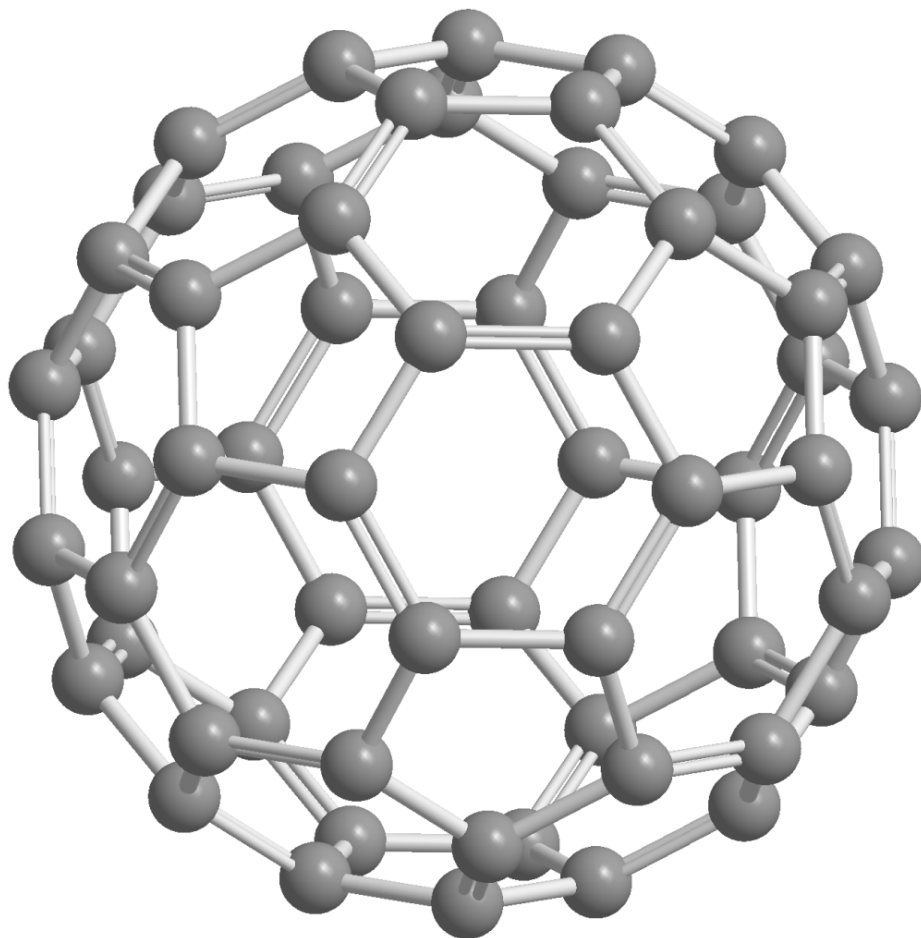




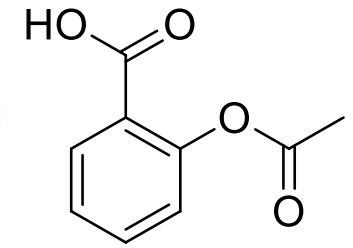
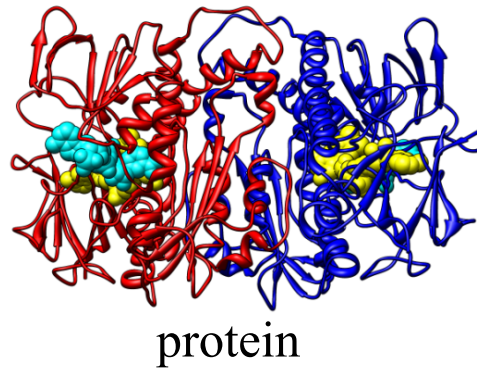
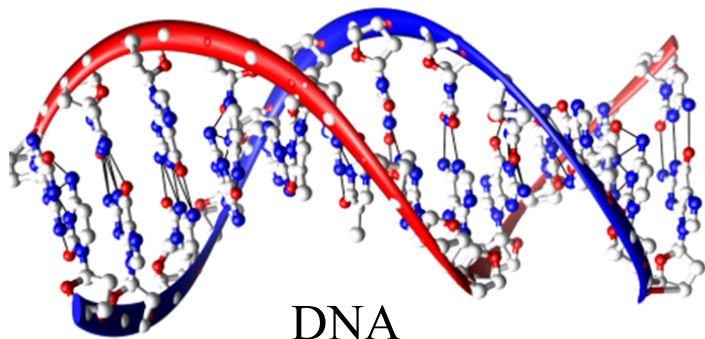
# Chemistry and Introduction to Biochemistry

## Organic Chemistry

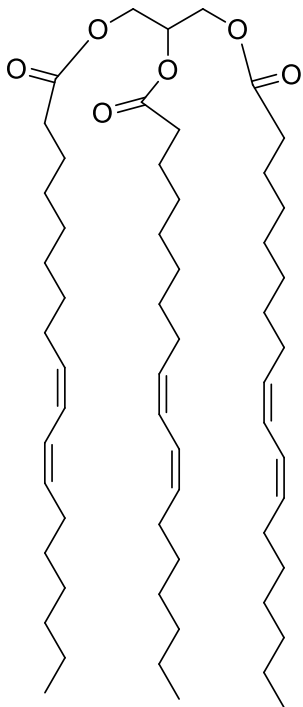


$C_{60}$   
a fullerene

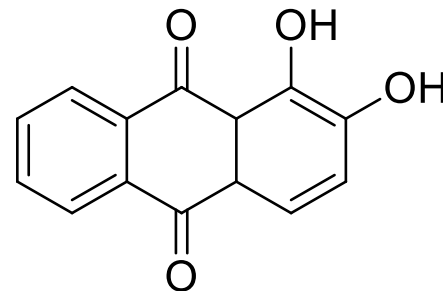
# Some organic compounds



drug



olive oil (including trilinoleylglycerol)



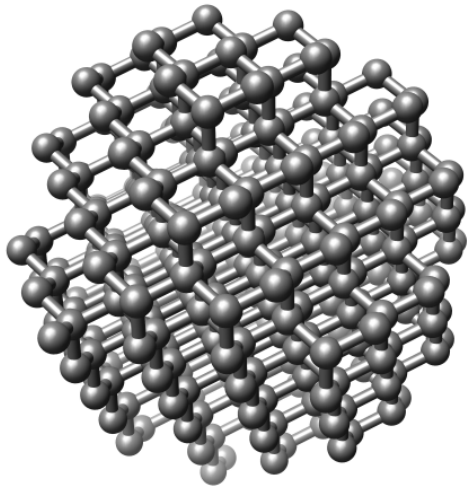
pigments: alizarin  
extracted from madder



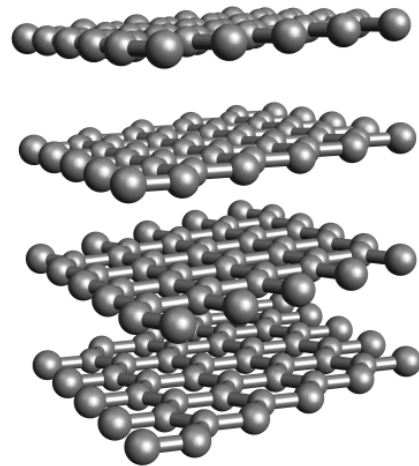
# Carbon: the atomic "Lego"

- C can form long covalent chains giving rise to many different compounds
- C can form **single**, **double** and **triple** bonds C forms strong covalent bonds with H, O, S, P, N and with halogens

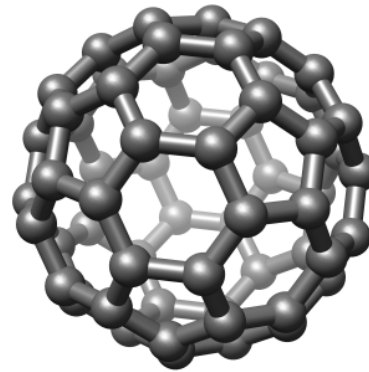
allotropic forms of carbon



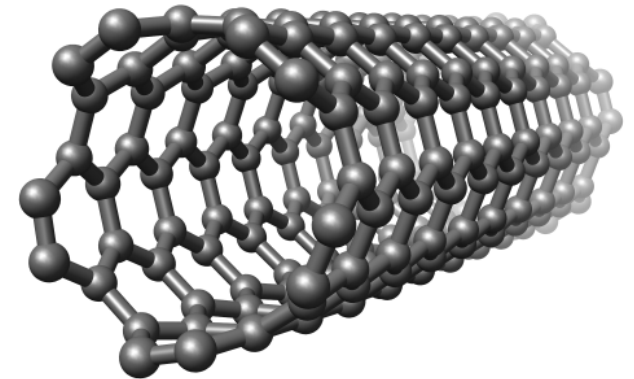
diamond



graphite



fullerene



nanotube

# Petroleum derivatives and their composition



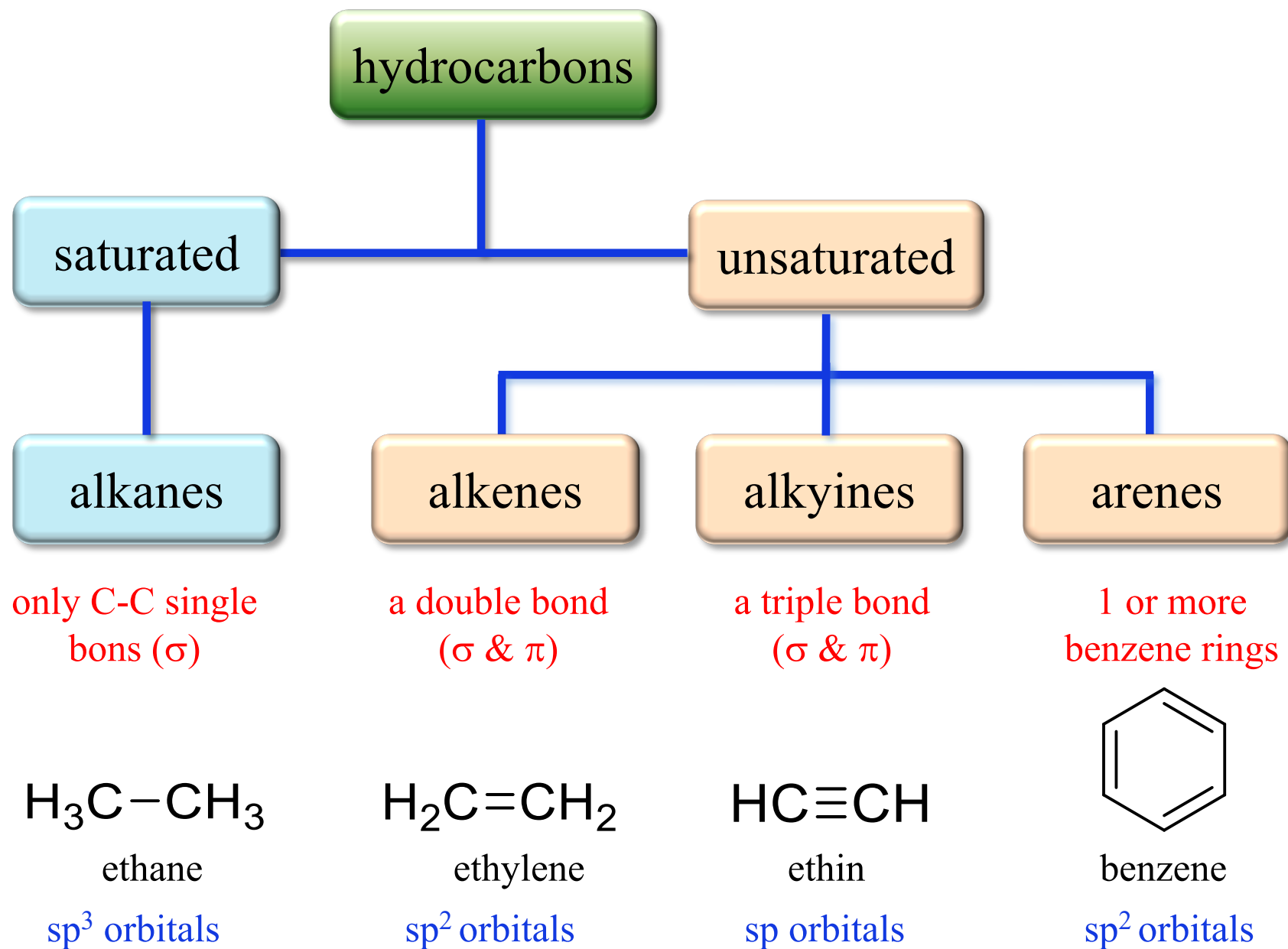
methane	$\text{CH}_4$	Natural gas
ethane	$\text{C}_2\text{H}_6$	
propane	$\text{C}_3\text{H}_8$	Liquid Propane Gas
buthane	$\text{C}_4\text{H}_{10}$	
pentane	$\text{C}_5\text{H}_{12}$	petroleum ether
hexane	$\text{C}_6\text{H}_{14}$	
eptane	$\text{C}_7\text{H}_{16}$	petrol
octane	$\text{C}_8\text{H}_{18}$	
nonane	$\text{C}_9\text{H}_{20}$	
decane	$\text{C}_{10}\text{H}_{22}$	
undecane	$\text{C}_{11}\text{H}_{24}$	
dodecane	$\text{C}_{12}\text{H}_{26}$	
tridecane	$\text{C}_{13}\text{H}_{28}$	
tetradecane	$\text{C}_{14}\text{H}_{30}$	
pentadecane	$\text{C}_{15}\text{H}_{32}$	
esadecane	$\text{C}_{16}\text{H}_{34}$	
eptadecane	$\text{C}_{17}\text{H}_{36}$	
octadecane	$\text{C}_{18}\text{H}_{38}$	diesel
nonadecane	$\text{C}_{19}\text{H}_{40}$	
eicosane	$\text{C}_{20}\text{H}_{42}$	lubricating oils
		petrolatum (petroleum gel)



Name	Molecular formula	Condensed structural formula
Methane	CH <sub>4</sub>	CH <sub>4</sub>
Ethane	C <sub>2</sub> H <sub>6</sub>	CH <sub>3</sub> CH <sub>3</sub>
Propane	C <sub>3</sub> H <sub>8</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>
Butane	C <sub>4</sub> H <sub>10</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>3</sub>
Pentane	C <sub>5</sub> H <sub>12</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>
Hexane	C <sub>6</sub> H <sub>14</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>3</sub>
Eptane	C <sub>7</sub> H <sub>16</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>5</sub> CH <sub>3</sub>
Octane	C <sub>8</sub> H <sub>18</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CH <sub>3</sub>
Nonane	C <sub>9</sub> H <sub>20</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH <sub>3</sub>
Decane	C <sub>10</sub> H <sub>22</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>8</sub> CH <sub>3</sub>

