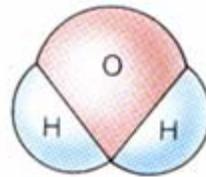
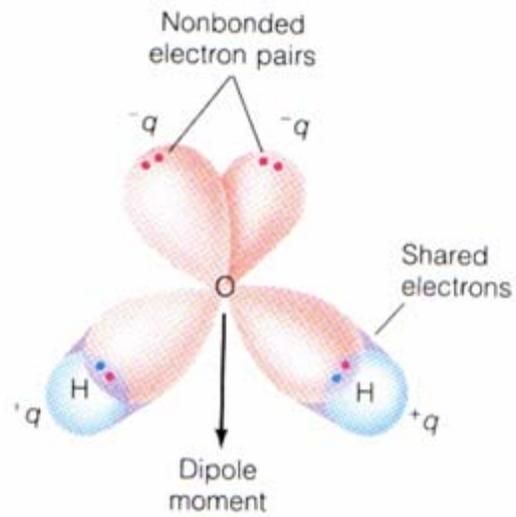
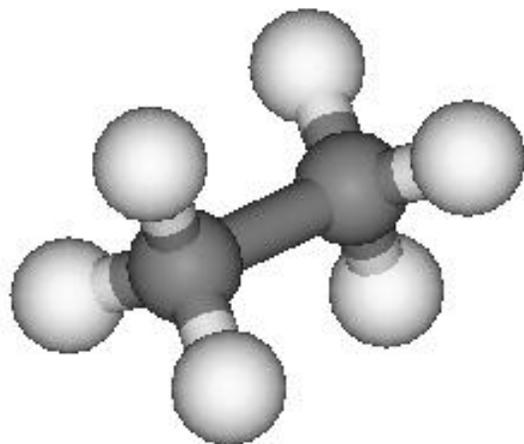


(a)



(b)

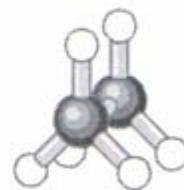
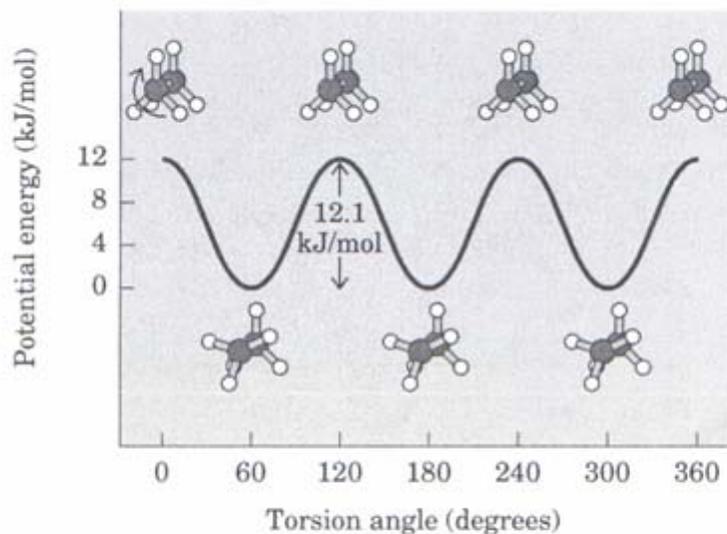




