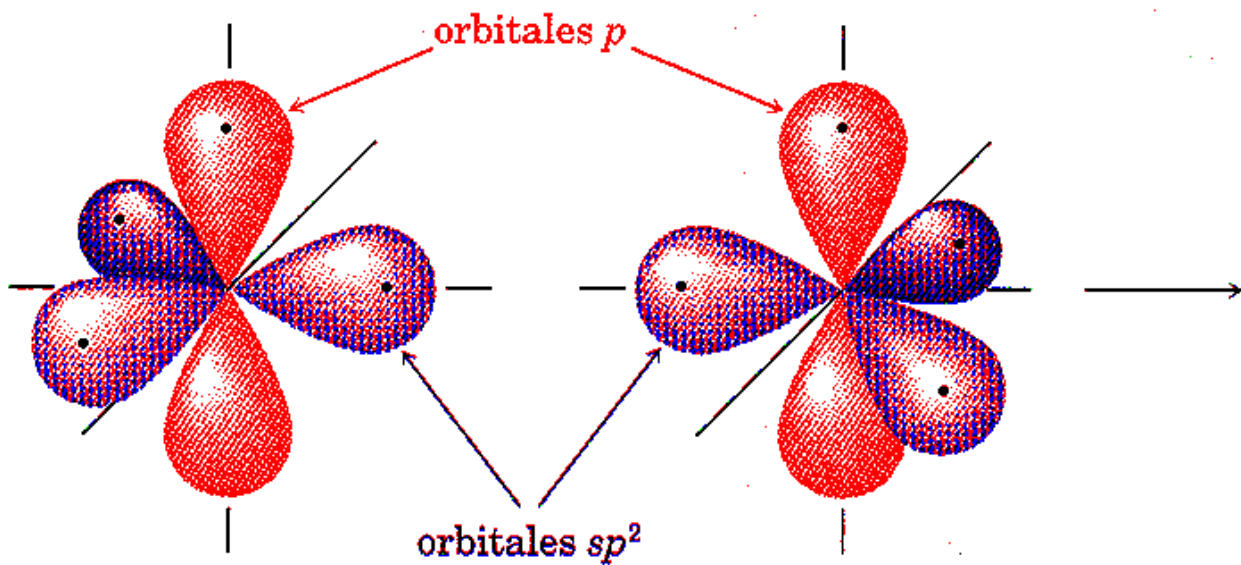
Propriétés chimiques

Activation enzymatique des alcanes

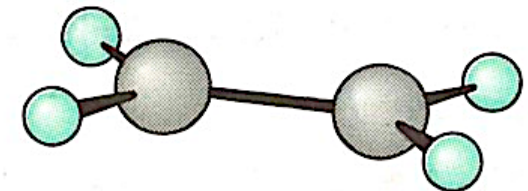
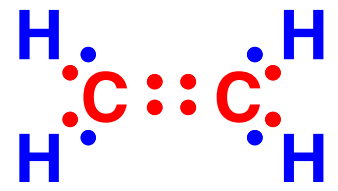
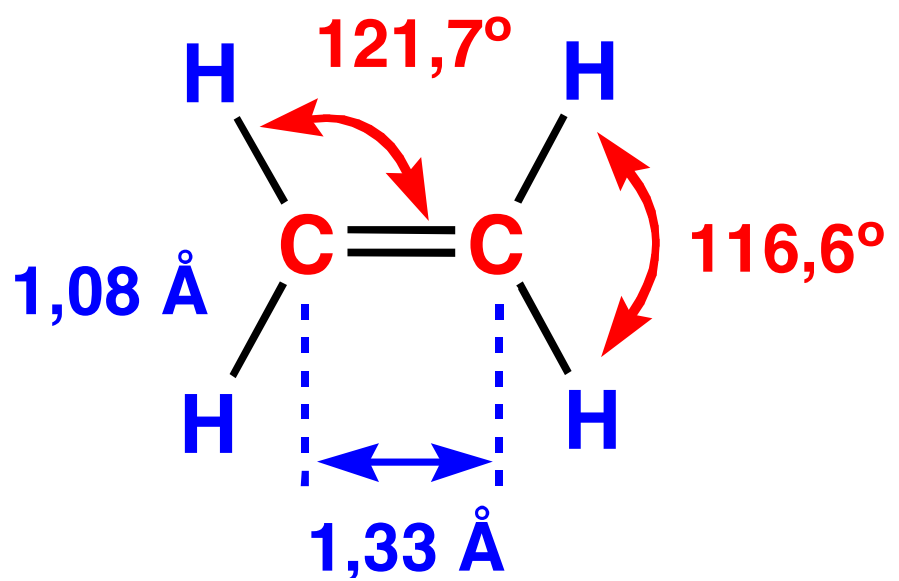


Alcènes

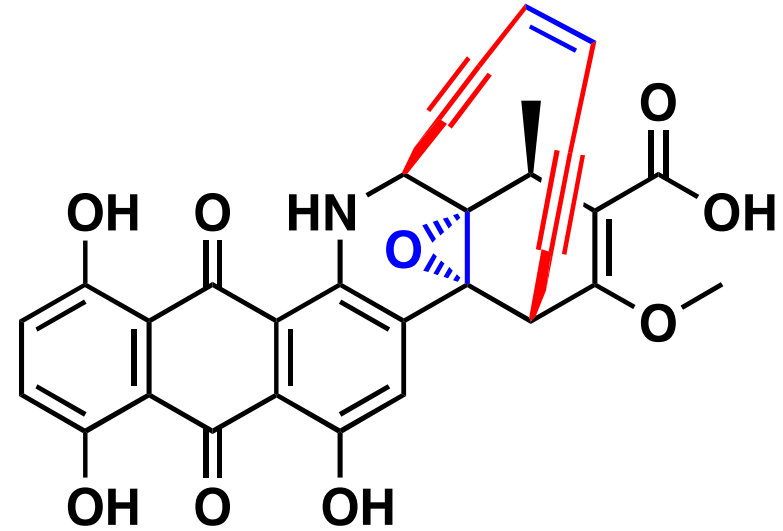
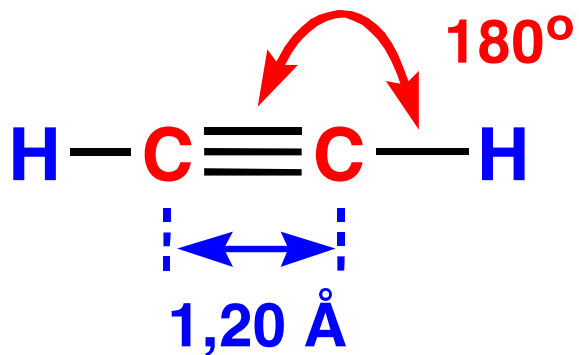
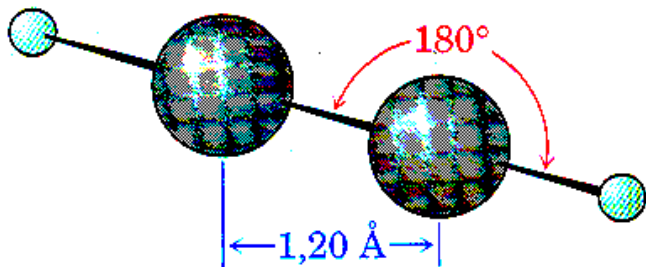
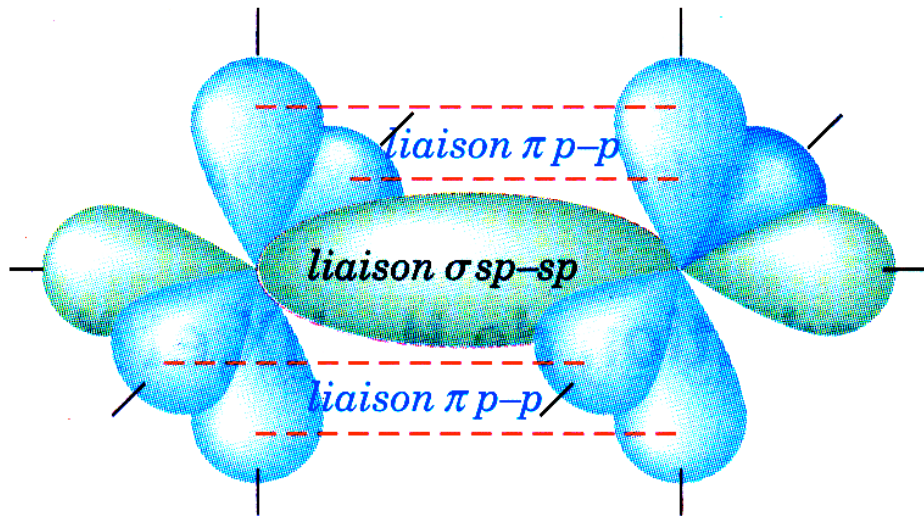
carbones sp^2