Name	Molecular formula	Condensed structural formula
Undecane	C <sub>11</sub> H <sub>24</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>9</sub> CH <sub>3</sub>
Dodecane	C <sub>12</sub> H <sub>26</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>10</sub> CH <sub>3</sub>
Tridecane	C <sub>13</sub> H <sub>28</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>11</sub> CH <sub>3</sub>
Tetradecane	C <sub>14</sub> H <sub>30</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>12</sub> CH <sub>3</sub>
Pentadecane	C <sub>15</sub> H <sub>32</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>13</sub> CH <sub>3</sub>
Hexadecane	C <sub>16</sub> H <sub>34</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> CH <sub>3</sub>
Eptadecane	C <sub>17</sub> H <sub>36</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>15</sub> CH <sub>3</sub>
Octadecane	C <sub>18</sub> H <sub>38</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>16</sub> CH <sub>3</sub>
Nonadecane	C <sub>19</sub> H <sub>40</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>17</sub> CH <sub>3</sub>
Eicosane	C <sub>20</sub> H <sub>42</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>18</sub> CH <sub>3</sub>

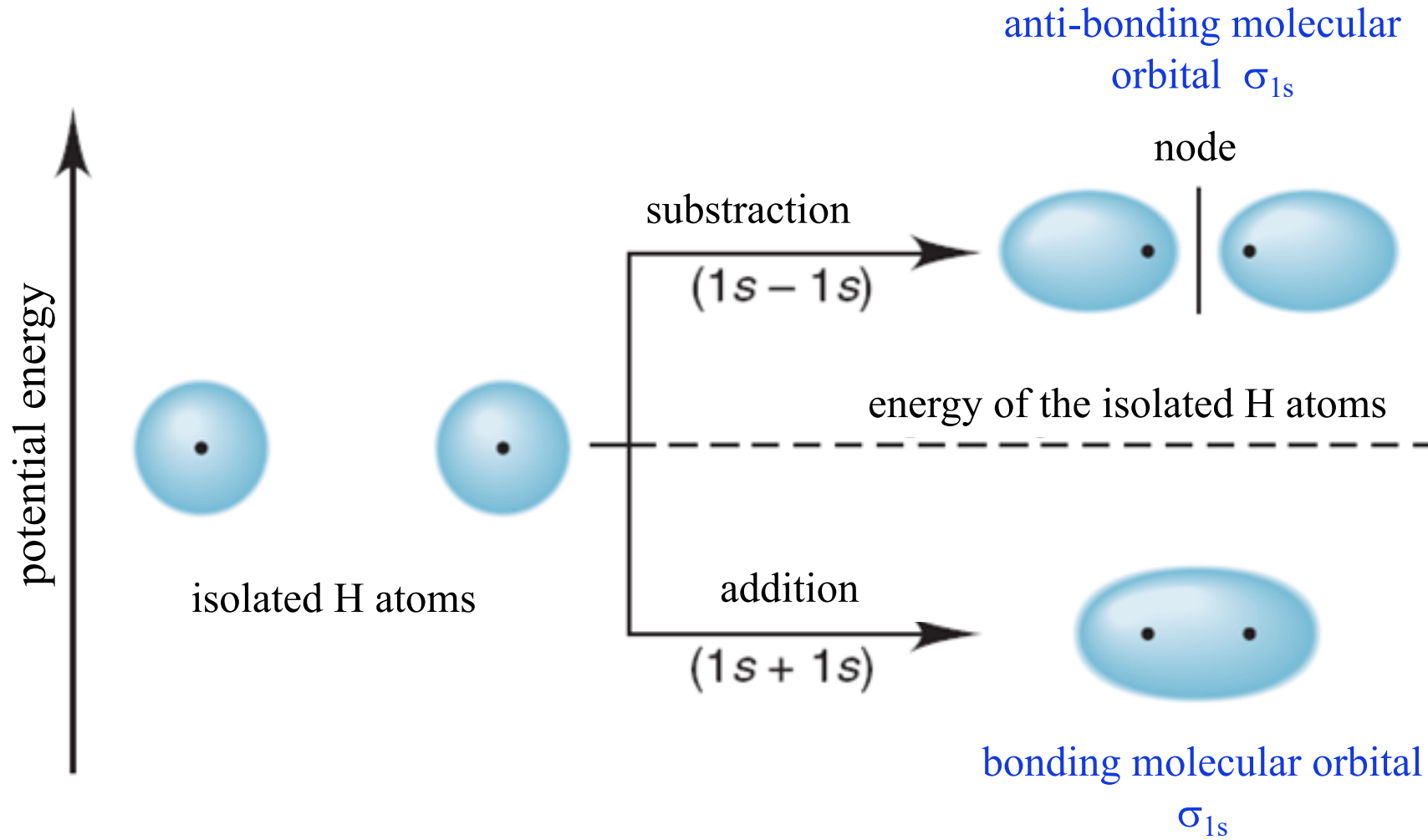
# Classification of hydrocarbons



# Molecular orbital theory (MO)

- in atoms, electrons are found in atomic orbitals
  - in molecules electrons are found in molecular orbitals (Molecular Orbitals)
  - using the Schrödinger equation, the shape and energies of the MOs can be calculated
- 1) from the combination of  $n$  atomic orbitals (mathematically a sum and subtraction of wave functions) we obtain  $n$  MO (i.e.  $n$  new wave functions)
  - 2) the MOs are ordered according to increasing energy
  - 3) the **filling of the MO** follows and the same rules used for atomic orbitals:
    - the principle of aufbau
    - the Pauli exclusion principle
    - Hund's rule

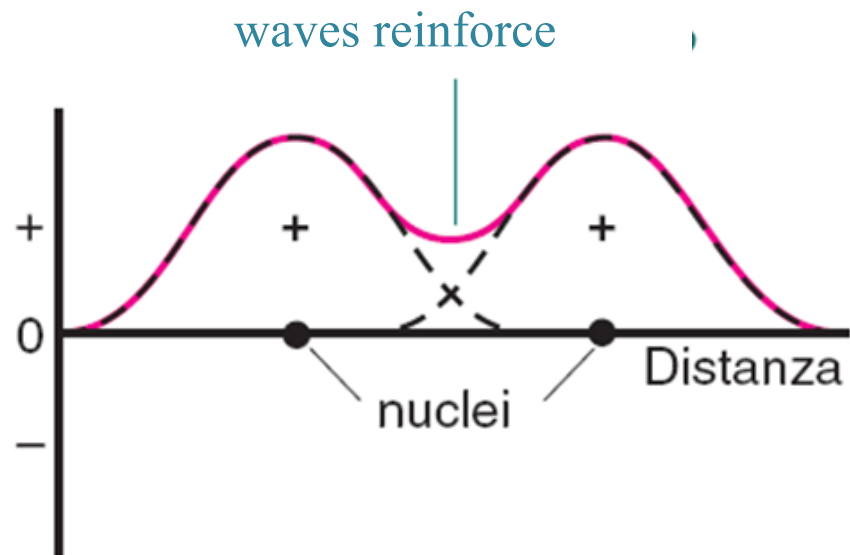
# The molecular orbitals of the H<sub>2</sub> molecule



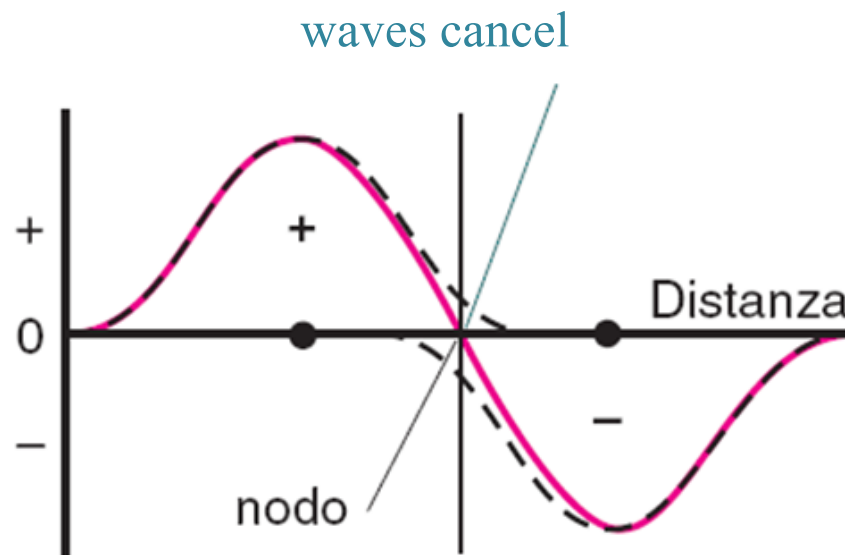


An analogy between light waves and atomic wave functions (wave-particle dualism)

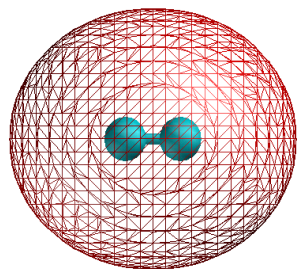
When light waves undergo interference, their amplitudes can **add up** or **subtract**



The amplitudes of the wave functions add

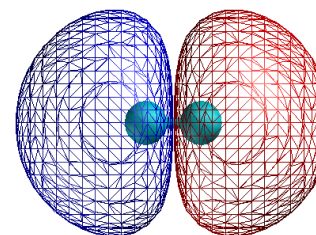


The amplitudes of the wave functions subtract



low energy

bonding molecular orbital,  $\sigma_{1s}$

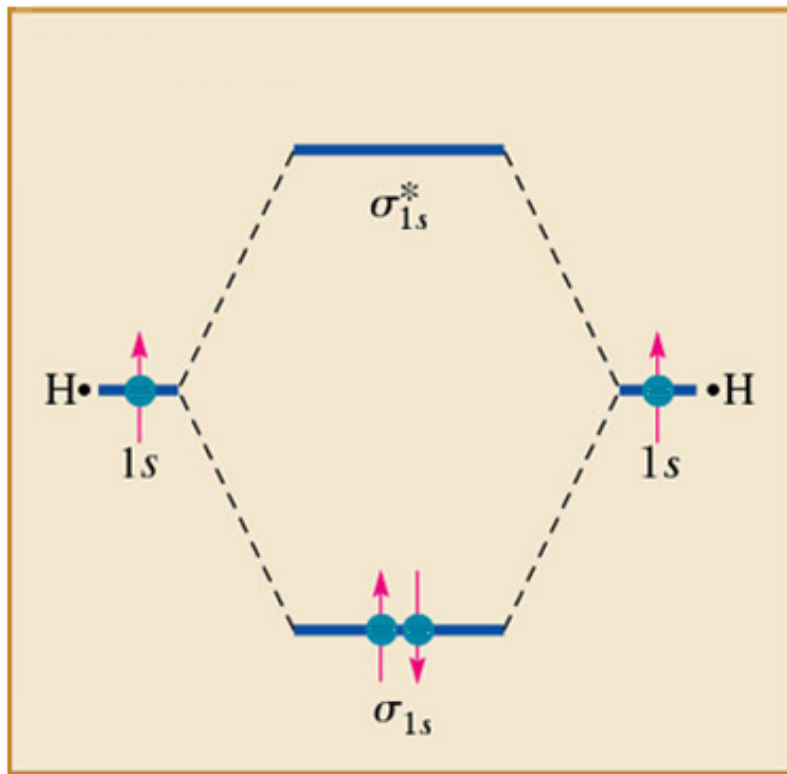


high energy

anti-bonding molecular orbital,  $\sigma_{1s}^*$

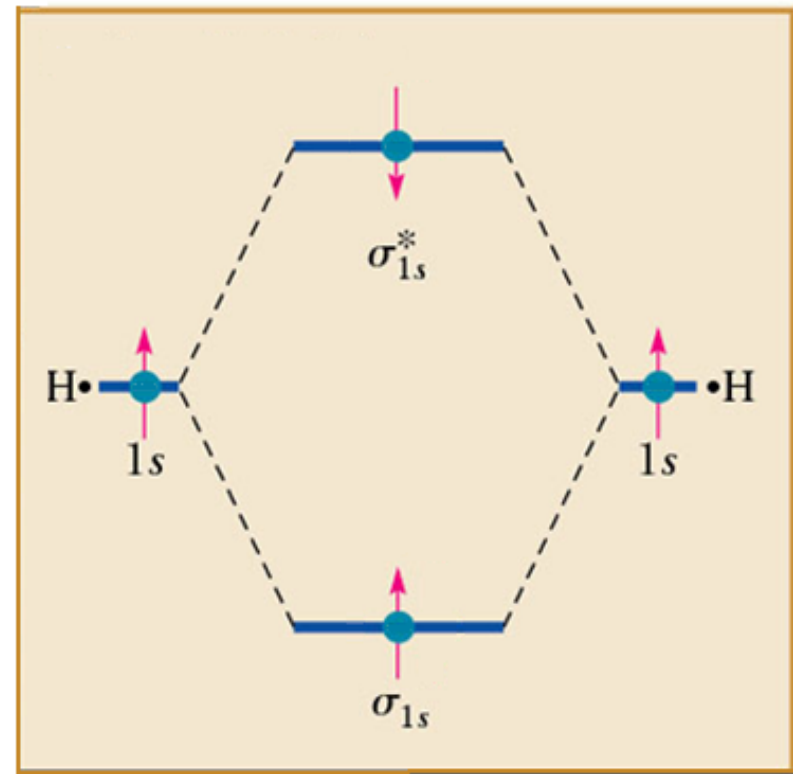
The filling of the MO follows and the same rules used for the atomic orbitals