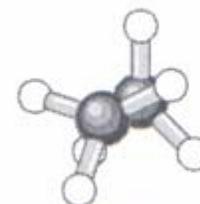
2 cuerpos = enlace

3 cuerpos = angulo

4 cuerpos = angulo torsional



Eclipsed



Staggered

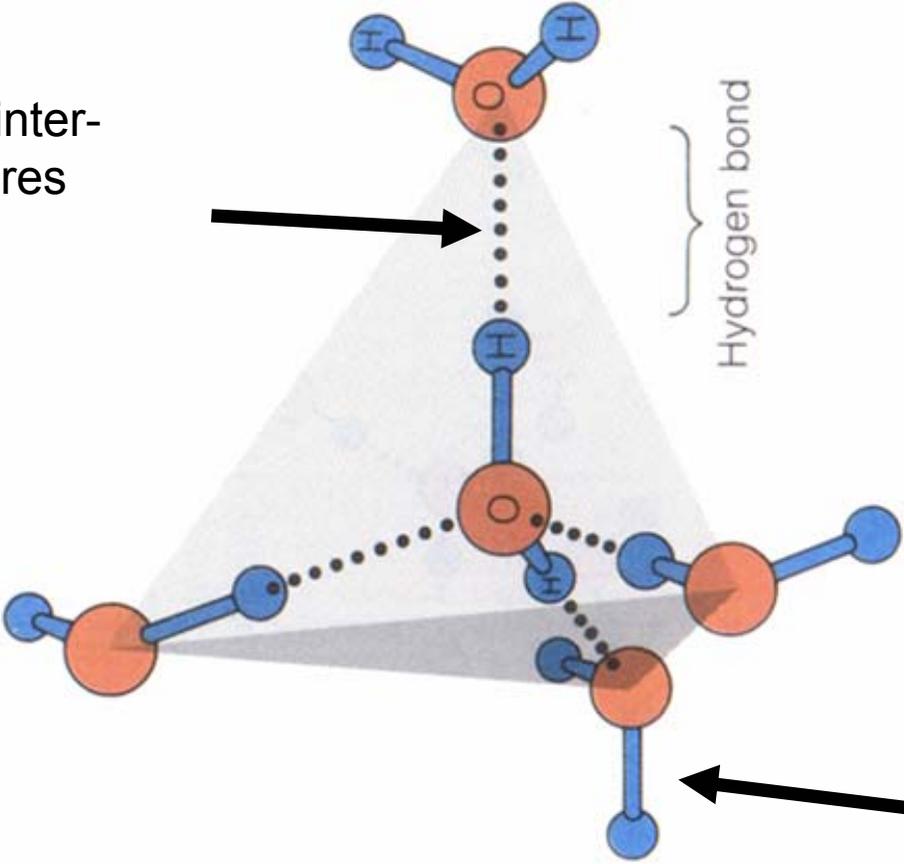
**figure 3-11**

Many conformations of ethane are possible because of freedom of rotation around the C—C bond. When the front carbon atom (as viewed by the reader) with its three attached hydrogens is rotated relative to the rear carbon atom, the potential energy of the molecule rises in the fully eclipsed conformation (torsion angle  $0^\circ$ ,  $120^\circ$ , etc.), then falls in the fully staggered conformation (torsion angle  $60^\circ$ ,  $180^\circ$ , etc.). Because the energy differences are small enough to allow rapid interconversion of the two forms (millions of times per second), the eclipsed and staggered forms cannot be separately isolated.

# **La estructura de una molécula depende de su energía ya que**

- la distribución electrónica define ángulos de enlaces
- existen distintas conformaciones que resultan de la rotación y vibración de átomos o grupos de átomos alrededor de esos enlaces

Enlaces inter-  
moleculares

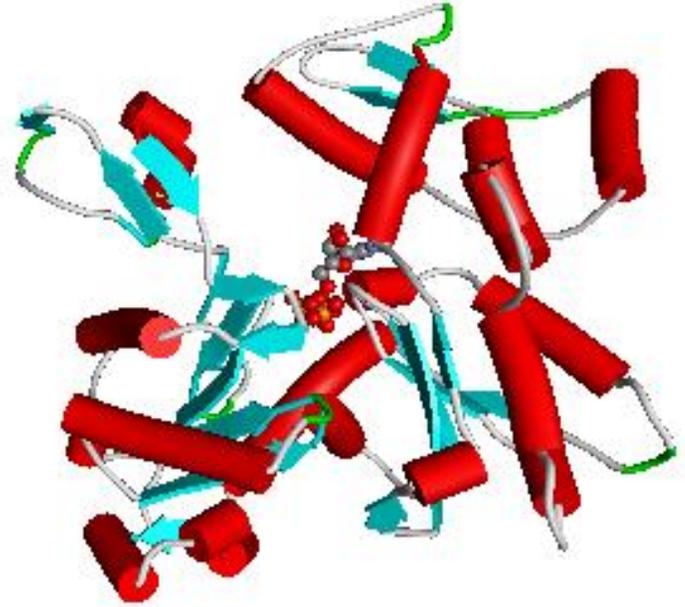
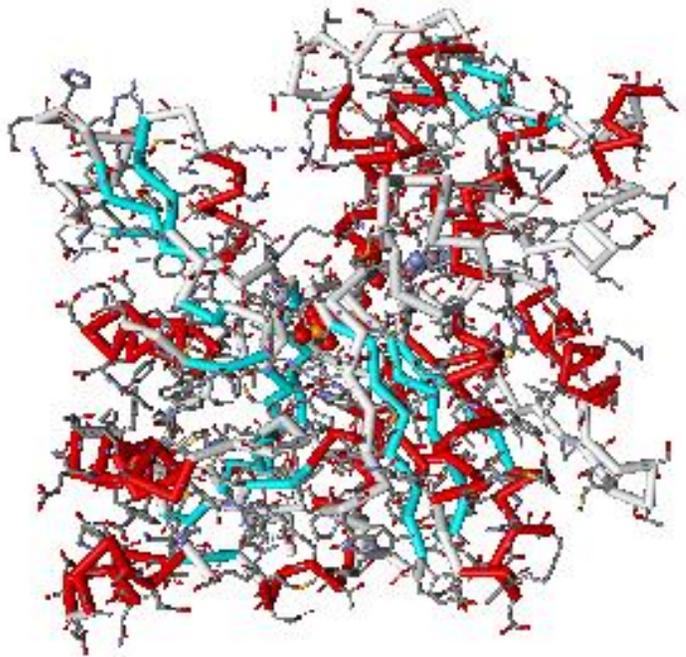