Double liaison :
liaison σ du type sp^2-sp^2
liaison π du type $p-p$



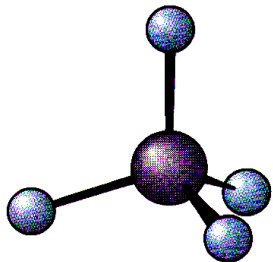
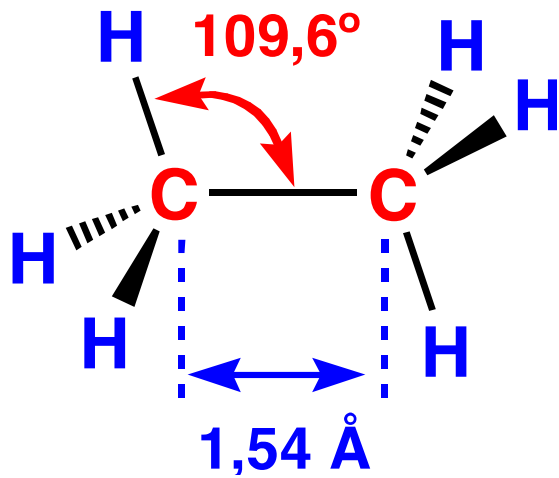
Alcynes



Dynémicine A
(anticancéreux)

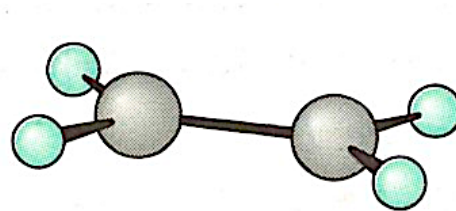
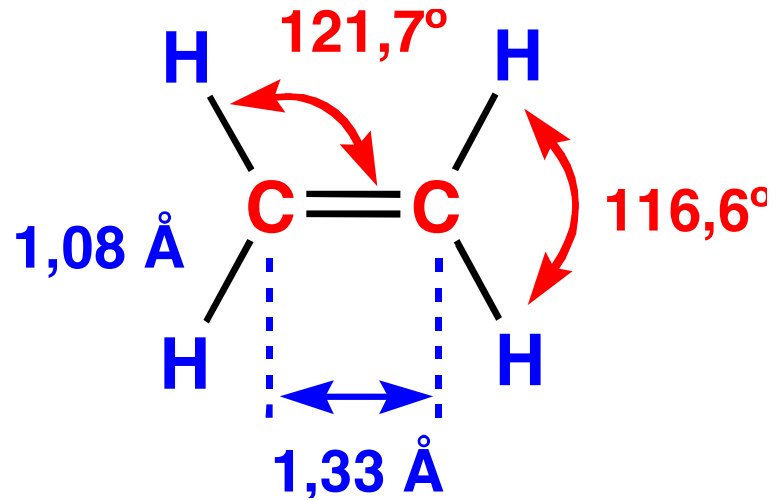
Alcanes

Carbones sp^3



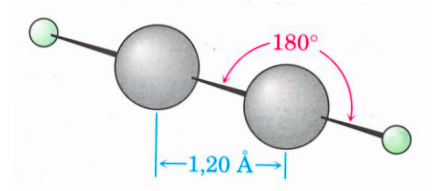
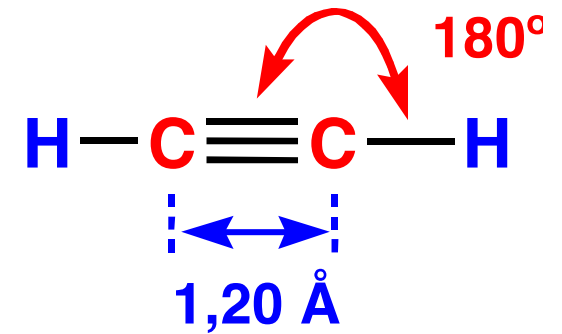
Alcènes

Carbones sp^2

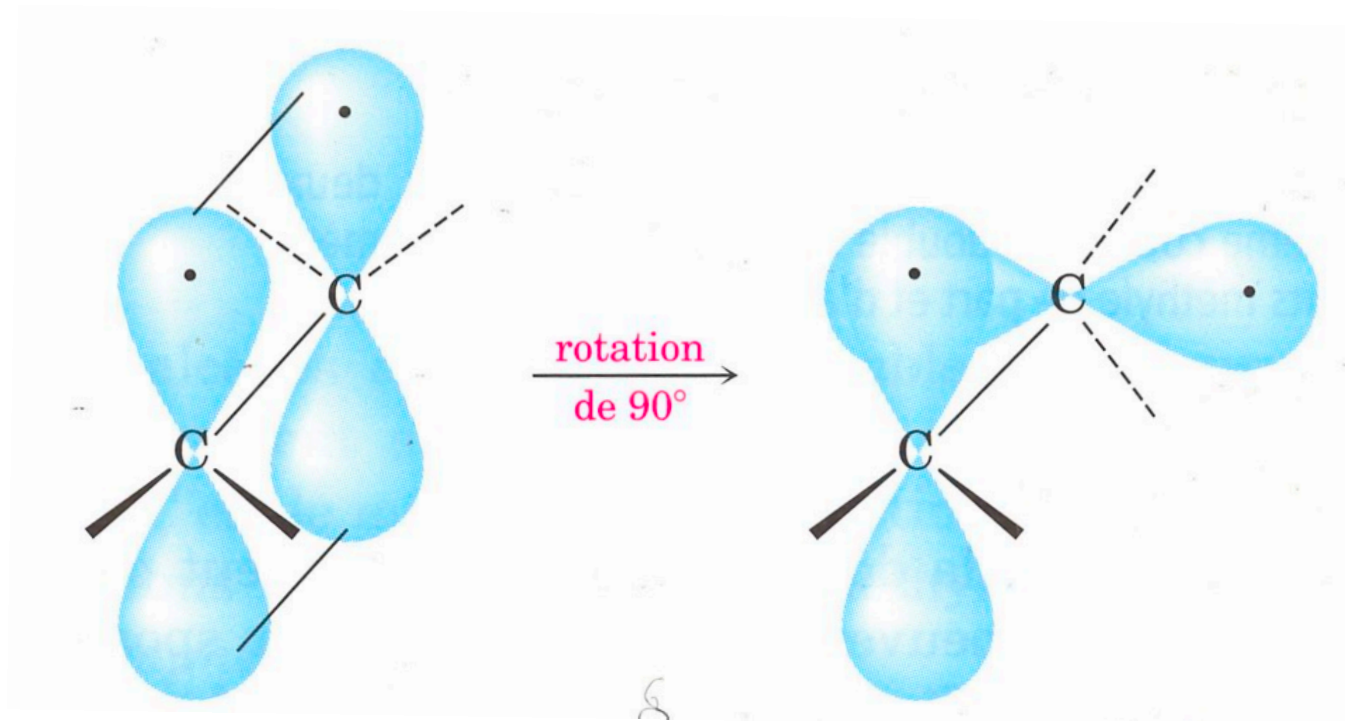
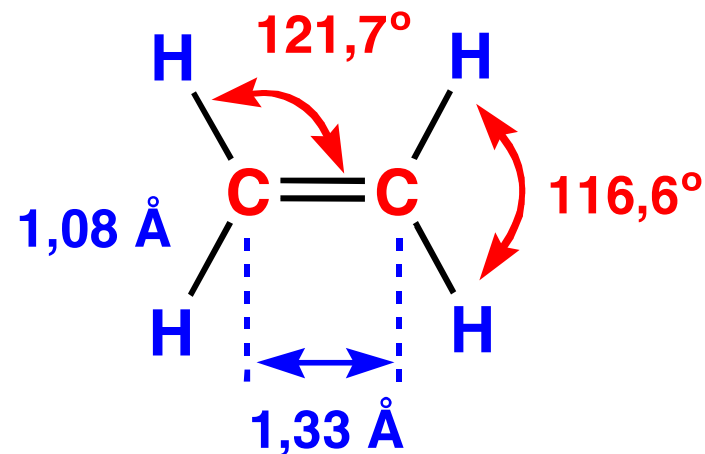
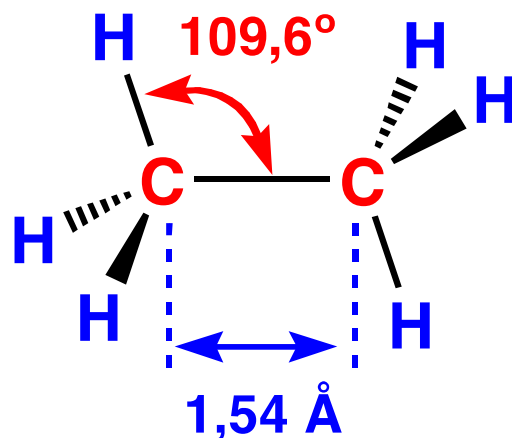