Ground state



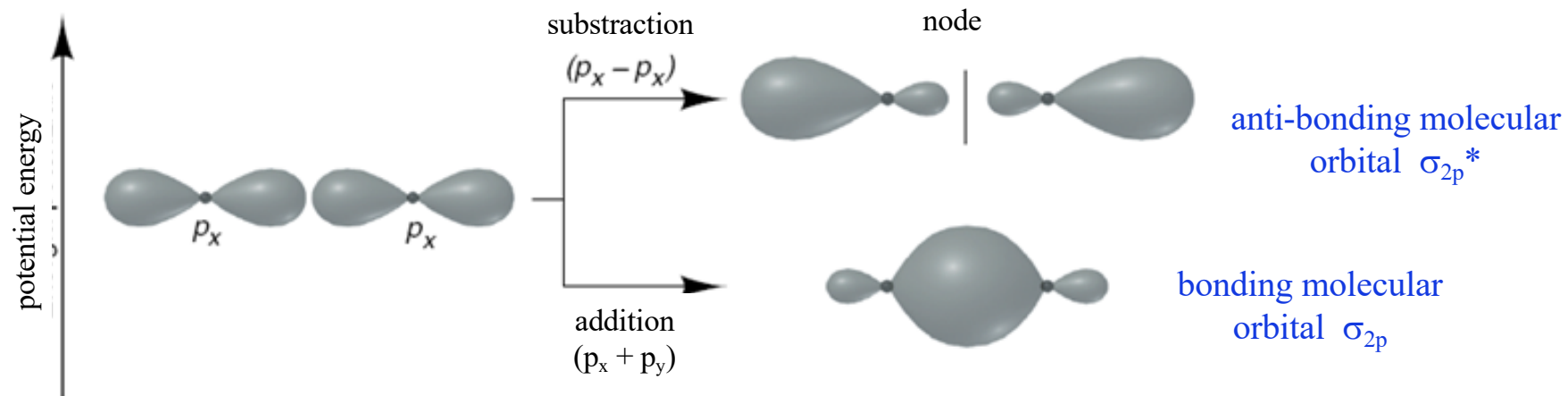
energy  $\rightarrow$

excited state

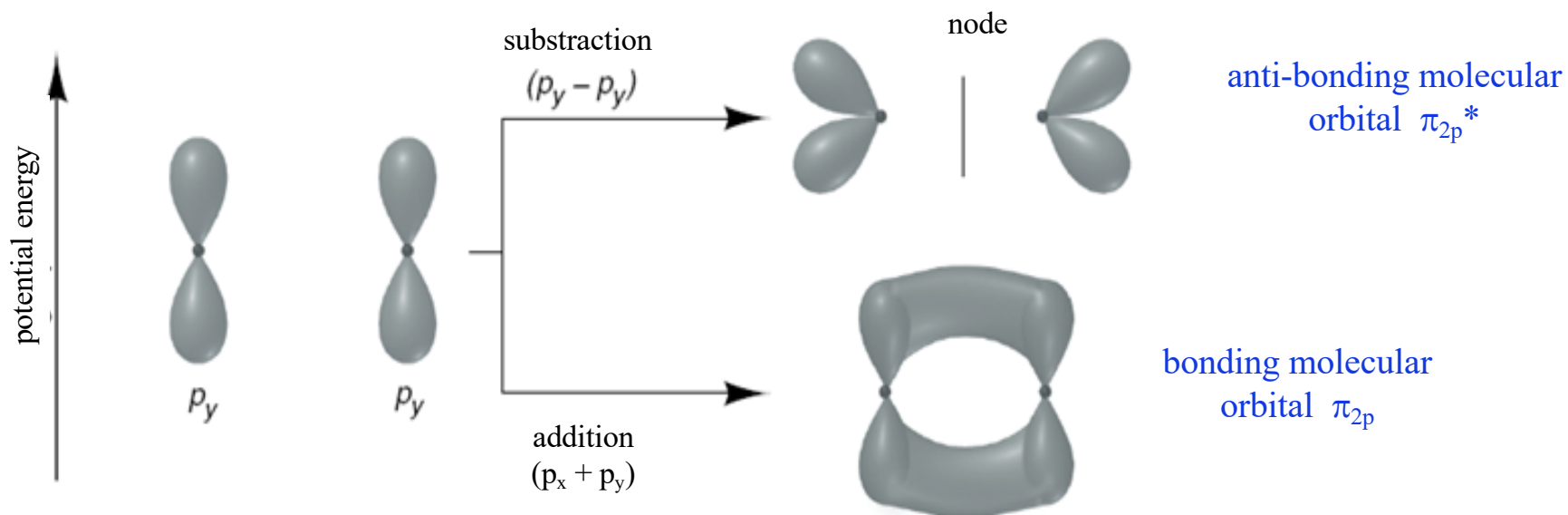


# Molecular orbitals from combinations of p atomic orbitals and $\pi$ molecular orbitals

Coaxial combination of atomic orbitals to form molecular  $\sigma$  orbitals can take place with other orbitals (p, sp,  $sp^2$  and  $sp^3$ )



By lateral overlap of 2 p orbitals, the molecular  $\pi$  orbital is obtained



Hybridization of orbitals (L. Pauling) predicts:

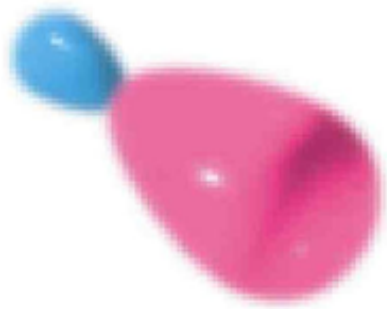
- 3 hybrid orbitals:
  - $sp^3$  (1 s orbital + 3 p orbitals)
  - $sp^2$  (1 s orbital + 2 p orbitals)
  - $sp$  (1 s orbital + 1 p orbital)

the superposition of hybrid orbitals produces 2 types of bonds depending on the geometry of the overlap:

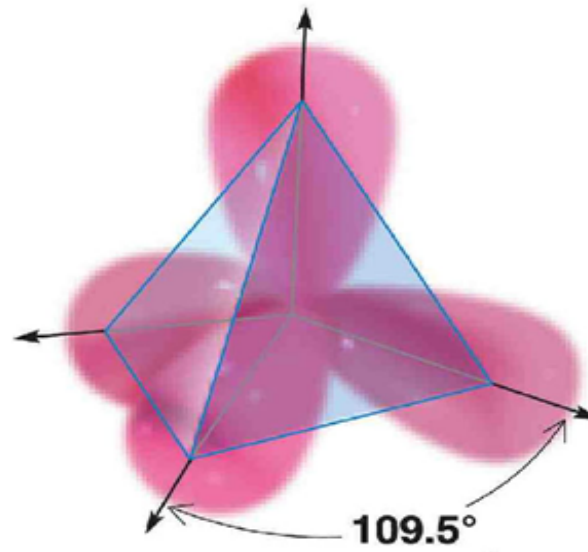
- $\sigma$  bonds formed by coaxial overlap
- $\pi$  bonds formed by lateral overlap

## $sp^3$ hybrid orbitals (all alkanes)

- 1 2s orbitals and 3 2p orbitals mix to give 4  $sp^3$  orbitals
- each  $sp^3$  hybrid orbital has 2 lobes of different size
- the sign of the wave function is positive in a lobe, negative in the other and it is null to the core
- the 4  $sp^3$  hybrid orbitals are directed to the vertices of a regular tetrahedron regular with  $109.5^\circ$  angles



a single  $sp^3$  orbital



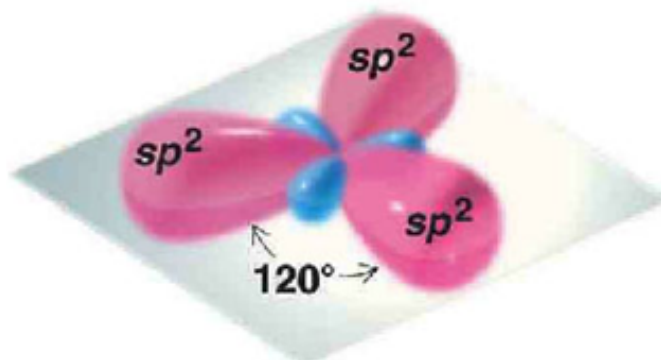
4  $sp^3$  tetrahedral hybrid orbitals

## $sp^2$ hybrid orbitals (alkenes & arenes)

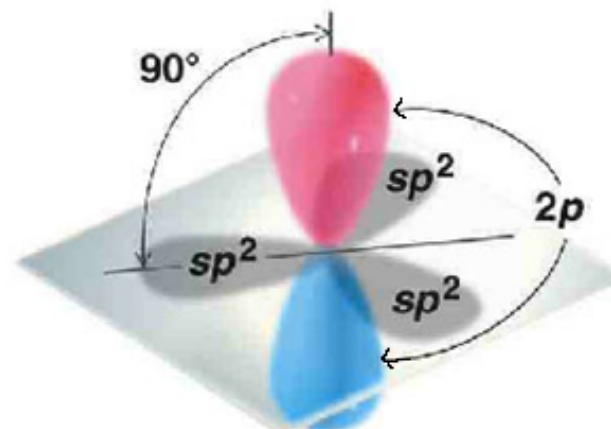
- 1 2s orbital and 2 2p orbitals mix to give 3  $sp^2$  orbitals  
1 unhybridized 2p orbital remains
- each  $sp^2$  hybrid orbital has 2 lobes of different size
- the axes of the 3  $sp^2$  hybrid orbitals lie on a plane and are directed to the vertices of an equilateral triangle with angles of  $120^\circ$
- the non-hybridized 2p orbital is perpendicular to the plane of 3  $sp^2$  hybrid orbitals



a single  $sp^2$  orbital



3  $sp^2$  planar trigonal hybrid orbitals



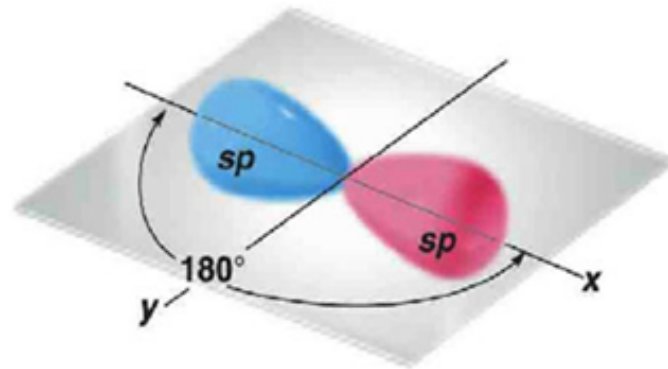
3  $sp^2$  orbitals and 1 non-hybridized 2p orbital

# Sp hybrid orbitals (presenti in tutti gli alchini)

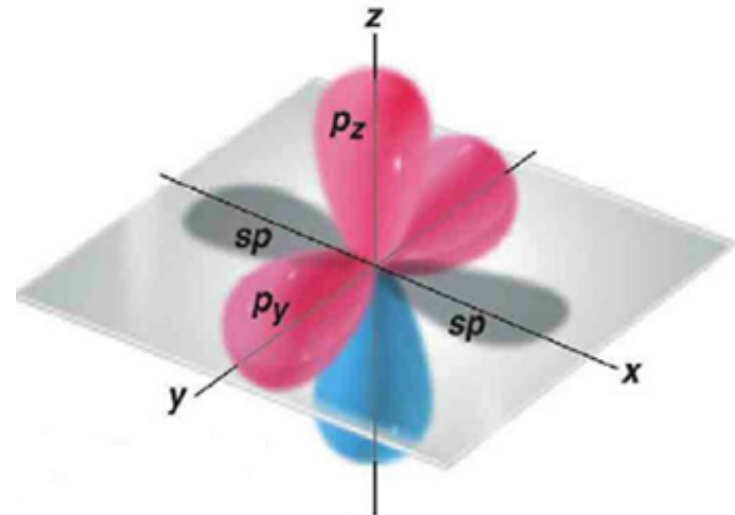
- 1 2s orbital and 2 2p orbitals mix to give 2 sp orbitals  
2 unhybridized 2p orbitals remain
- each sp hybrid orbital has 2 lobes of different size
- the 2 sp orbitals are coaxial ( $180^\circ$  angle)
- the 2 non-hybridized 2p orbitals are perpendicular to each other and perpendicular to the axis that connects the 2 orbitals sp



an hybrid  
sp orbital



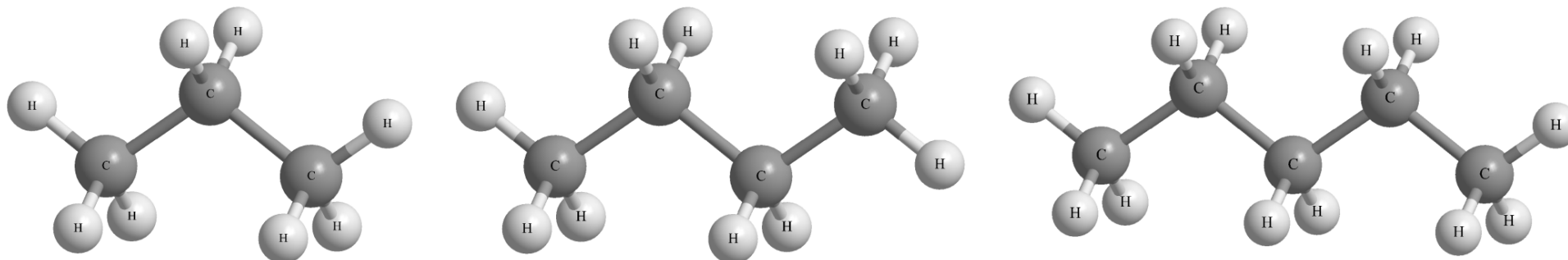
2 hybrid sp  
orbitals



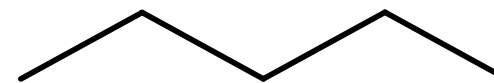
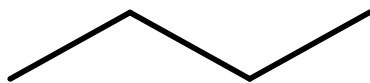
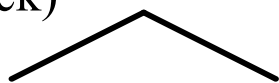
2 sp and 2 unhybridized  
2p orbitals

# Ways of representing organic molecules

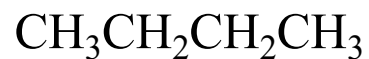
## Ball and stick model



lines and angles formula  
(stick)



shortened structural formula



propane (C<sub>3</sub>H<sub>8</sub>)

butane (C<sub>4</sub>H<sub>10</sub>)

pentane (C<sub>5</sub>H<sub>12</sub>)