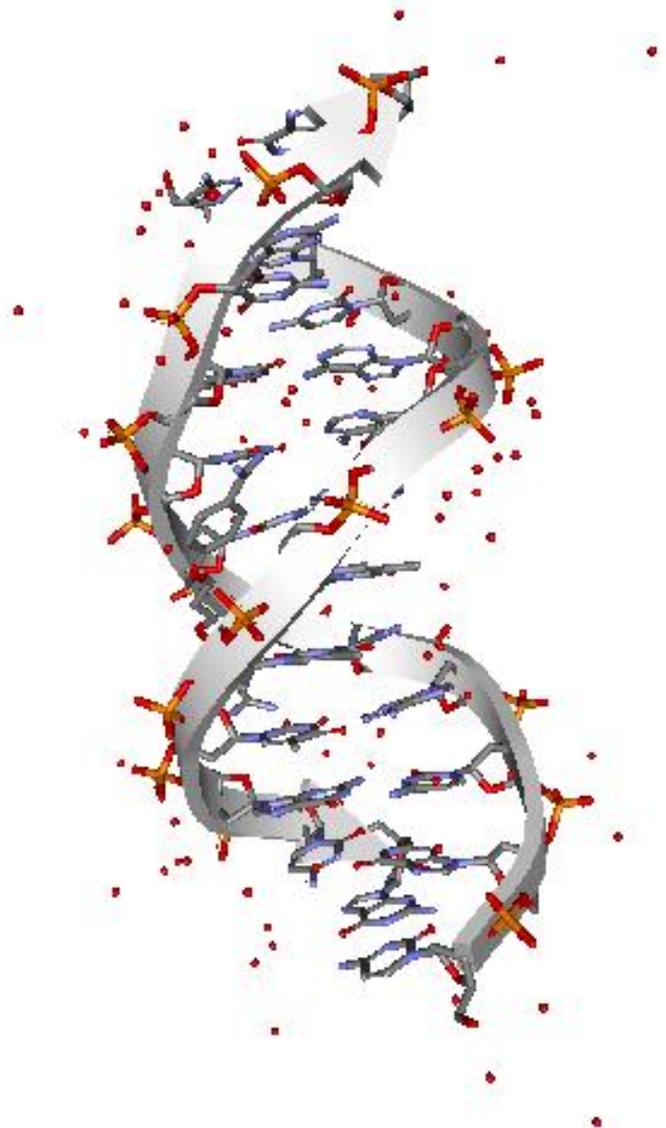
Hydrogen bond

Enlaces  
intramoleculares

**Los bioquímicos estamos interesados en estudiar moléculas que estén relacionadas con procesos biológicos ...**

- Proteínas, lípidos, hidratos de carbono y ácidos nucleicos





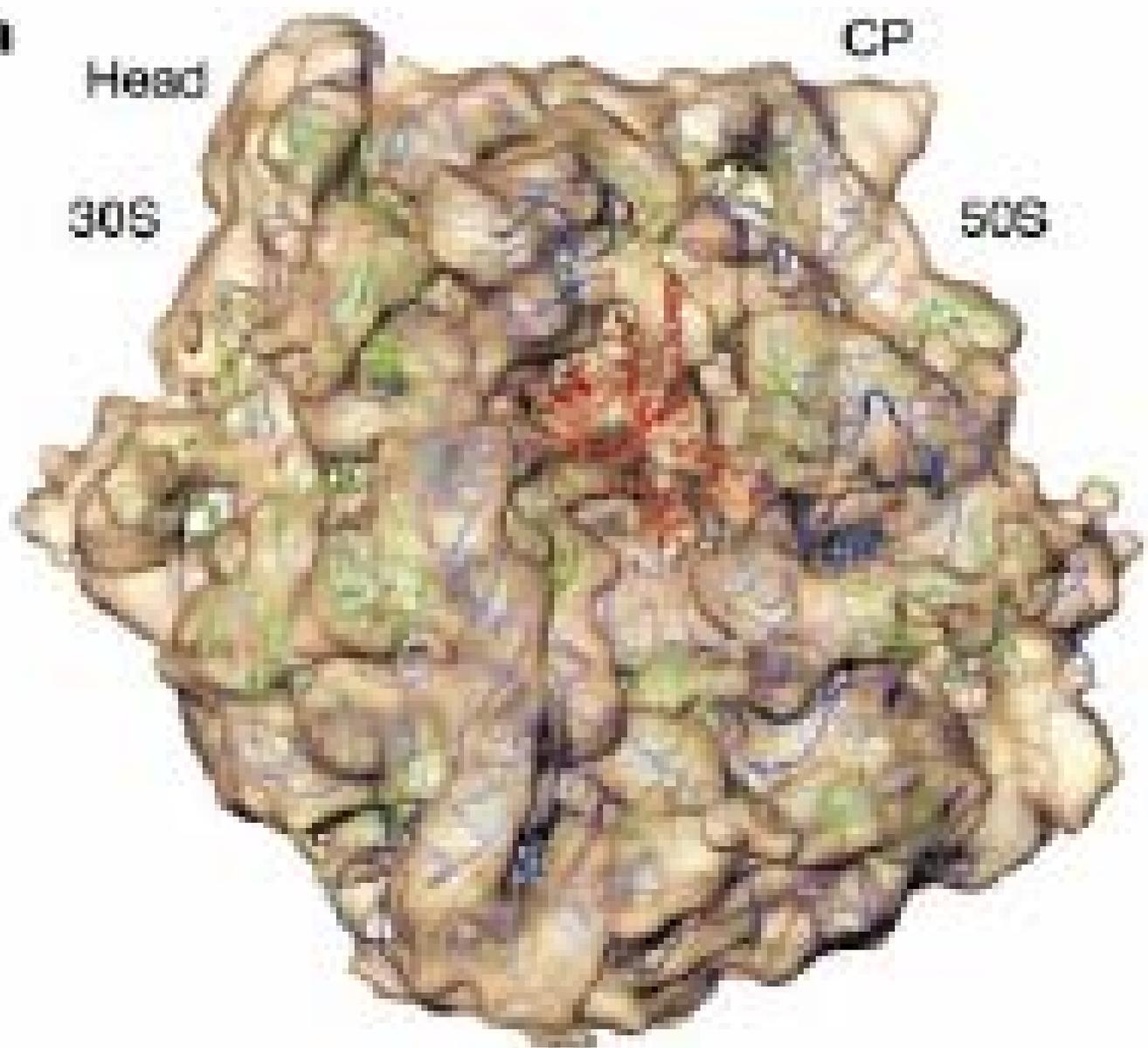