Alcynes

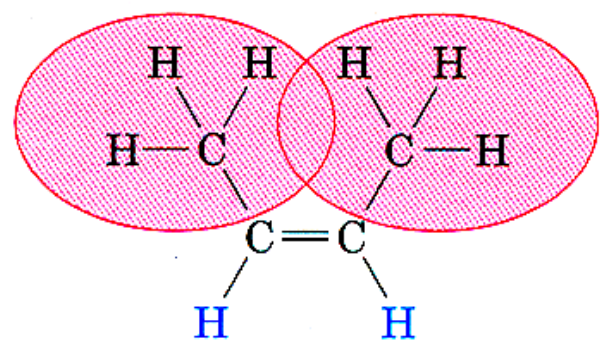
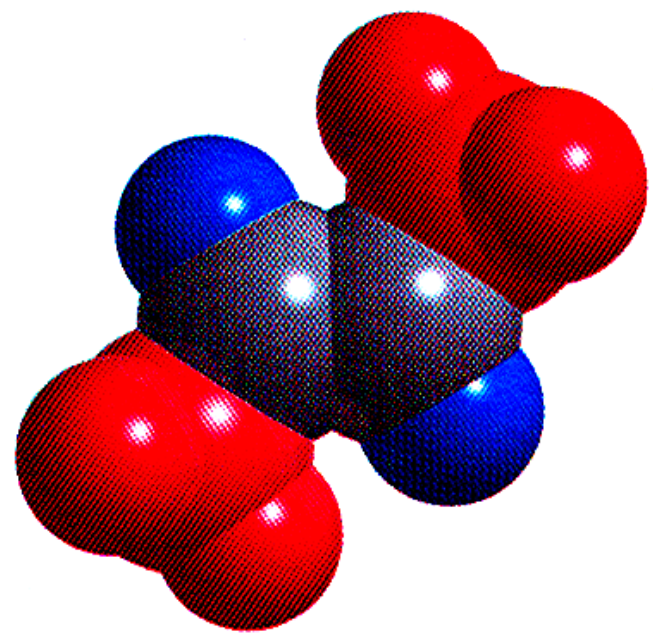
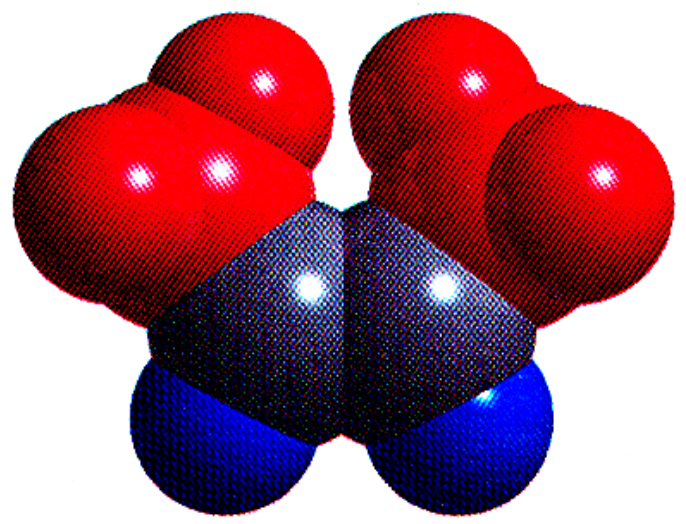
Carbones sp