# Hydrocarbons

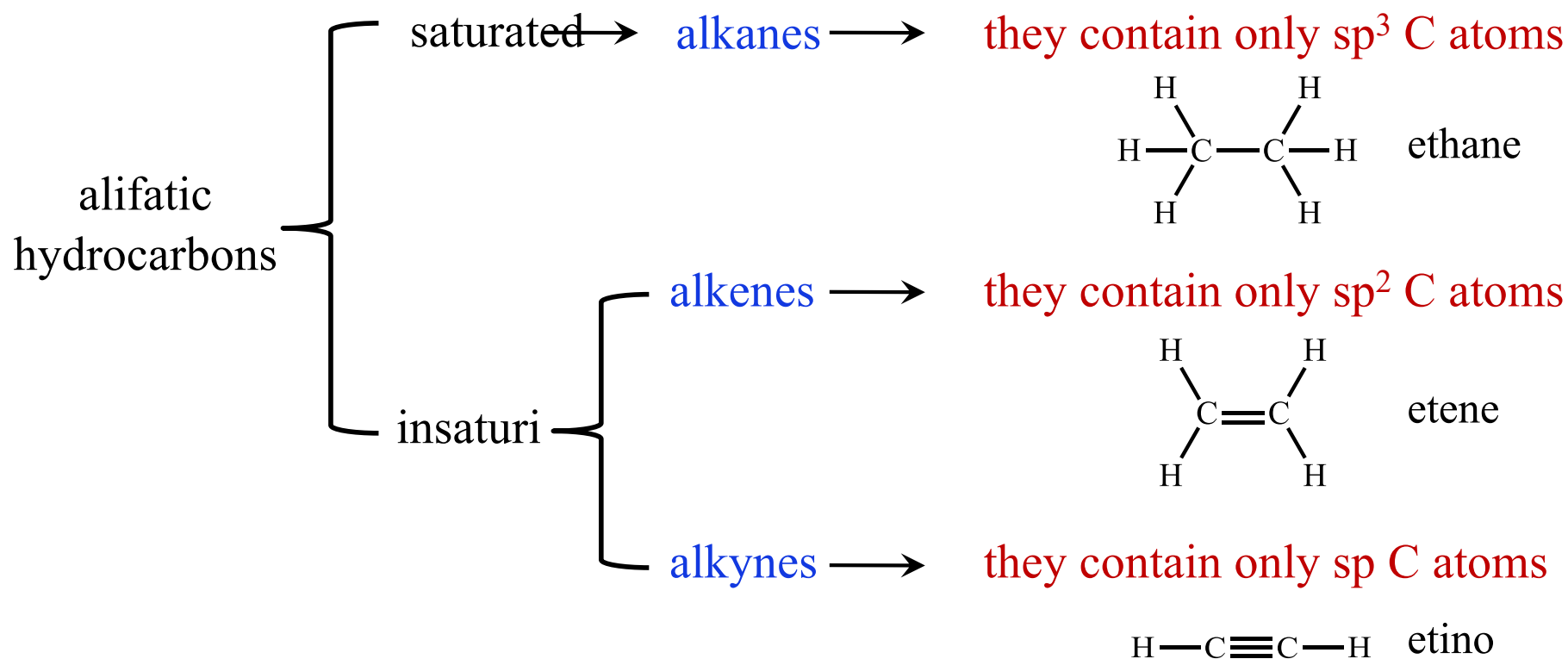
They can be divided into four large groups:

1 aliphatic: open chain, linear or branched, saturated or unsaturated

2 cyclic

3 aromatic: contain at least one benzene ring

4 heterocyclic: containing atoms other than carbon in the ring



# Alkanes

Names, molecular formulas and abbreviated structural formulas of the first 20 **linear alkanes**( $C_n H_{2n+2}$ )

name	molecular formula	abbreviated structural formula	name	molecular formula	abbreviated structural formula
methane	CH <sub>4</sub>	CH <sub>4</sub>	undecane	C <sub>11</sub> H <sub>24</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>9</sub> CH <sub>3</sub>
ethane	C <sub>2</sub> H <sub>6</sub>	CH <sub>3</sub> CH <sub>3</sub>	dodecane	C <sub>12</sub> H <sub>26</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>10</sub> CH <sub>3</sub>
propane	C <sub>3</sub> H <sub>8</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>	tridecane	C <sub>13</sub> H <sub>28</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>11</sub> CH <sub>3</sub>
butane	C <sub>4</sub> H <sub>10</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>3</sub>	tetradecane	C <sub>14</sub> H <sub>30</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>12</sub> CH <sub>3</sub>
pentane	C <sub>5</sub> H <sub>12</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	pentadecane	C <sub>15</sub> H <sub>32</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>13</sub> CH <sub>3</sub>
hexane	C <sub>6</sub> H <sub>14</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>3</sub>	hexadecane	C <sub>16</sub> H <sub>34</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> CH <sub>3</sub>
eptane	C <sub>7</sub> H <sub>16</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>5</sub> CH <sub>3</sub>	eptadecane	C <sub>17</sub> H <sub>36</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>15</sub> CH <sub>3</sub>
octane	C <sub>8</sub> H <sub>18</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CH <sub>3</sub>	octadecane	C <sub>18</sub> H <sub>38</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>16</sub> CH <sub>3</sub>
nonano	C <sub>9</sub> H <sub>20</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH <sub>3</sub>	nonadecane	C <sub>19</sub> H <sub>40</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>17</sub> CH <sub>3</sub>
decane	C <sub>10</sub> H <sub>22</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>8</sub> CH <sub>3</sub>	eicosane	C <sub>20</sub> H <sub>42</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>18</sub> CH <sub>3</sub>

## Physical properties of alkanes

They are non-polar molecules, less dense than the water in which they are insoluble.

Intermolecular attractions are due to weak van der Waals forces, the stronger the larger the molecule.

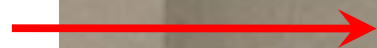
Name	abbreviated structural formula	melting point (°C)	boiling point (°C)	density (g/mL at 0 °C)
methane	CH <sub>4</sub>	-182	-164	(gas)
ethane	CH <sub>3</sub> CH <sub>3</sub>	-183	-88	(gas)
propane	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>	-190	-42	(gas)
butane	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>3</sub>	-138	0	(gas)
pentane	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	-130	36	0.626
hexane	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>3</sub>	-95	69	0.659
heptane	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>5</sub> CH <sub>3</sub>	-90	98	0.684
octane	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CH <sub>3</sub>	-57	126	0.703
nonane	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH <sub>3</sub>	-51	151	0.718
decane	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>8</sub> CH <sub>3</sub>	-30	174	0.730

hexane  
 $\text{CH}_3(\text{CH}_2)_4\text{CH}_3$



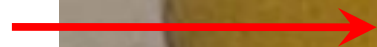
$$\delta^{25\text{ }^\circ\text{C}} = 0.655 \text{ g/mL}$$

$\text{H}_2\text{O}$

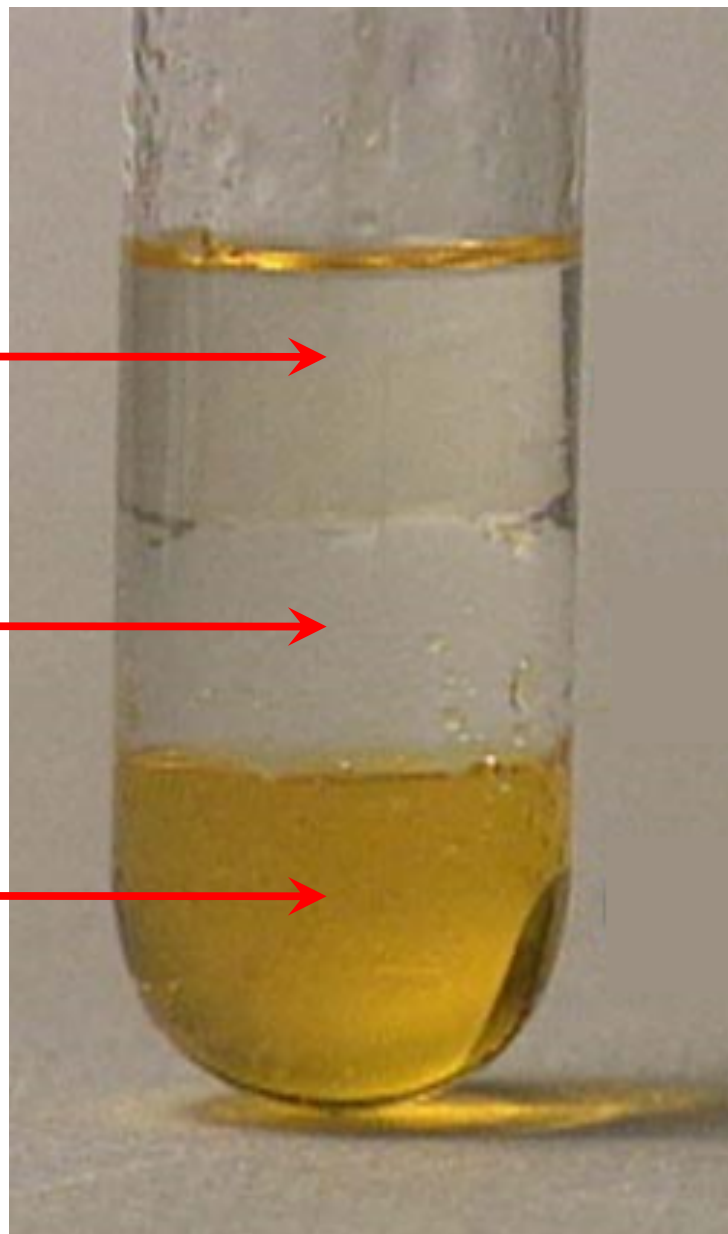


$$\delta^{25\text{ }^\circ\text{C}} = 0.997 \text{ g/mL}$$

carbon  
tetrachloride  
 $\text{CCl}_4$



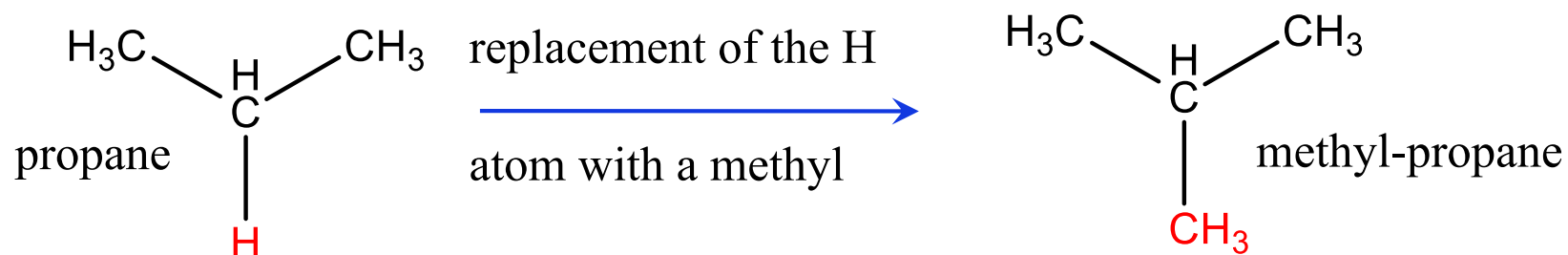
$$\delta^{25\text{ }^\circ\text{C}} = 1.584 \text{ g/mL}$$



## IUPAC nomenclature of alkanes

1. the longest possible linear chain is chosen as the basic structure.
2. the compound is considered as derived from this structure by substitution of hydrogen atoms with alkyl groups (see below).
3. the carbon atoms of the main chain are numbered starting with from the extremity that allows to use the lower numbers to indicate the substituents.
4. if the same group appears more than once as a side chain, the prefix di-, tri-, tetra-, etc. is added.
5. if there are different alkyl groups linked to the main chain, they are listed in alphabetical order.

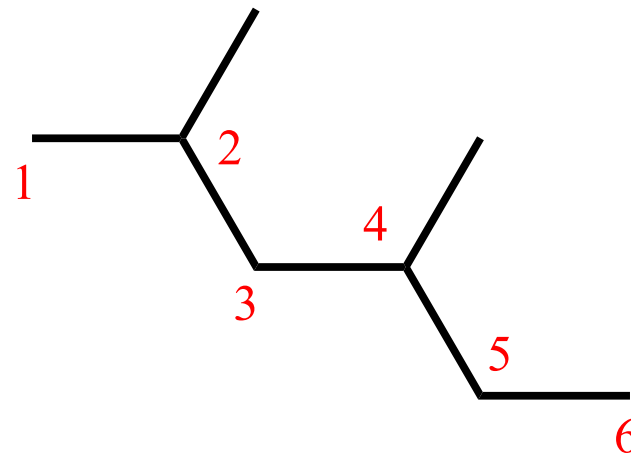
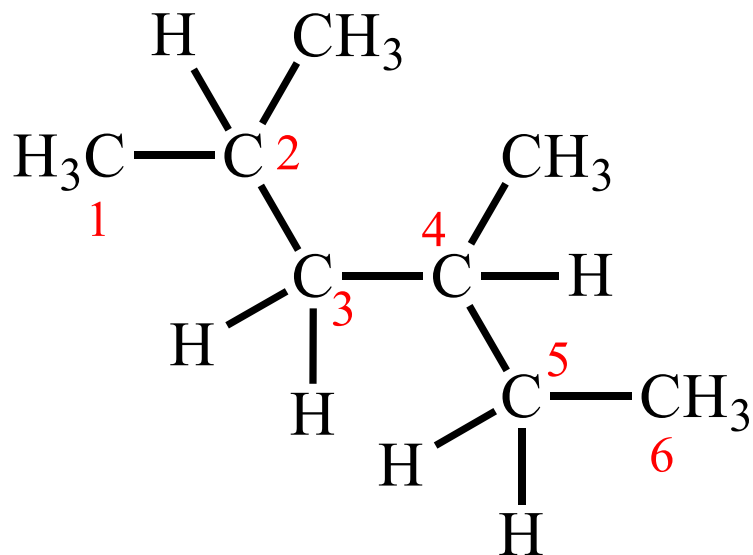
The branched alkanes can be considered as derived from a linear alkane by substitution of a hydrogen atom with an alkyl group



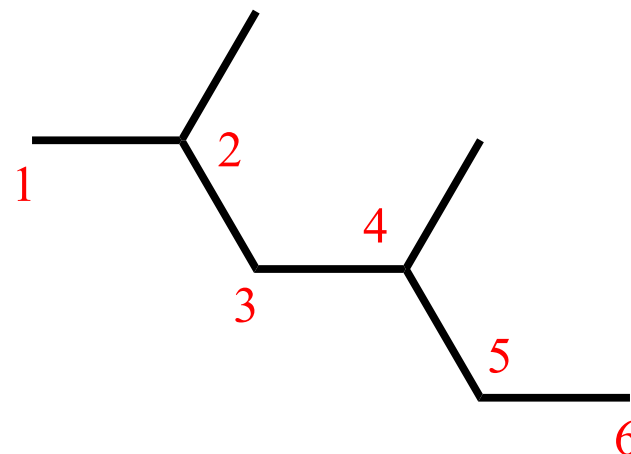
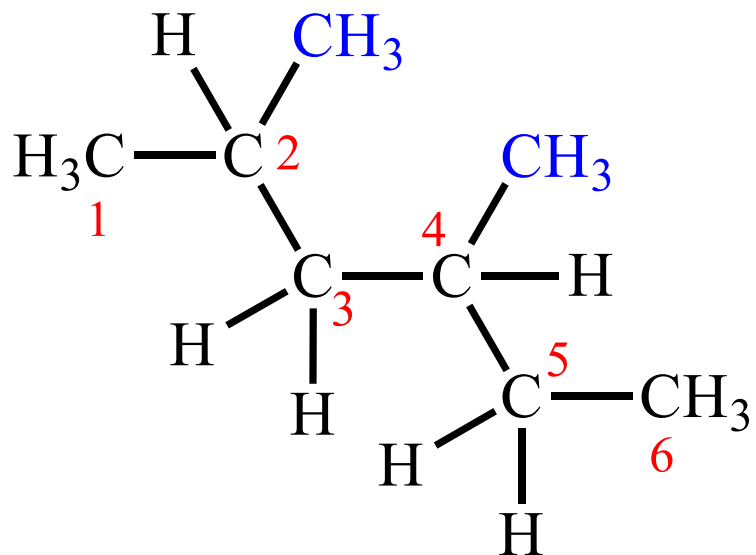
### Nomi dei più comuni gruppi alchilici