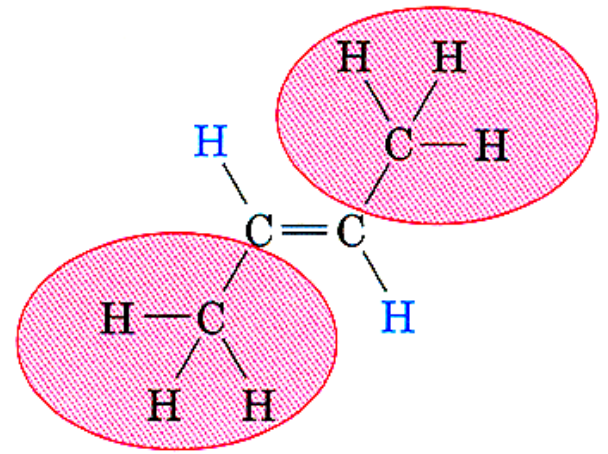
Isomérisie *cis* - *trans*



Isomérisie *cis* - *trans*



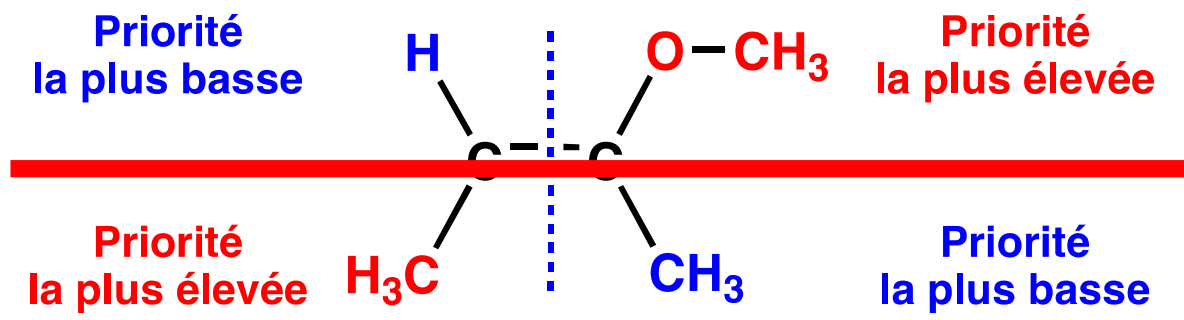
***cis*-alcène (24%)**



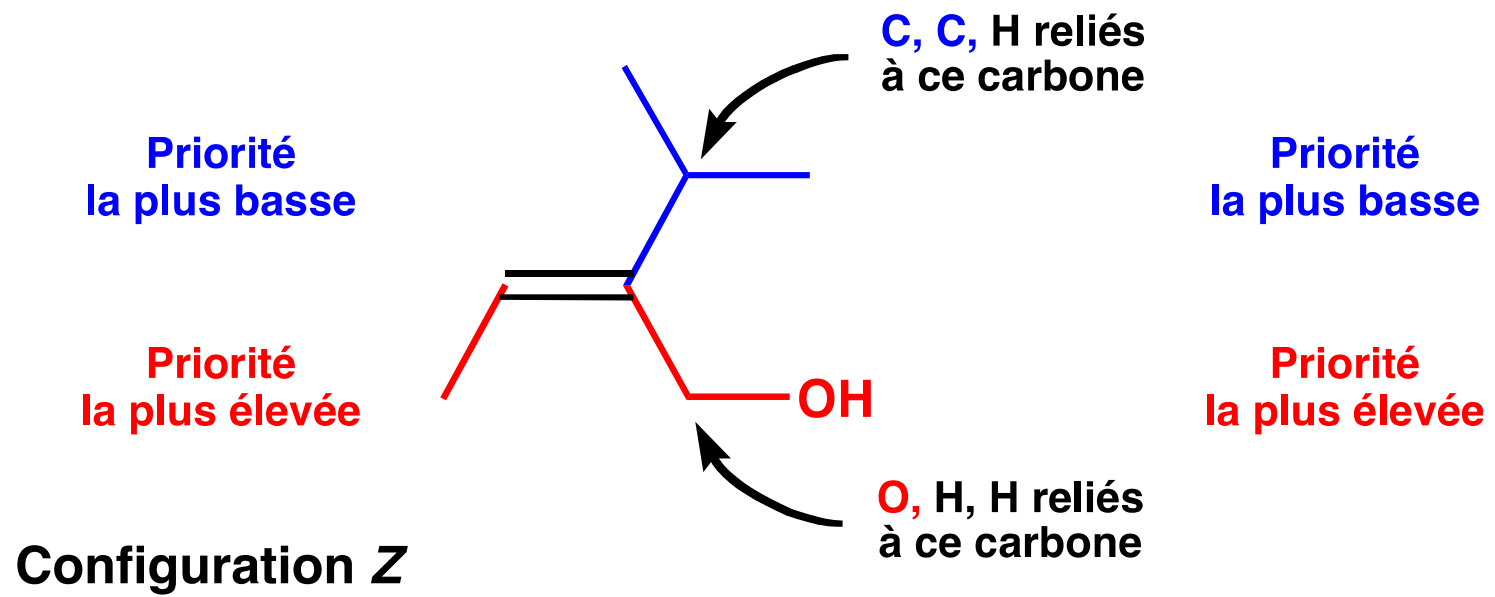
***trans*-alcène (76%)**

Nomenclature E - Z : Règles séquentielles

Br > Cl > O > N > C > H
35 17 8 7 6 1

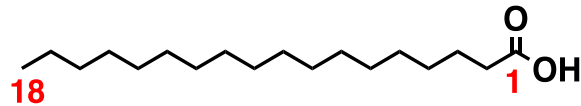
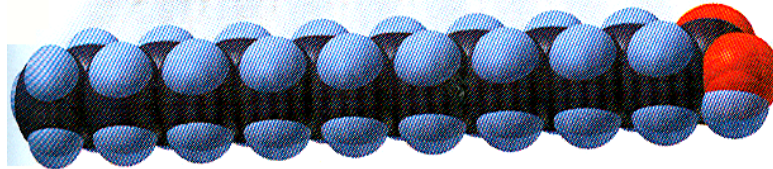
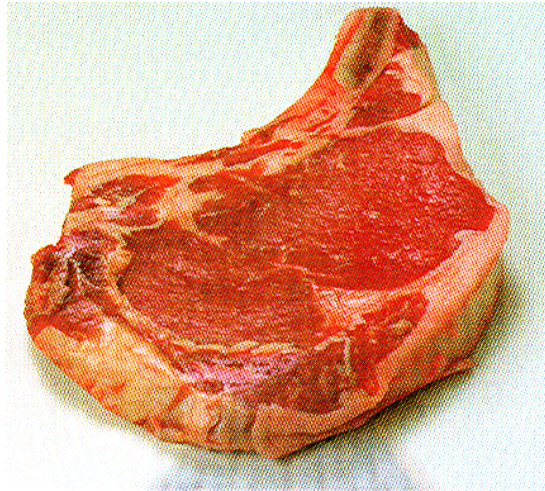
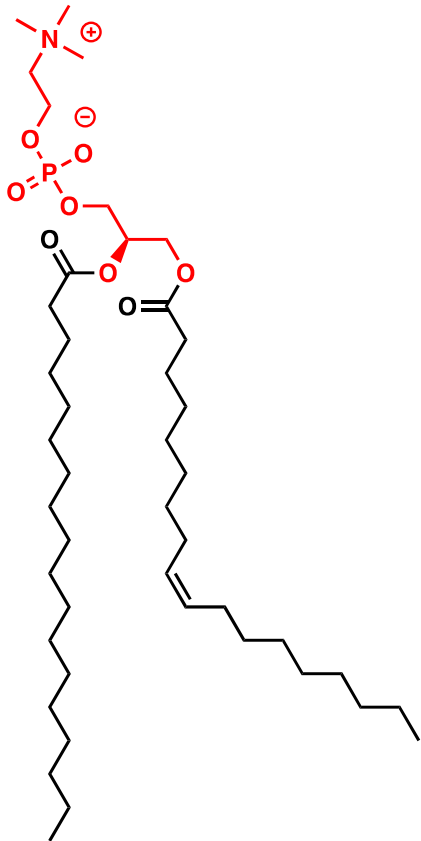
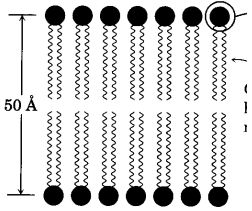
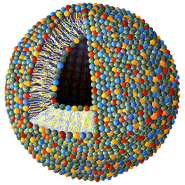


Configuration *E*

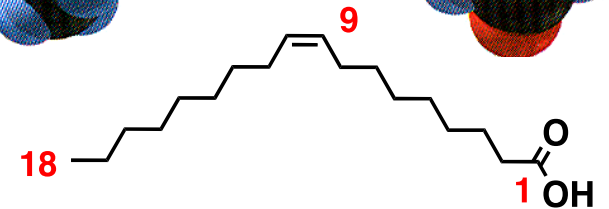
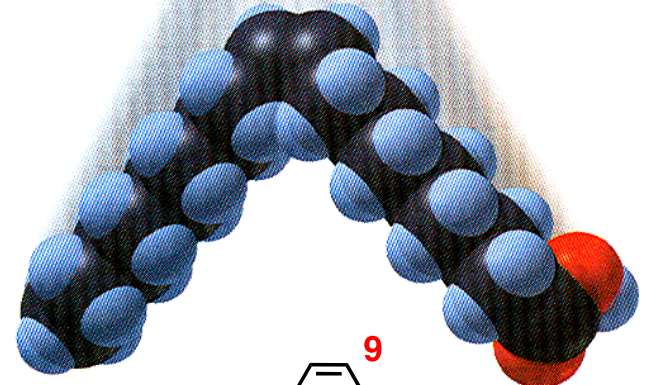