Nome	Formula di struttura abbreviata	Nome	Formula di struttura abbreviata
metile	—CH <sub>3</sub>	isobutile	—CH <sub>2</sub> CHCH <sub>3</sub>   CH <sub>3</sub>
etile	—CH <sub>2</sub> CH <sub>3</sub>	<i>sec</i> -butile	—CHCH <sub>2</sub> CH <sub>3</sub>   CH <sub>3</sub>
propile	—CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	<i>terz</i> -butile	—CCH <sub>3</sub>   CH <sub>3</sub>
isopropile	—CHCH <sub>3</sub>   CH <sub>3</sub>		
butile	—CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>		

Name the following compound  $C_8H_{18}$



It is a substituted hexane

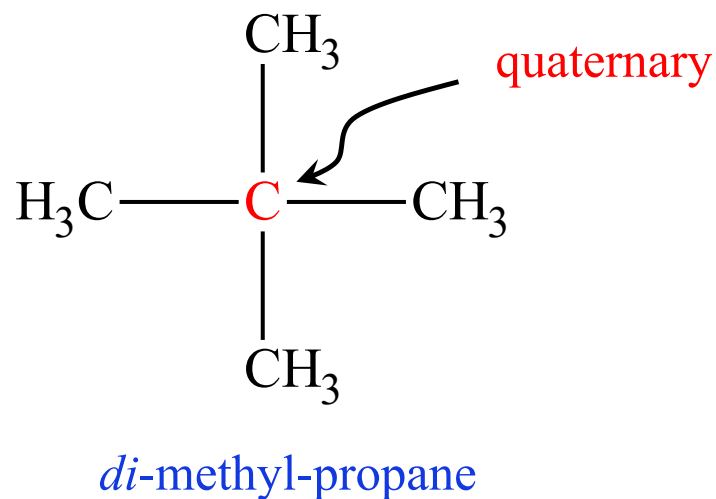
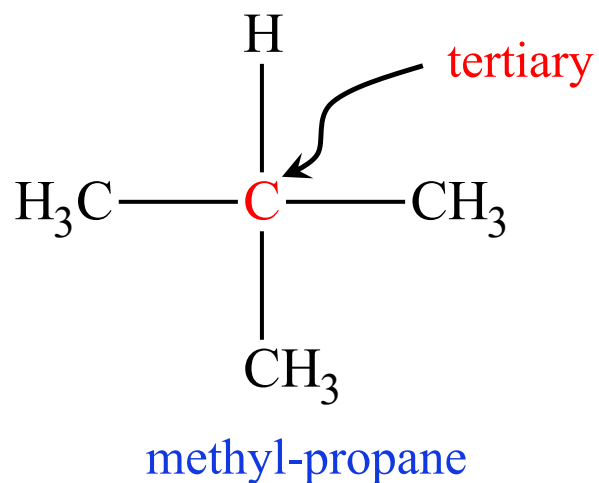
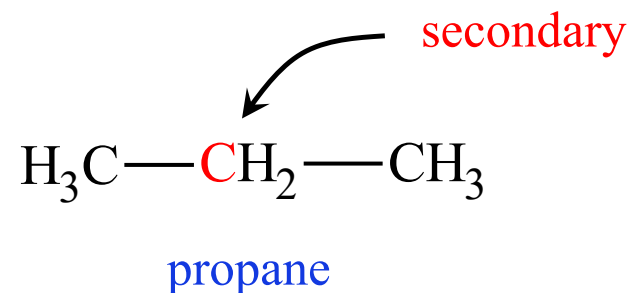
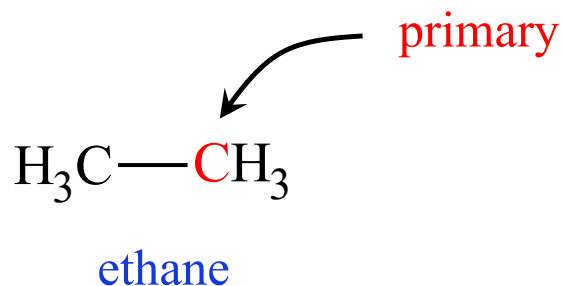


There are 2 methyl groups in positions 2 and 4

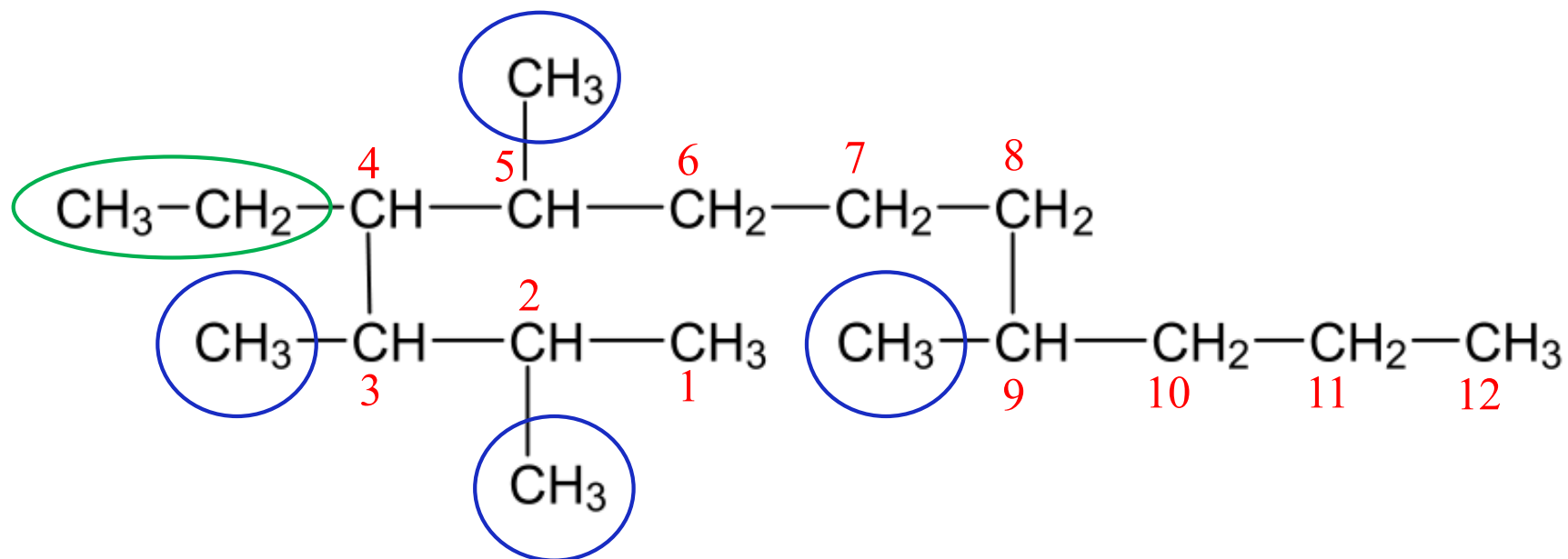
This is 2,4-dimethylhexane



Classification of carbon atoms A carbon atom can be: primary, secondary, tertiary or quaternary, depending on whether it binds 1, 2, 3 or 4 other carbon atoms.

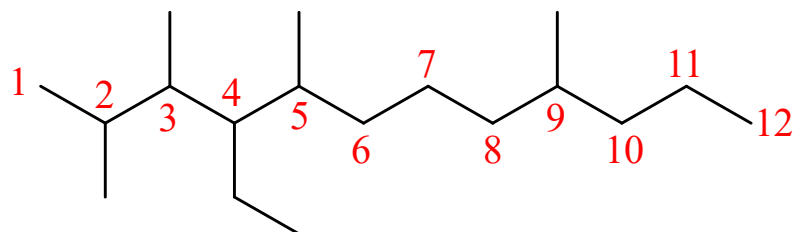


Example: What is the systematic name of the following hydrocarbon?



- the longest linear alkane contains 12 carbon atoms → **dodecane**
- there is an **ethyl group** in position 4
- there are 4 **methyl groups** in positions 2, 3, 5 and 9

The alkane is therefore 4-ethyl-2,3,5,9-tetramethyldodecane.

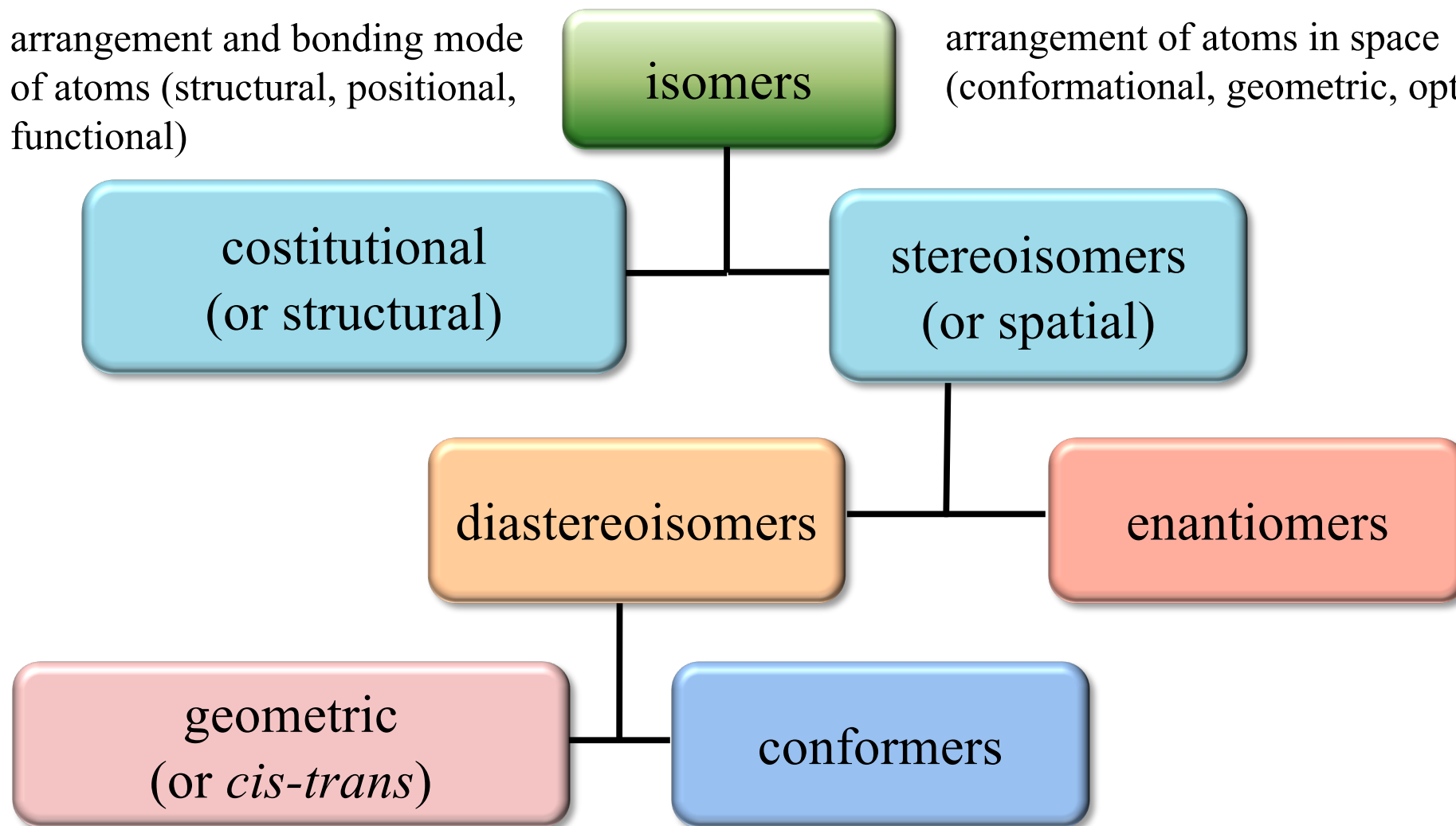


# Isomerism

Isomerism (from the Greek  $\text{ισος}$ , equal,  $\text{μερος}$ , part) occurs when substances that differ in physical properties and often also in chemical behavior have the **same brute formula**, i.e. the same molecular mass and the same percentage composition. So isomers differ in how the atoms are connected.