Configuration *Z*

Acides gras insaturés

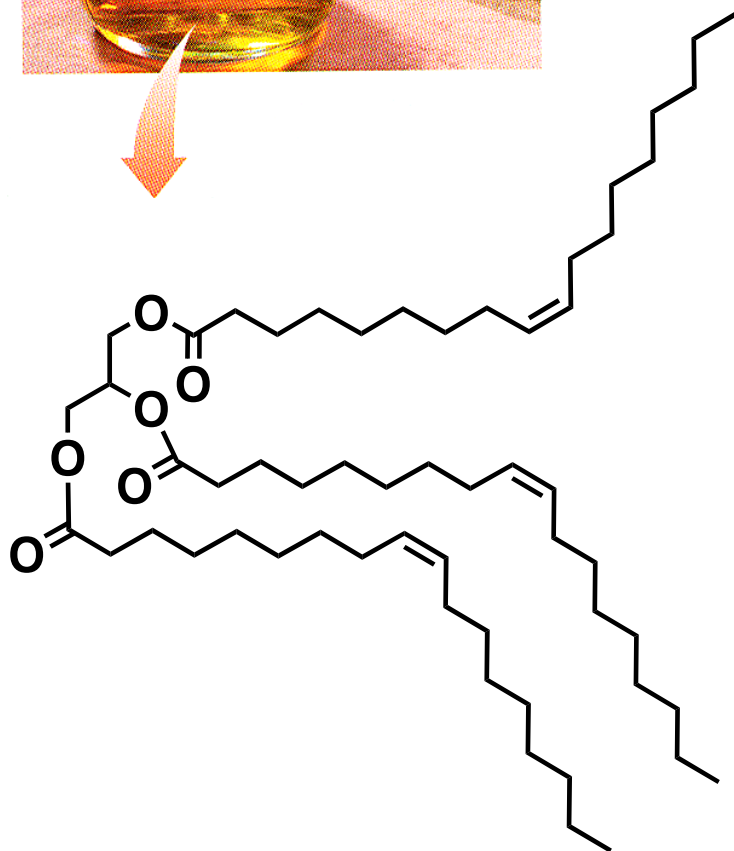
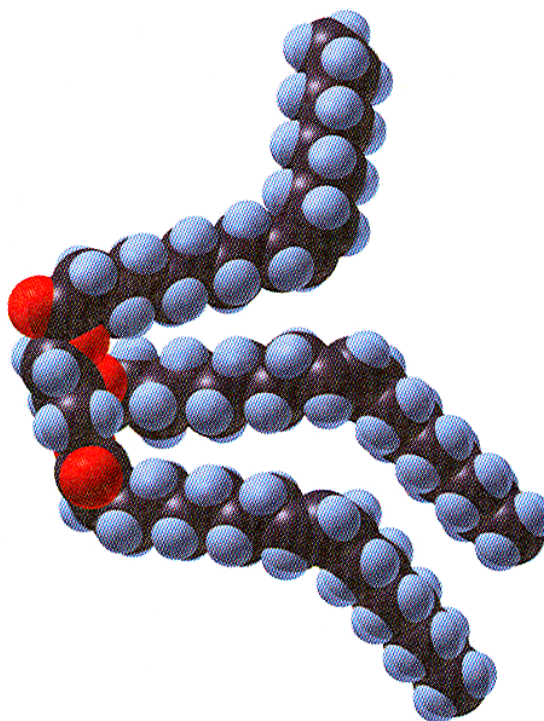


Acide stéarique
(Pf 69 °C)

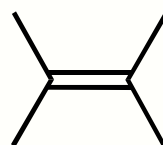


Acide oléique
(Pf 13 °C)

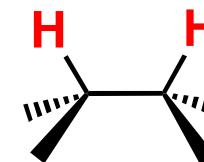
Graisses - réduction des alcènes



Hydrogénation

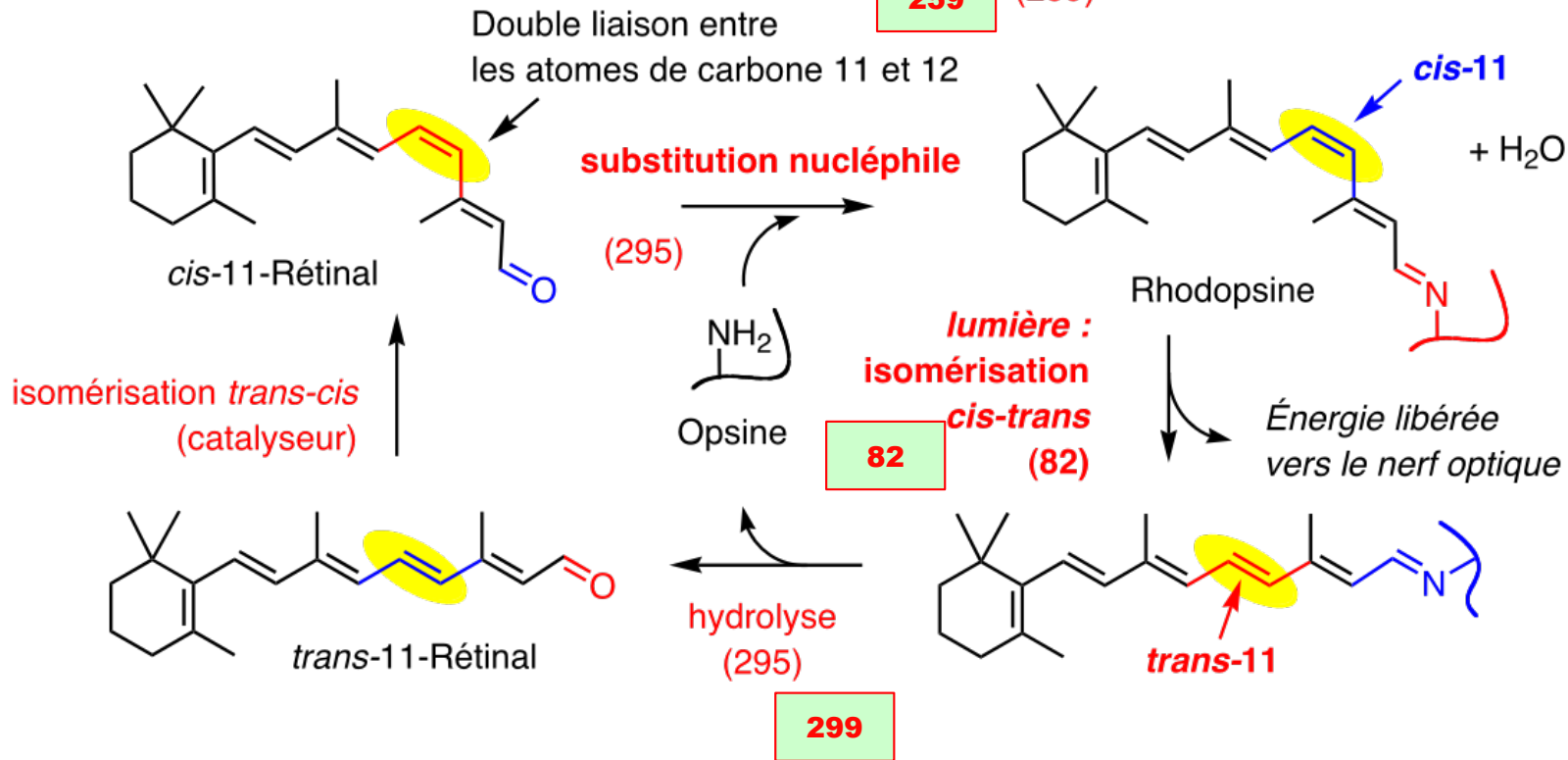
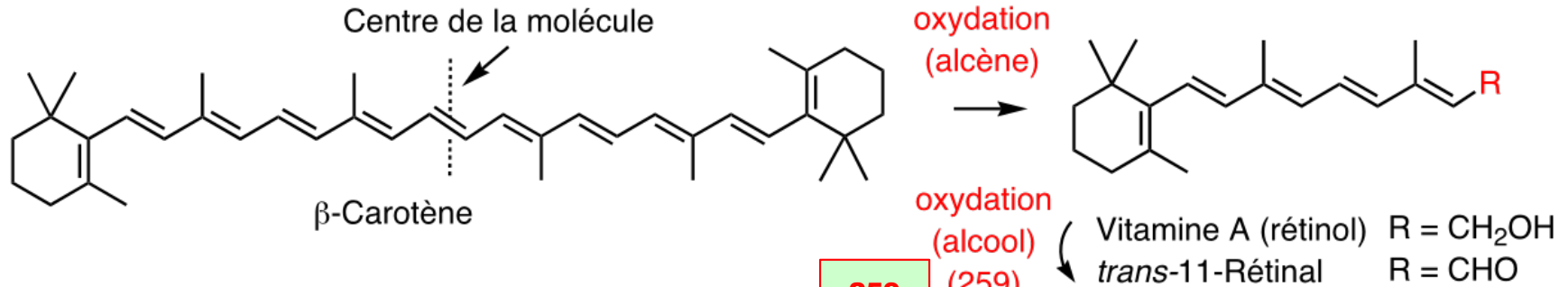
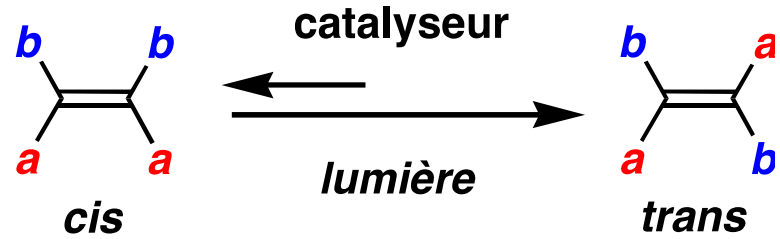


Alcène

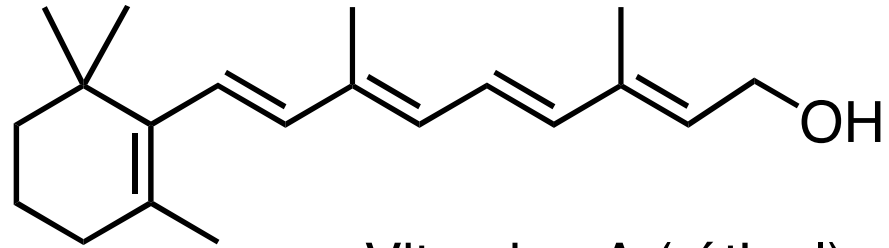


Alcane

La chimie de la vision

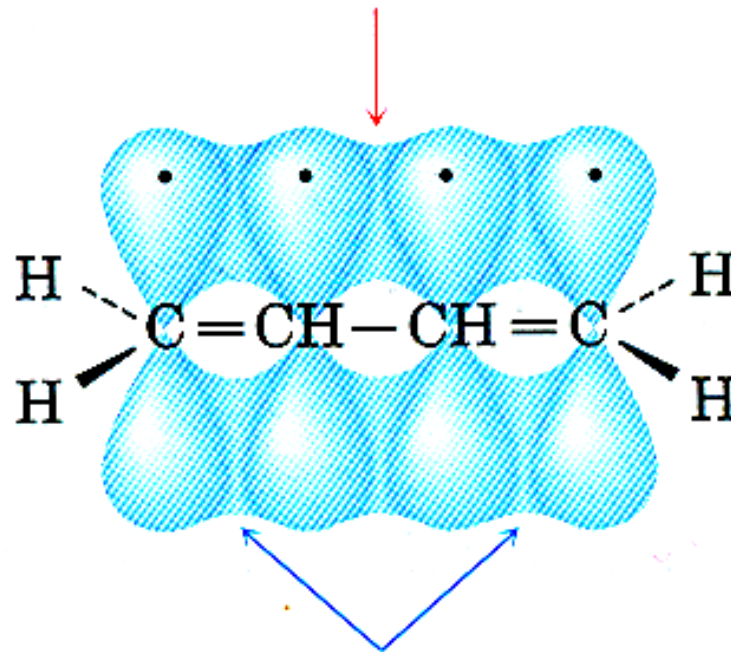


Alcènes conjugués



Vitamine A (rétinol)

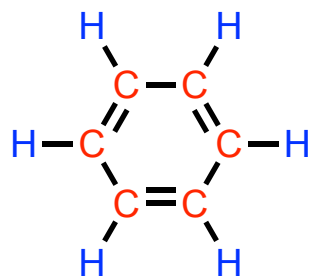
Liaison « partiellement » double



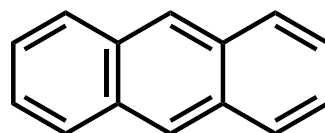
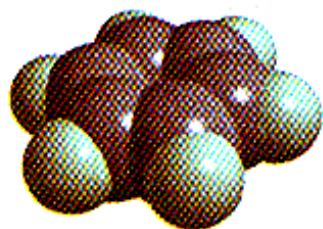
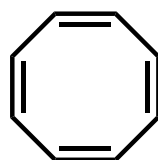
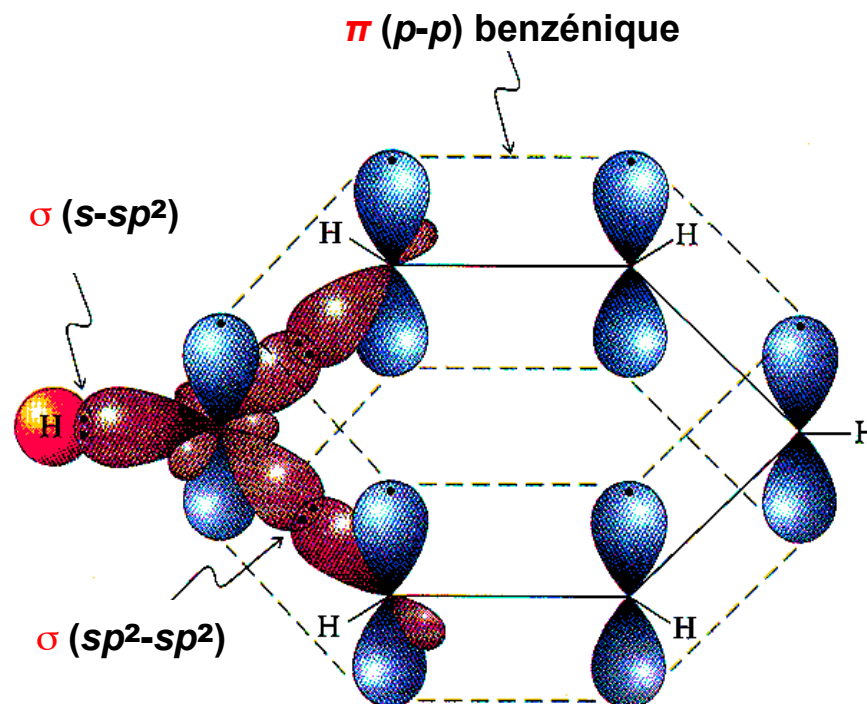
Liaisons doubles

Alternance de liaisons simples et multiples avec recouvrement des orbitales p

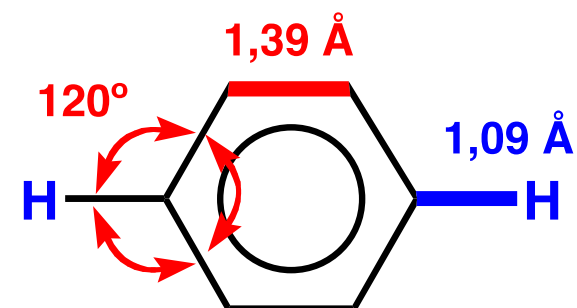
Les composés aromatiques



Benzène

Aromatique
($n = 3$)Non pas aromatique
($n \neq 1 \neq 2$)