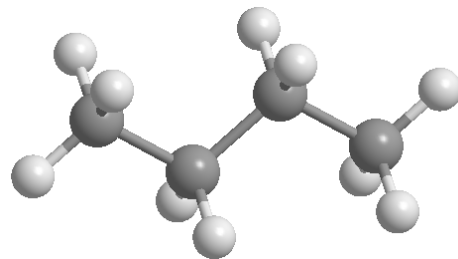
arrangement and bonding mode of atoms (structural, positional, functional)

arrangement of atoms in space (conformational, geometric, optical)

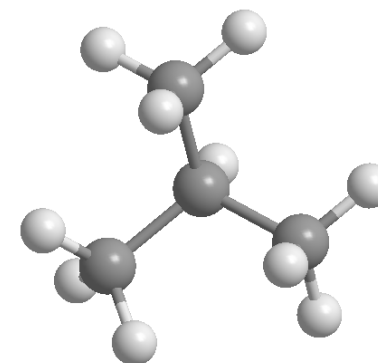


**Constitutional isomers:** arrangement and bonding modalities of atoms (of structure, position, function)

**Structural:** different carbonaceous skeleton

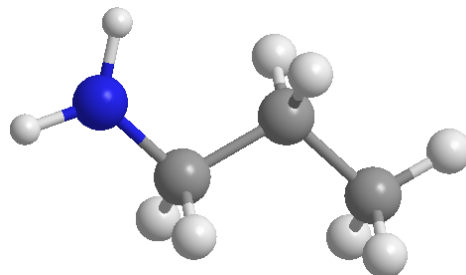


butane

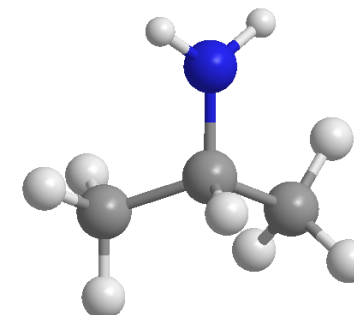
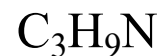


methylpropane

**Positional:** different position of functional groups

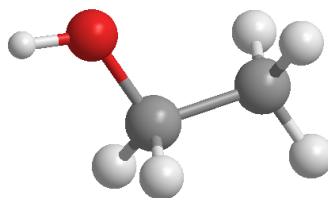


1-ammino-propane

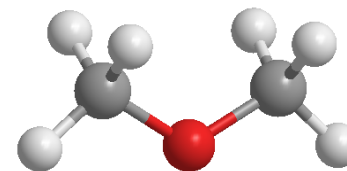
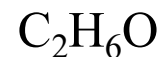


2-ammino-propane

**Functional:** different functional groups



ethanol

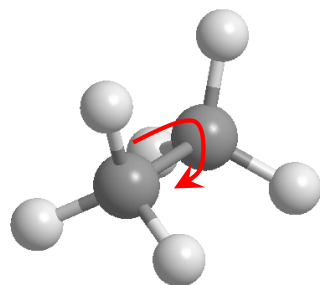


dimethylether

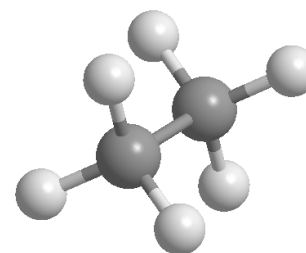
# Stereoisomers: arrangement of atoms in space (conformational, geometric, optical)

## Conformational:

rotation around a  $\sigma$  bond



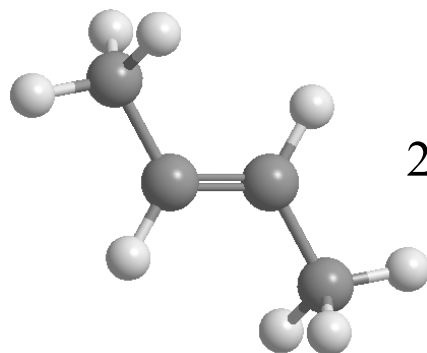
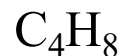
ethane



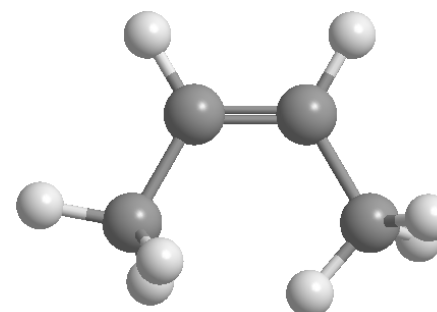
eclipsed

staggered

Geometric: impediment to rotation due to the presence of a double bond or ring



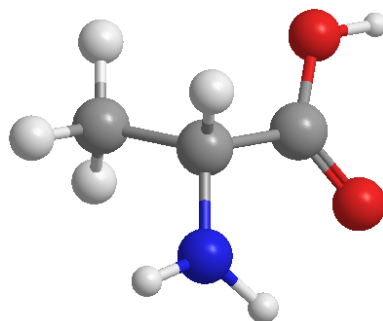
2-butene



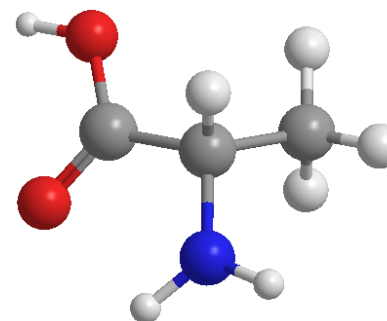
trans

cis

Optical: presence of chiral centers



alanina



R or D

S or L

## Constitutional isomers have different physical properties

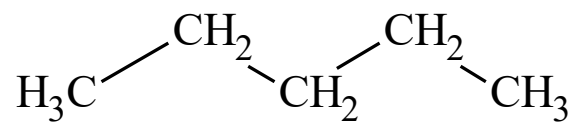
Molecular formula	Structural formula	T <sub>fus</sub> (°C)	T <sub>eb</sub> 1 atm (°C)	δ <sup>20°</sup> (g/mL)
C <sub>6</sub> H <sub>14</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	-95	68.7	0.6594
C <sub>6</sub> H <sub>14</sub>	$\begin{array}{c} \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	-153.7	60.3	0.6532
C <sub>6</sub> H <sub>14</sub>	$\begin{array}{c} \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	-118	63.3	0.6643
C <sub>6</sub> H <sub>14</sub>	$\begin{array}{c} \text{CH}_3\text{CH}-\text{CHCH}_3 \\   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \end{array}$	-128.8	58	0.6616
C <sub>6</sub> H <sub>14</sub>	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3-\text{C}-\text{CH}_2\text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	-98	49.7	0.6492

in order: n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane

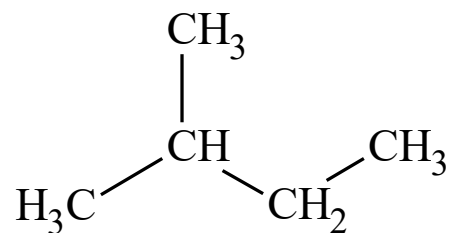
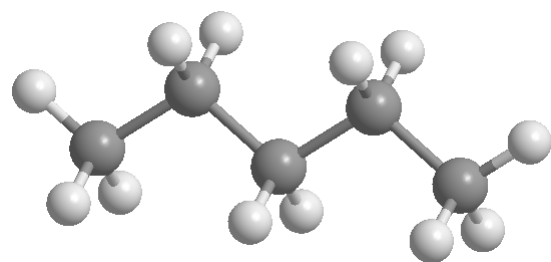
There are no constitutional isomers for methane, ethane and propane. These increase rapidly as the number of carbon atoms increases

Molecular formula	number of possible constitutional isomers
$C_4H_{10}$	2
$C_5H_{12}$	3
$C_6H_{14}$	5
$C_7H_{16}$	9
$C_8H_{18}$	18
$C_9H_{20}$	35
$C_{10}H_{22}$	75
$C_{15}H_{32}$	4347
$C_{20}H_{42}$ (eicosane)	366 319
$C_{30}H_{62}$ (triacontane)	4 111 846 763
$C_{40}H_{82}$ (tetracontane)	62 481 401 147 341

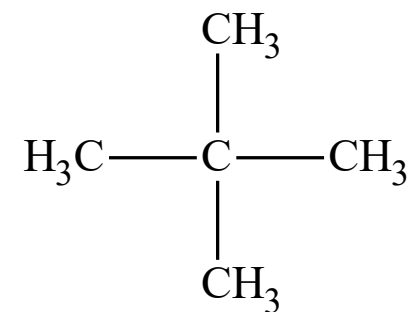
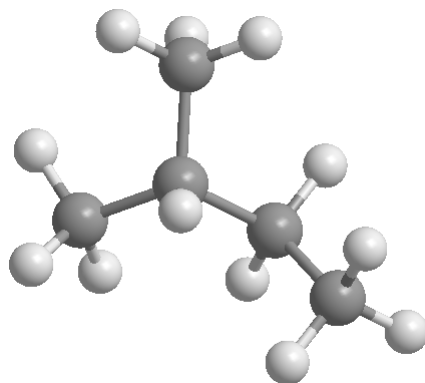
Example: How many isomers are possible for pentane (C<sub>5</sub>H<sub>12</sub>)?



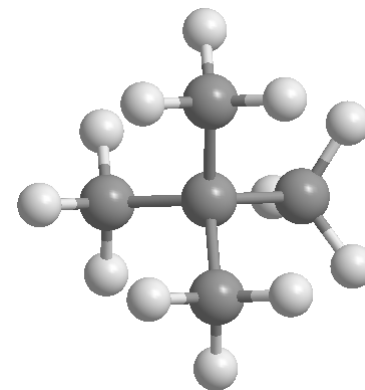
pentane



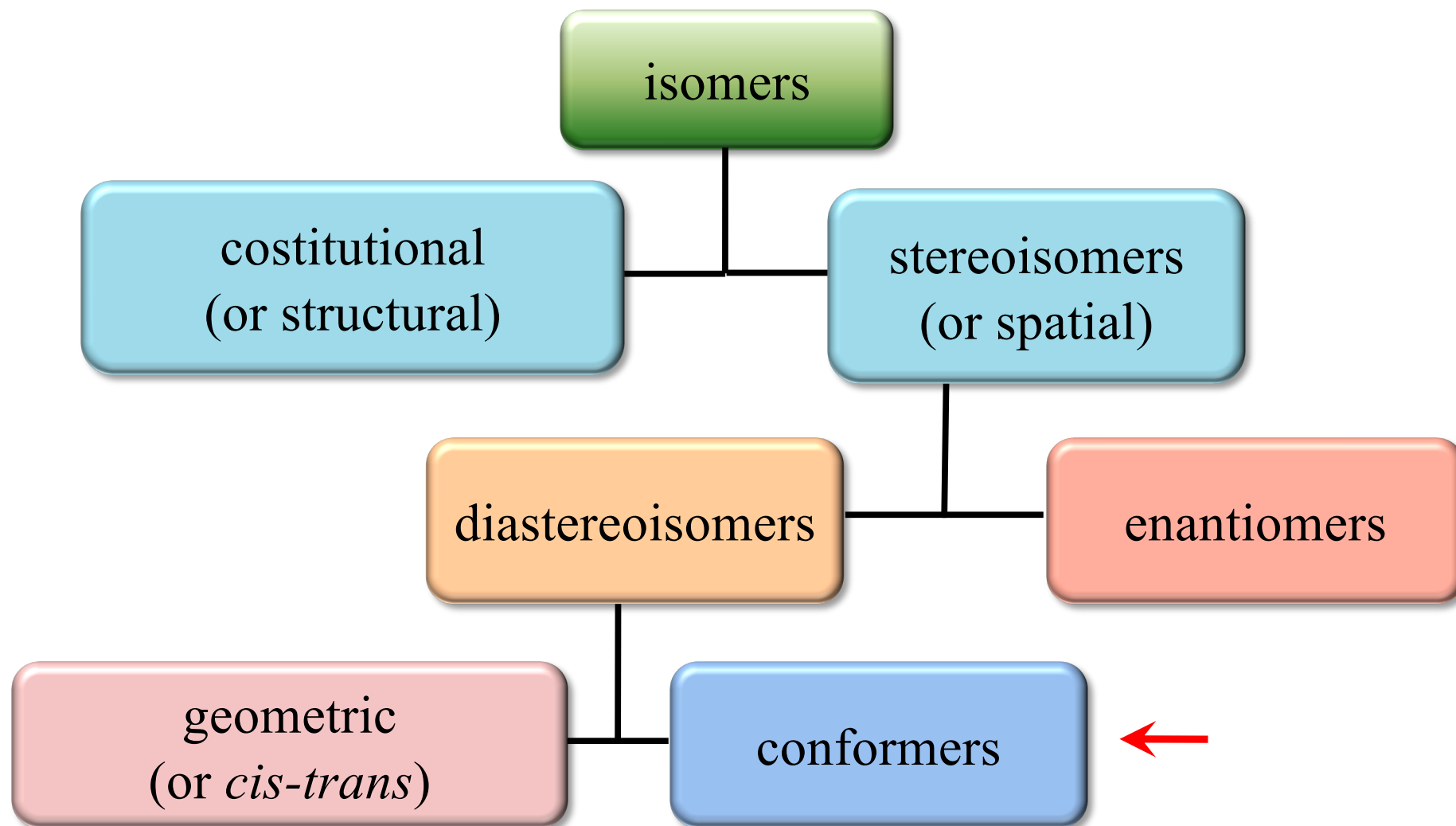
2-methyl-butane



dimethyl-propane







# The conformation of a molecule

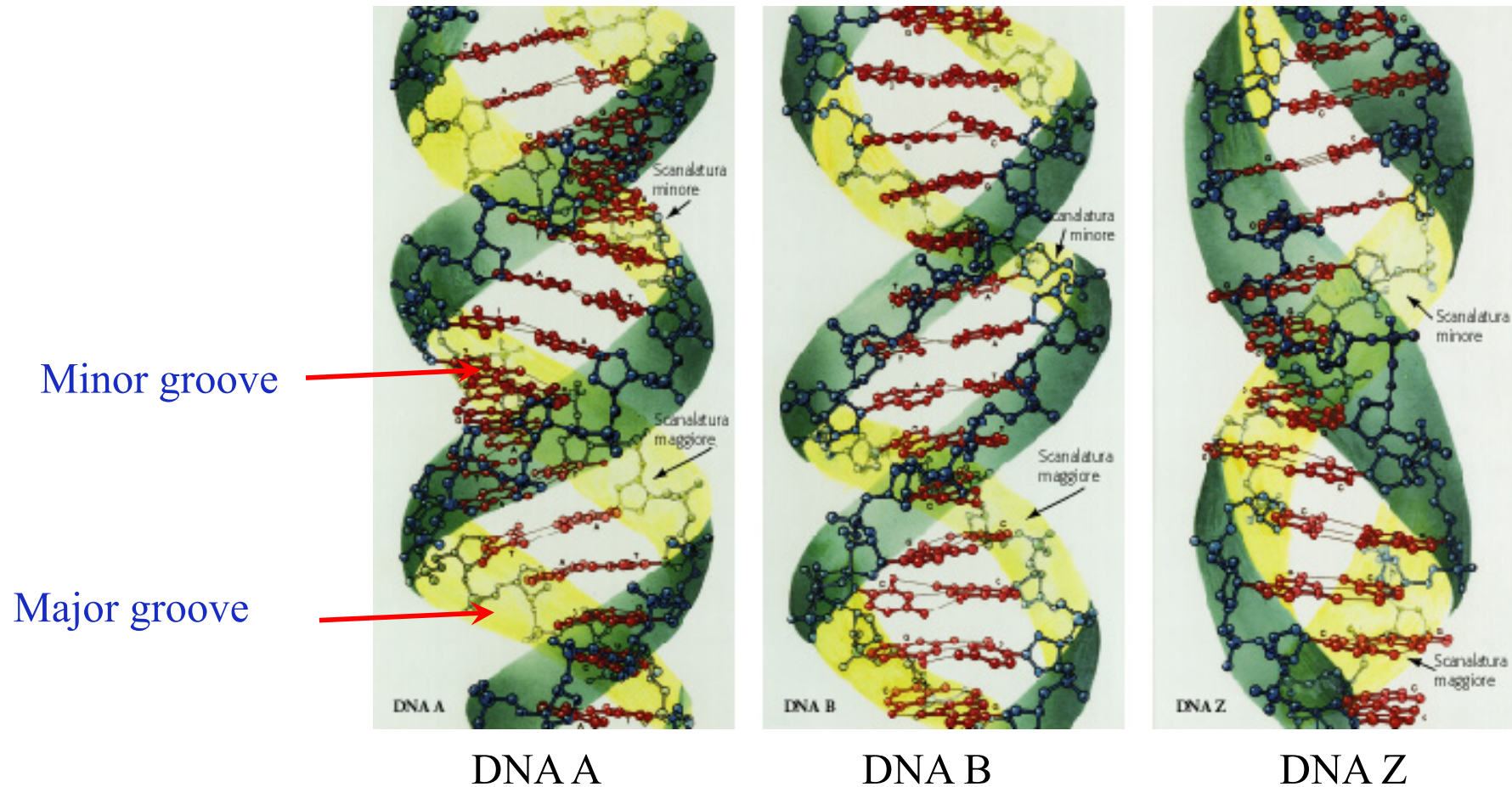
The conformation of a molecule is the **spatial arrangement that the atoms of a molecule assume upon rotation around simple bonds** ( $\sigma$ ). Each conformation that the molecule can assume is also called the conformational isomer, conformer (rotamer).