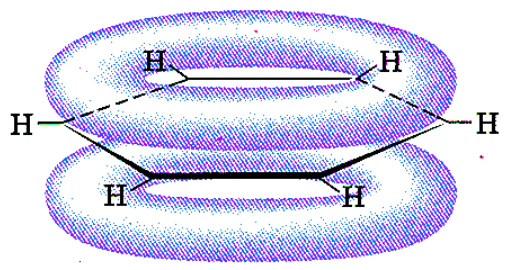
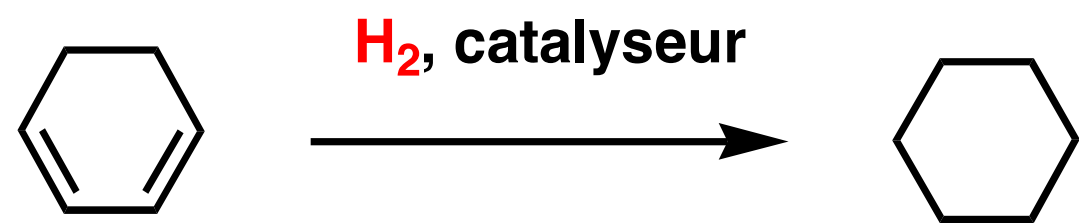
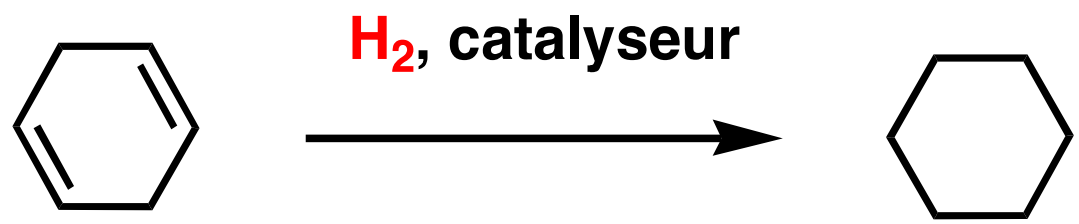
**Un ou plusieurs cycles d'atomes
avec une orbitale p et
 $4n + 2$ électrons délocalisés
($n = 1, 2, 3, \dots$)**



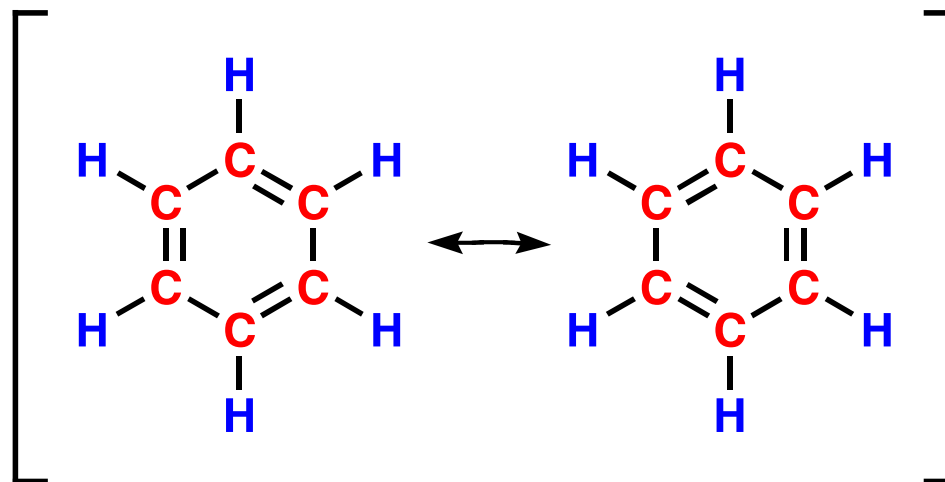
Aromatique : stable, planaire

Aromaticité et stabilité

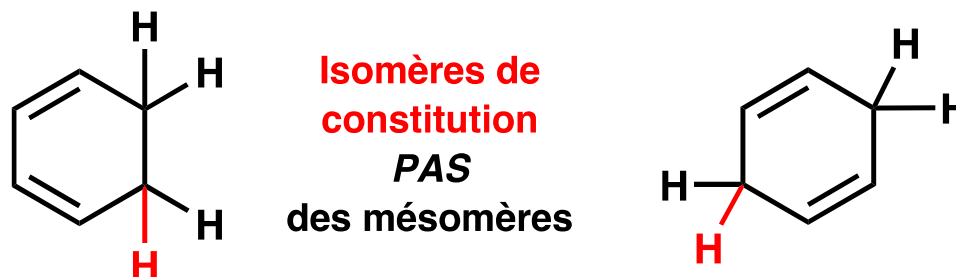
Hydrogénation (120)



Mésomères (formes de résonance)

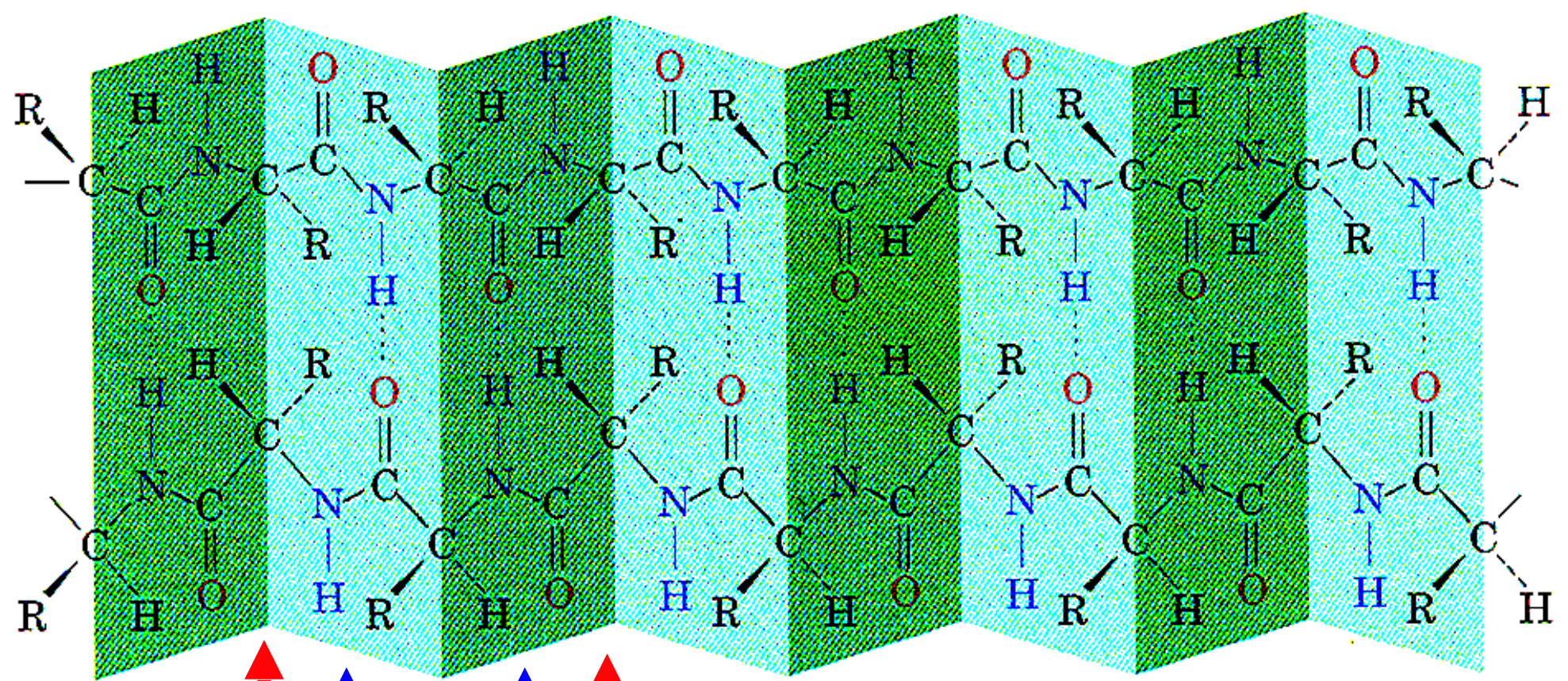


Benzène (deux formes de résonance)



Délocalisation d'électrons dans des molécules représenté par une combinaison virtuelle de structures aux électrons localisées différemment

Résonance : stable, planaire



sp^3
↑
↑
↑
↑
résonance

feuillelet plissé β

Résumé 2 (Alcanes - Alcènes - Arènes -)

- sp , sp^2 , sp^3 - $\sim 180^\circ$, $\sim 120^\circ$, $\sim 109^\circ$
- isomères de constitution - linéaire / ramifié
- conformères
 - décalé / éclipsé / gauche / anti
 - projection de Newman
 - basculement conformationnel - chaise / axiale / équatoriale
- stéréoisomères - *cis* / *trans* - *E* / *Z*
- cycloalcanes : tension du cycle - interaction 1,3-diaxiale
- conjugaison, mésomères, aromaticité
- liaison covalente - symétrique / polaire - électronégativité - dipôle -
- hydrophobe / hydrophile / amphiphile
- réduction des alcènes (hydrogénation)

A decorative border composed of a continuous chain of benzene rings, drawn with red outlines, framing the central text.