In the great majority of cases, at room temperature **the conformations rapidly interconvert into each other** and it is not possible to isolate a single conformer, however there may be cases in which the **steric hindrance** is such as to **block** the molecule in one of the possible conformations .

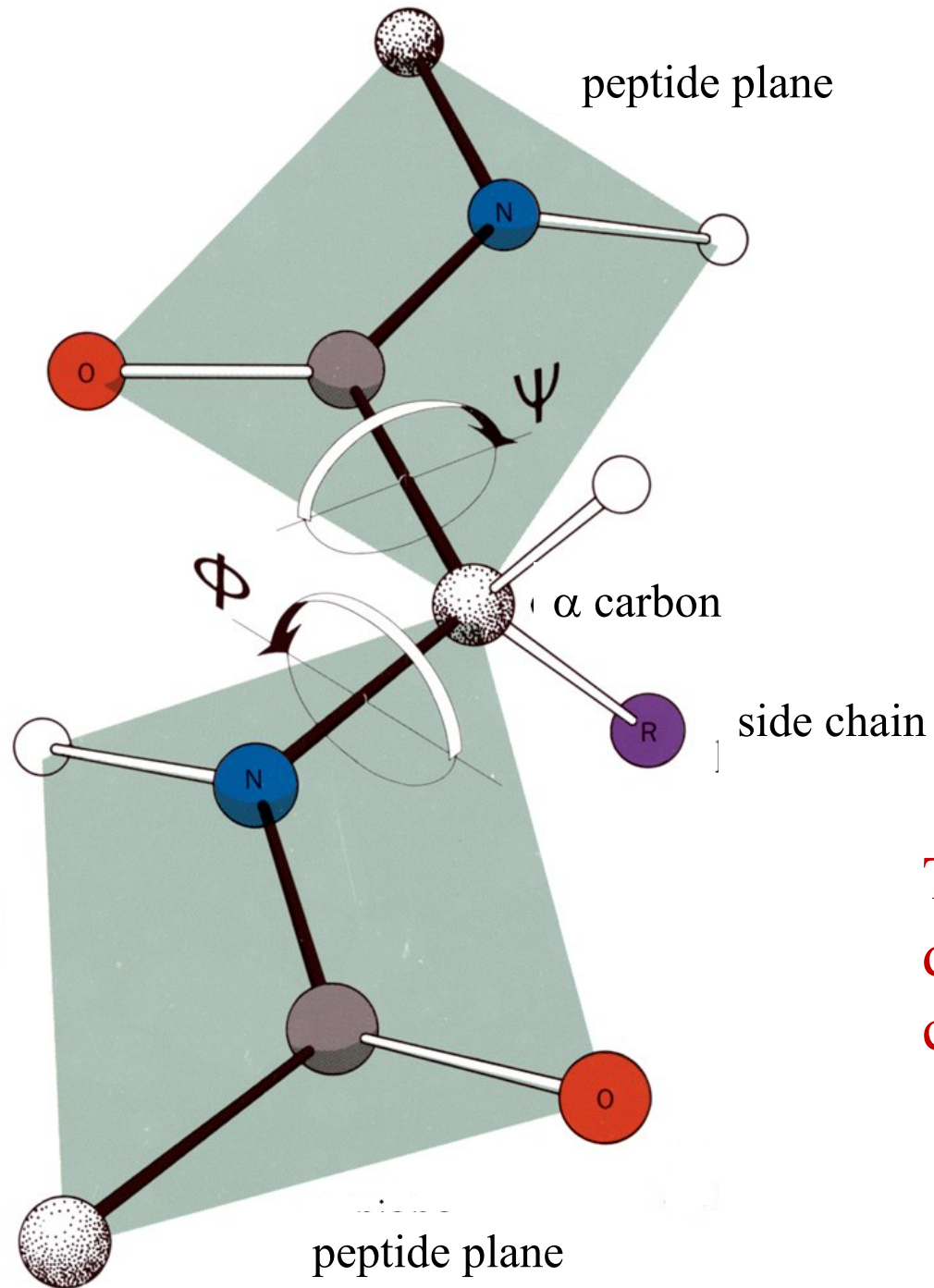
## **Conformational changes are of paramount importance in biology:**

- **protein folding** is a complex conformational process
- during the catalytic cycle many enzymes necessarily change their conformation
- **DNA** can take on different conformations
- **allosteric proteins** (hemoglobin)

The DNA double helix can take on different conformations, which can affect DNA-protein recognition. The relative dimensions of the major and minor sulcugrooves vary with the type of conformation



**A** = 11 base/turn (24.6Å) – diameter 26 Å – right-handed  
**B** = 10 base/turn (33.2Å) – diameter 20 Å – right-handed  
**Z** = 12 base/turn (45.6Å) – diameter 18 Å – left-handed



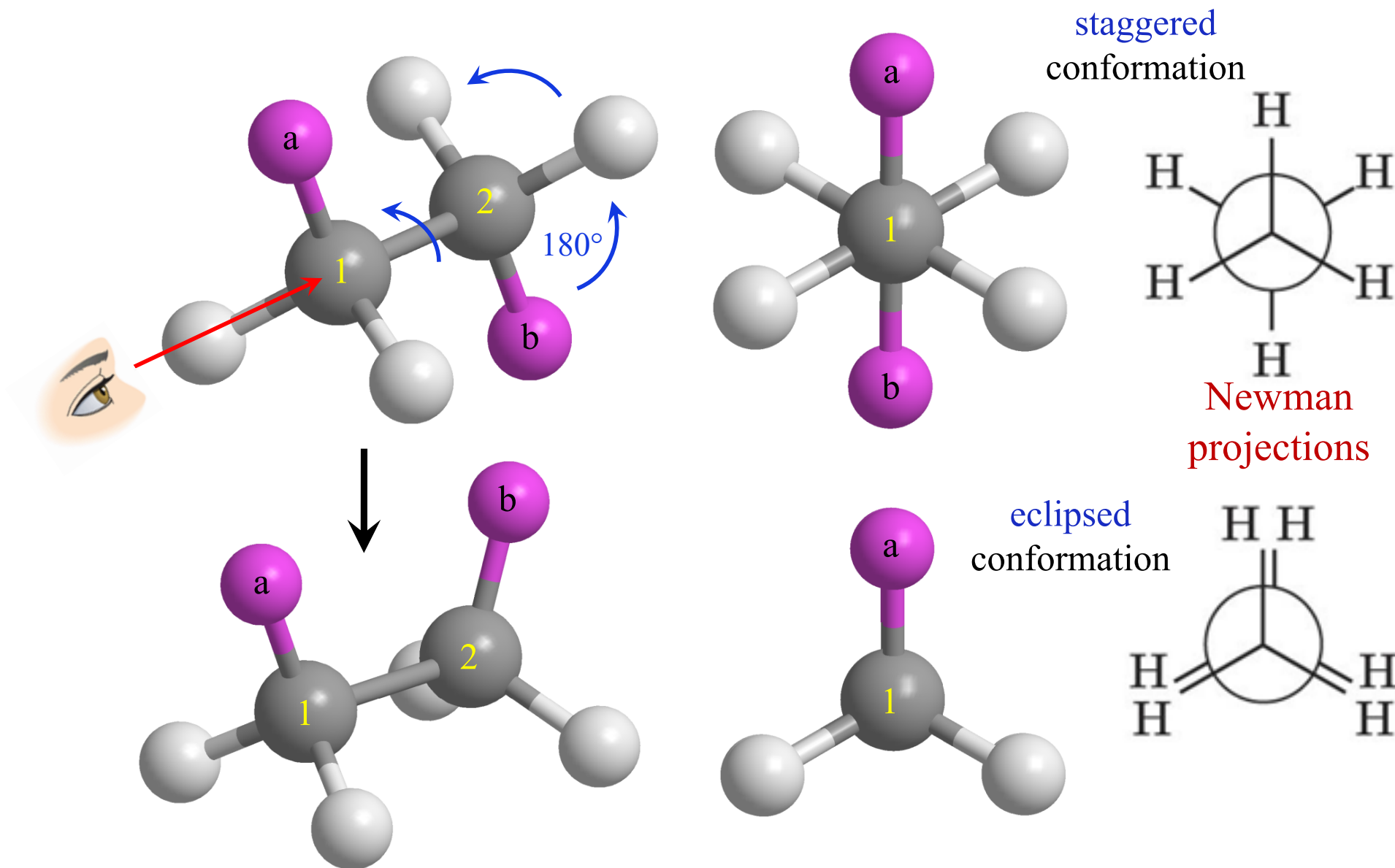
The peptide bond and the solid angles  $\phi$  and  $\psi$

$\phi$ : rotation around the amide  $C_{\alpha}$ -N bond

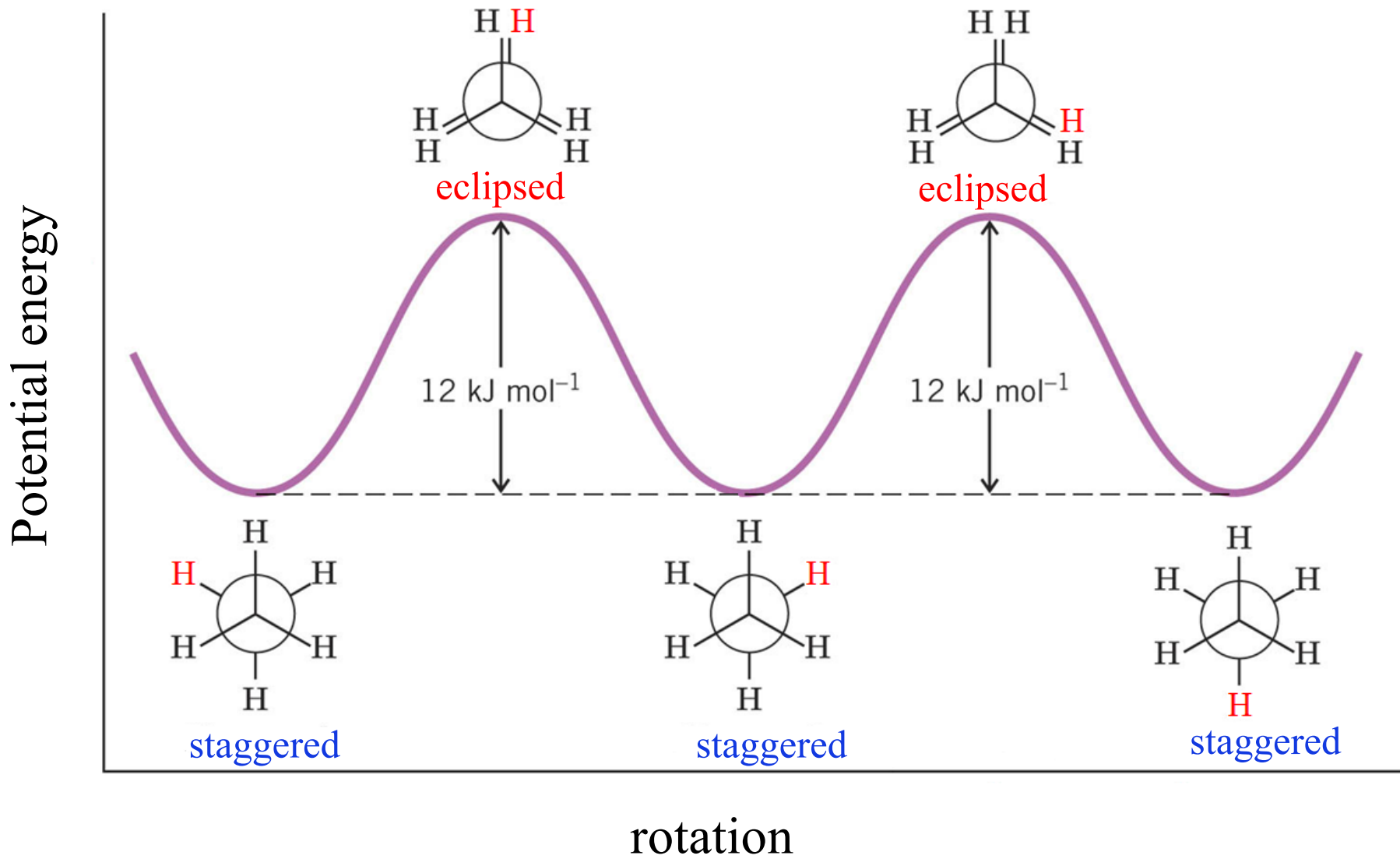
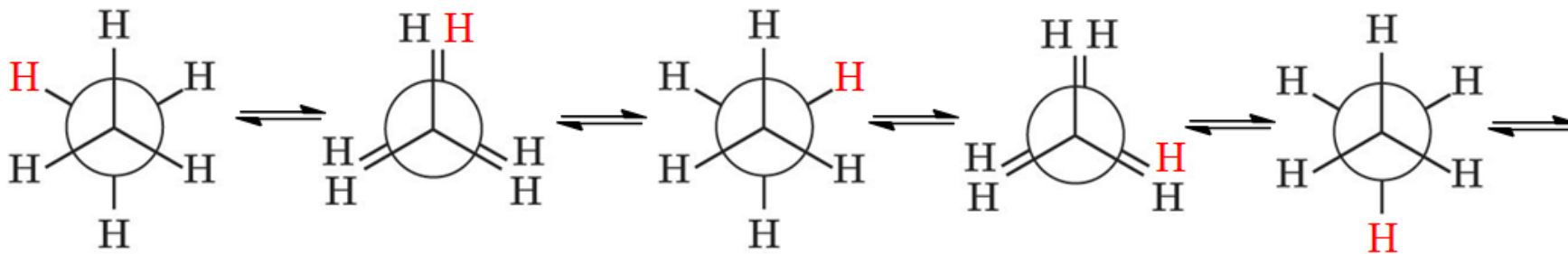
$\psi$ : rotation around the amide  $C_{\alpha}$ -C bond