Mésomères

A

Alternance de liaisons simples et multiples avec recouvrement des orbitales p

B

Délocalisation d'électrons dans des molécules représenté par une combinaison virtuelle de structures aux électrons localisés différemment

C

**Un cycle d'atomes avec une orbitale p et $4n + 2$ électrons délocalisés
(= système π conjugué formé de liaisons doubles et de doublets non-liants)**

D

Représentations d'une molécule ne différant que par la position des électrons de liaison

E

Stéréoisomères qui diffèrent par leur stéréochimie au niveau d'une double liaison ou d'un cycle

CONTENU

McMurry

1. Généralités

(1, 2, 15)

**2. Lipides - stéroïdes - alcanes -
alcènes - arènes -**

(2 - 5, 16)

3. Glucides - stéréochimie -

(6, 14)

4. Alcools - éthers - phénols -

(8, 16)

hydroquinones - thiols - disulfures

5. Glucides - aldéhydes - cétones -

(9, 14)

imines -

6. Protéines - lipides -

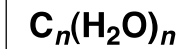
(10, 11, 15, 16)

acides - esters - amides -

7. Acides nucléiques - amines -

(12, 16)

Les glucides (carbohydrates, sucres)



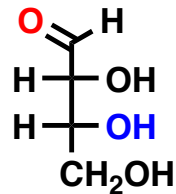
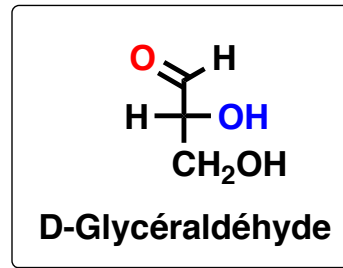
Aldoses (Cétones)

Aldotriose

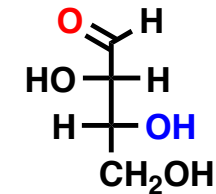
-tetroses

-pentoses

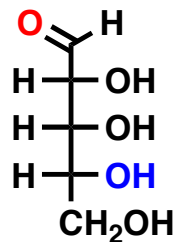
-hexoses



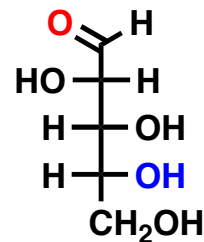
D-Érythrose



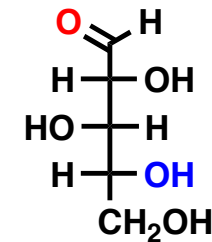
D-Thréose



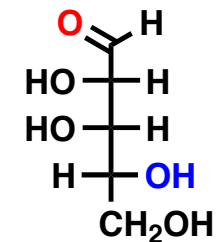
D-Ribose



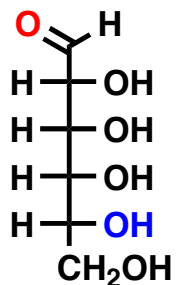
D-Arabinose



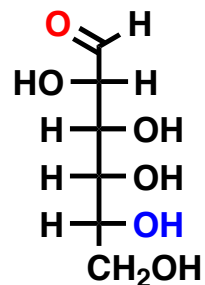
D-Xylose



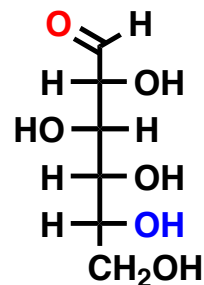
D-Lyxose



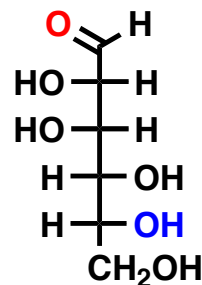
D-Allose



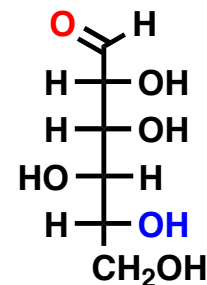
D-Altrose



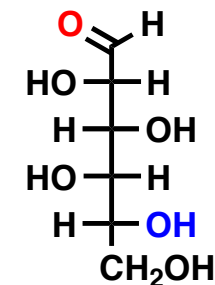
D-Glucose



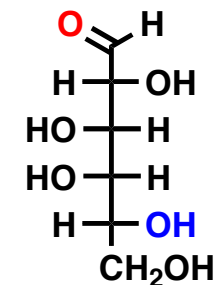
D-Mannose



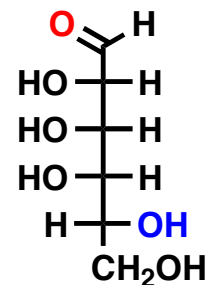
D-Gulose



D-Idose

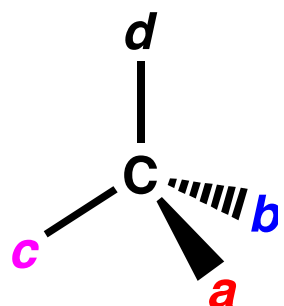


D-Galactose

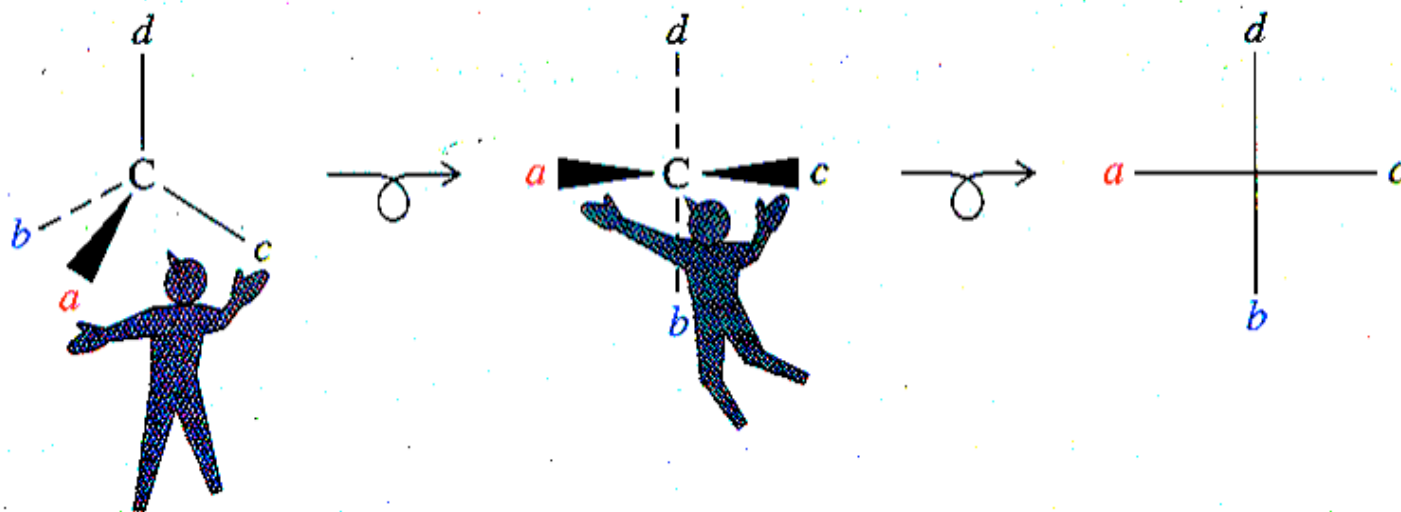


D-Talose

3. Stéréochimie - 4. Alcools - 5. Aldéhydes/cétones



Un exercice mental simple :
Convertir une structure perspective (avec tirets et coins) en projection de Fischer



Énantiomères