The numerical values of the dihedral angles identify the conformation of the polypeptide

# The conformations of ethane ( $C_2H_6$ )

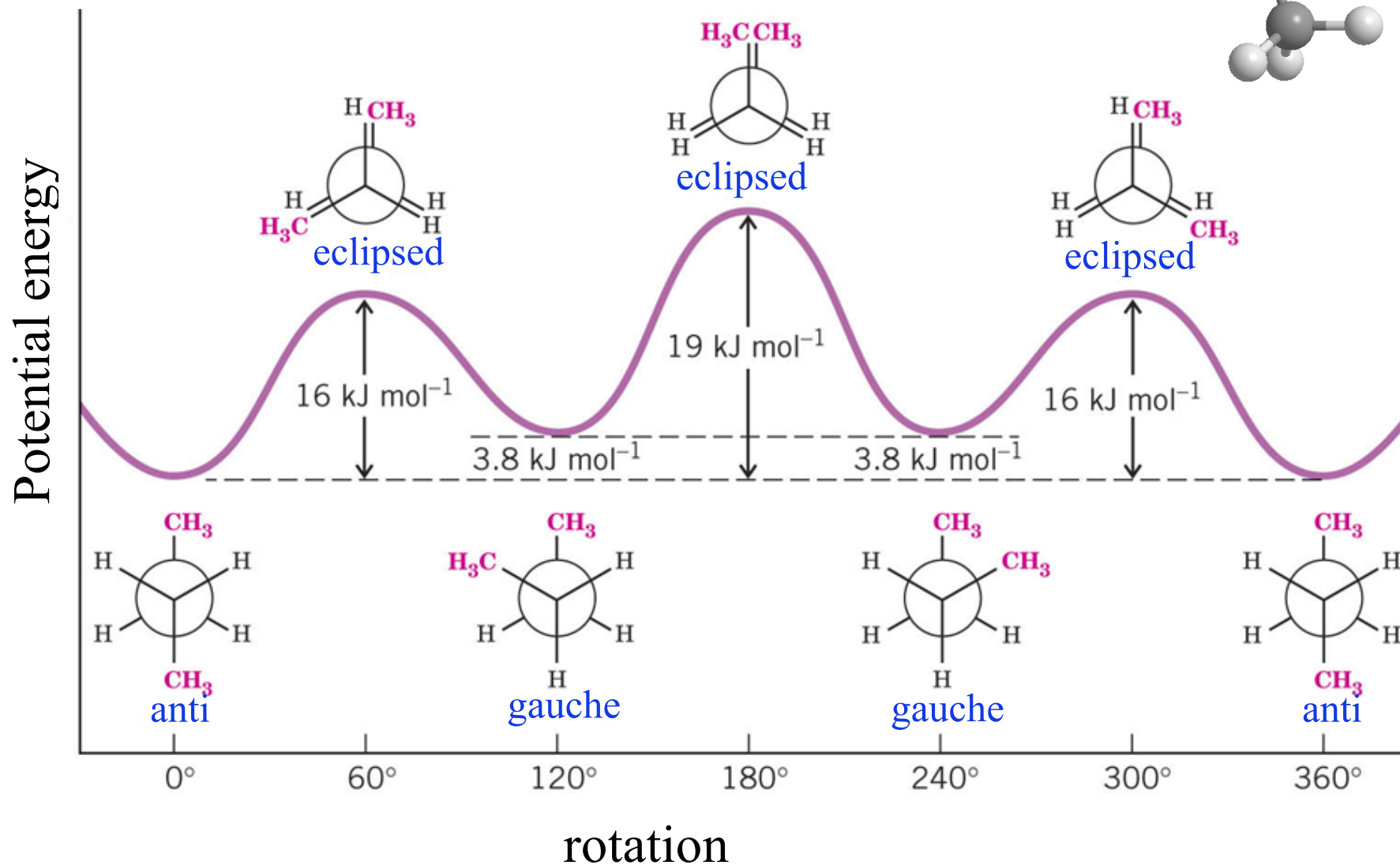
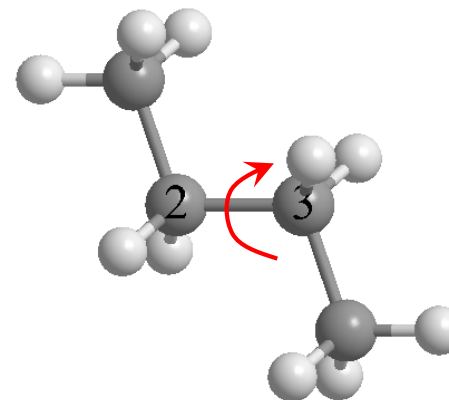


Due to the reciprocal electrostatic repulsion between the electrons, ethane tends to preferably assume a **staggered conformation**

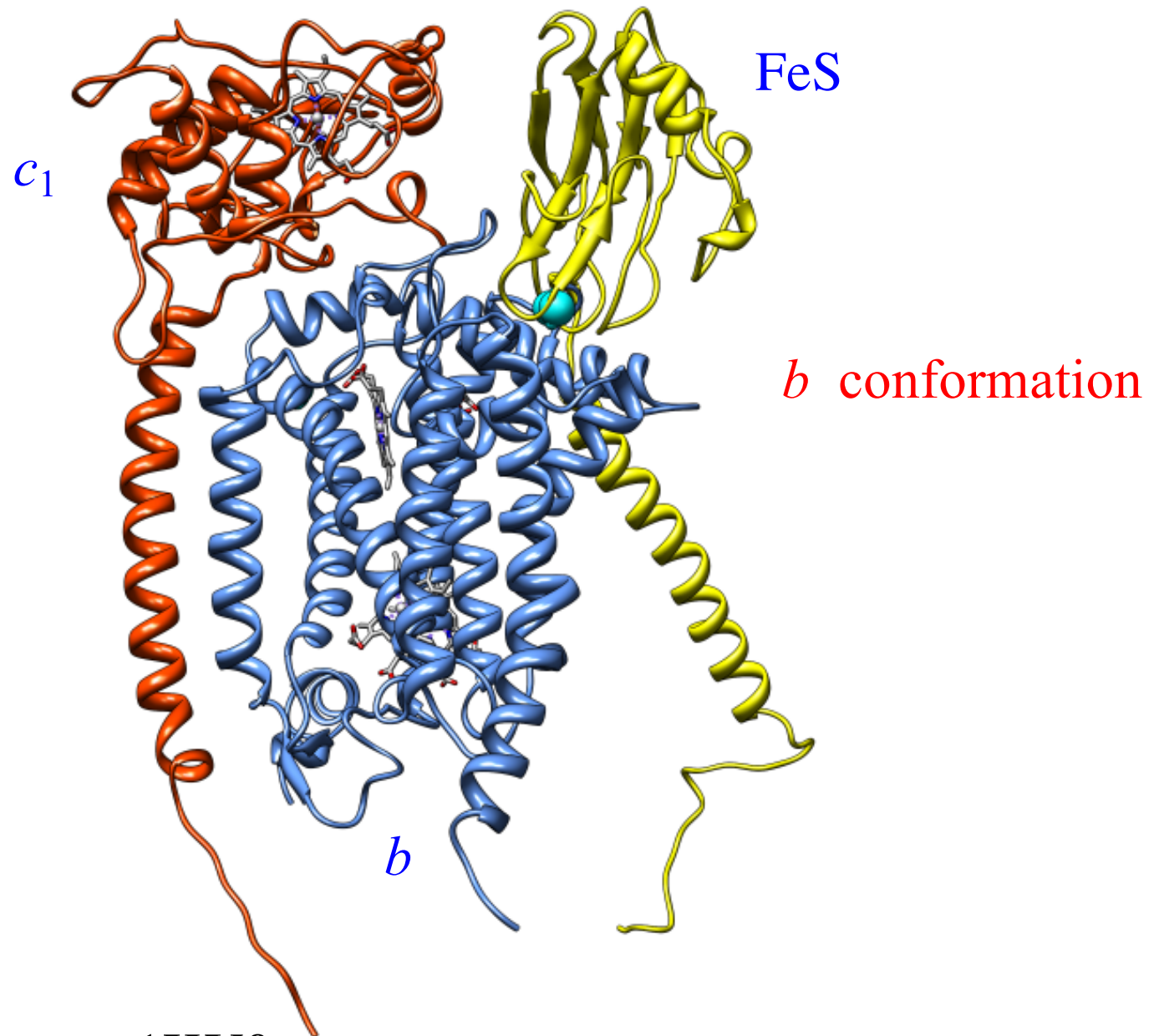


# The conformations of butane

The rotation around the C<sub>2</sub> - C<sub>3</sub> bond leads to the formation of at least 4 distinct conformers.



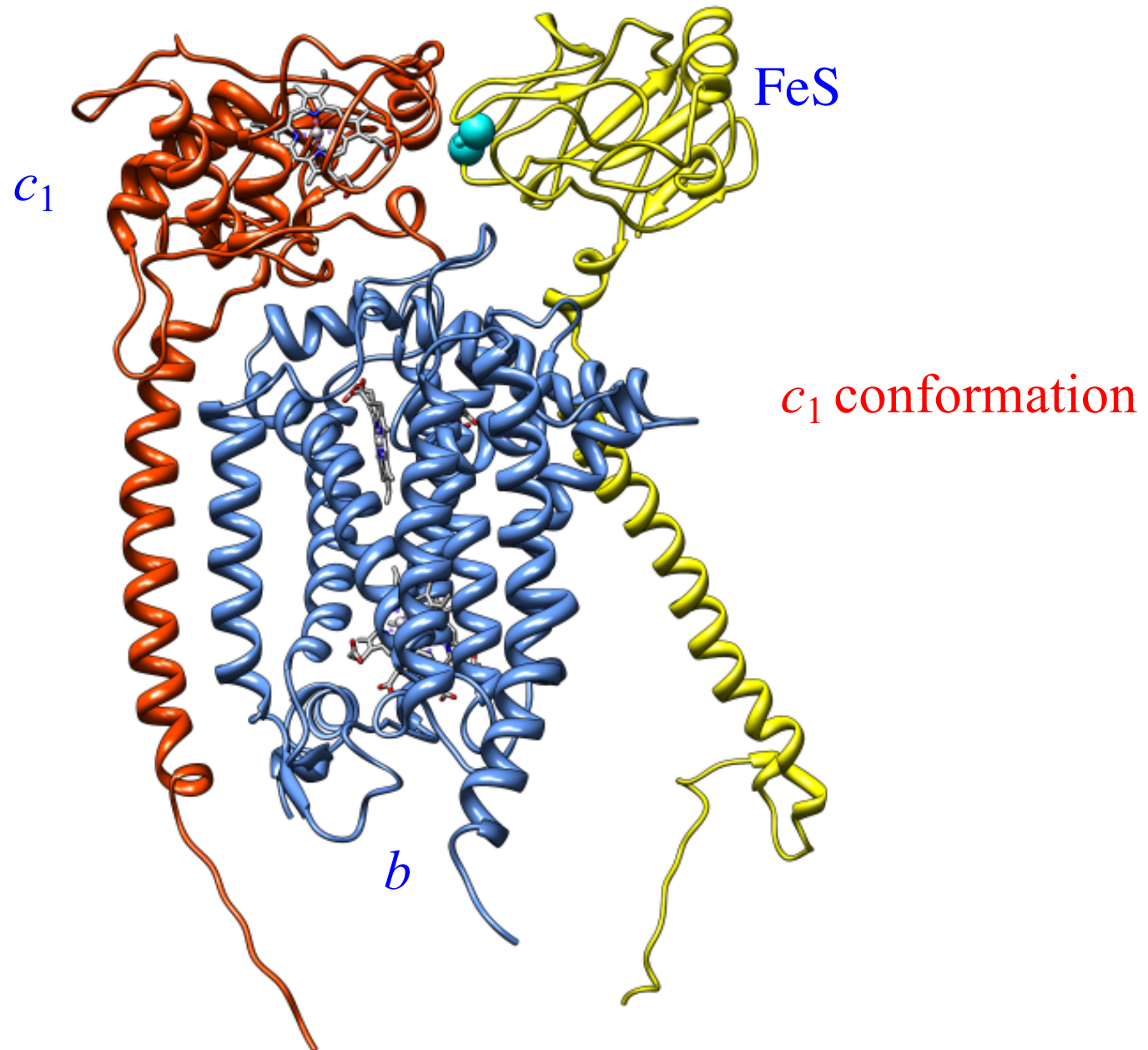
The Rieske protein in Complex III can adopt at least two stable conformations



from yeast structure 1KY0



The Rieske protein in Complex III can adopt at least two stable conformations

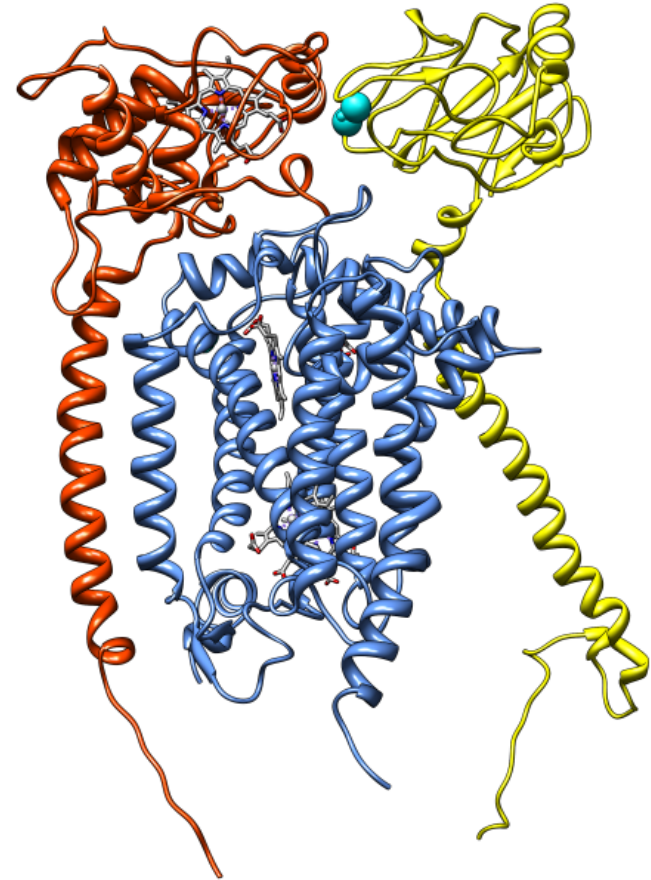


from beef structure 1BE3

*b* conformation



*c*<sub>1</sub> conformation



intramolecular ET  
between docked *c*<sub>1</sub>  
and FeS takes place