**a**

Head

CP

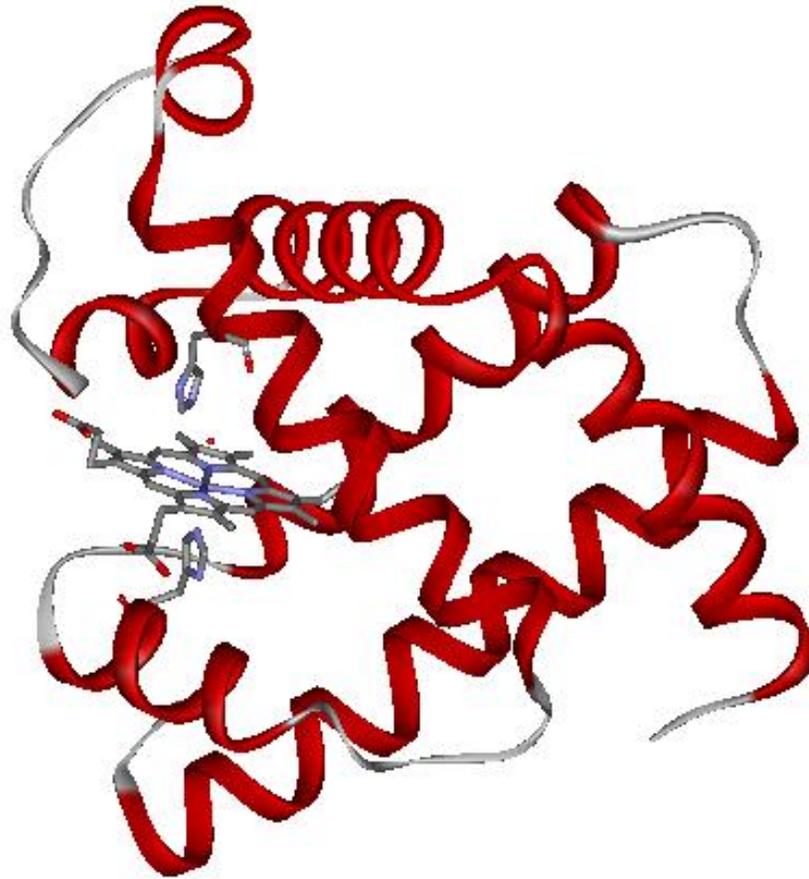
30S

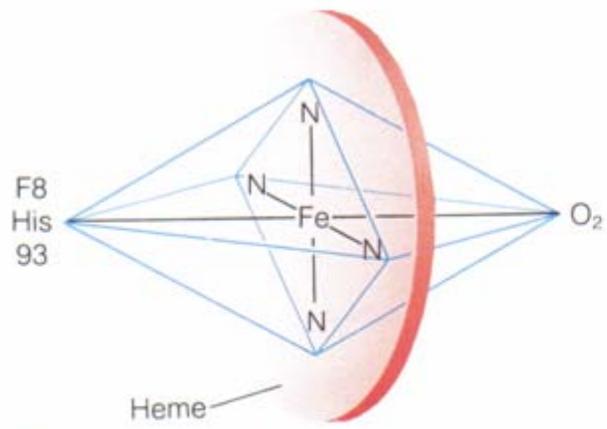
50S



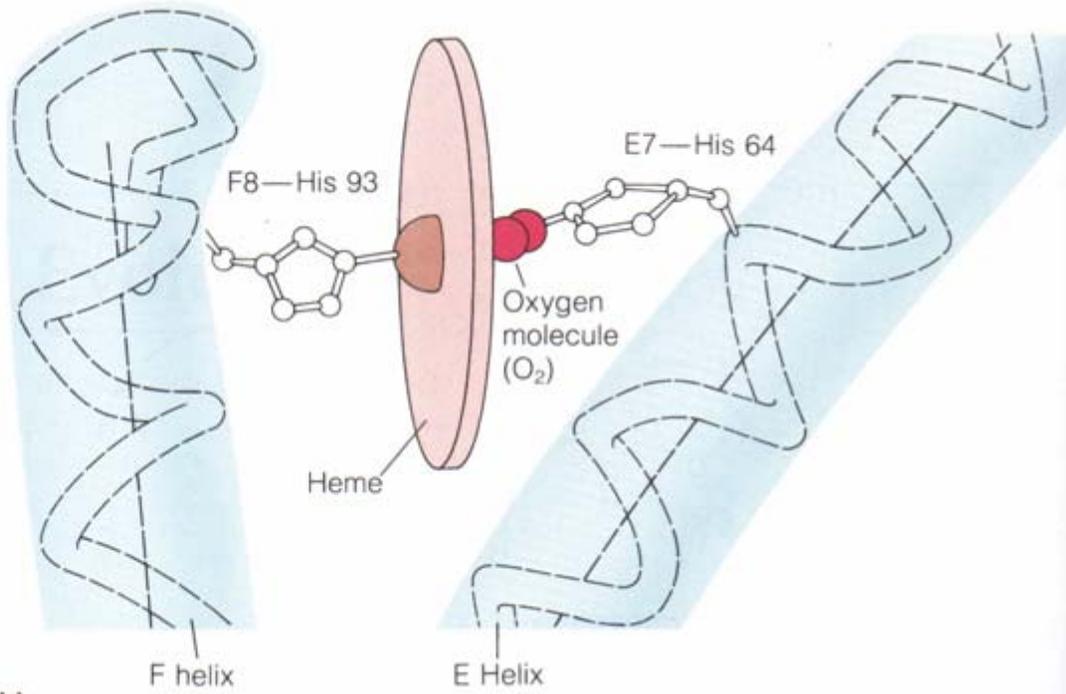
Toe

## Relación Estructura-Función?





(a)



(b)

## La energía de una molécula esta definida

$$\text{Energía} = V + K$$

$$V_{total} = \sum_{i=1}^N (V_{bonding} + V_{non-bonding})_i$$

**V bonding** : implica todas las interacciones que definen la estructura covalente de una molécula

**V non-bonding**: implica todas las interacciones entre átomos no covalentemente unidos. Abarca tanto a interacciones

*Intramoleculares*

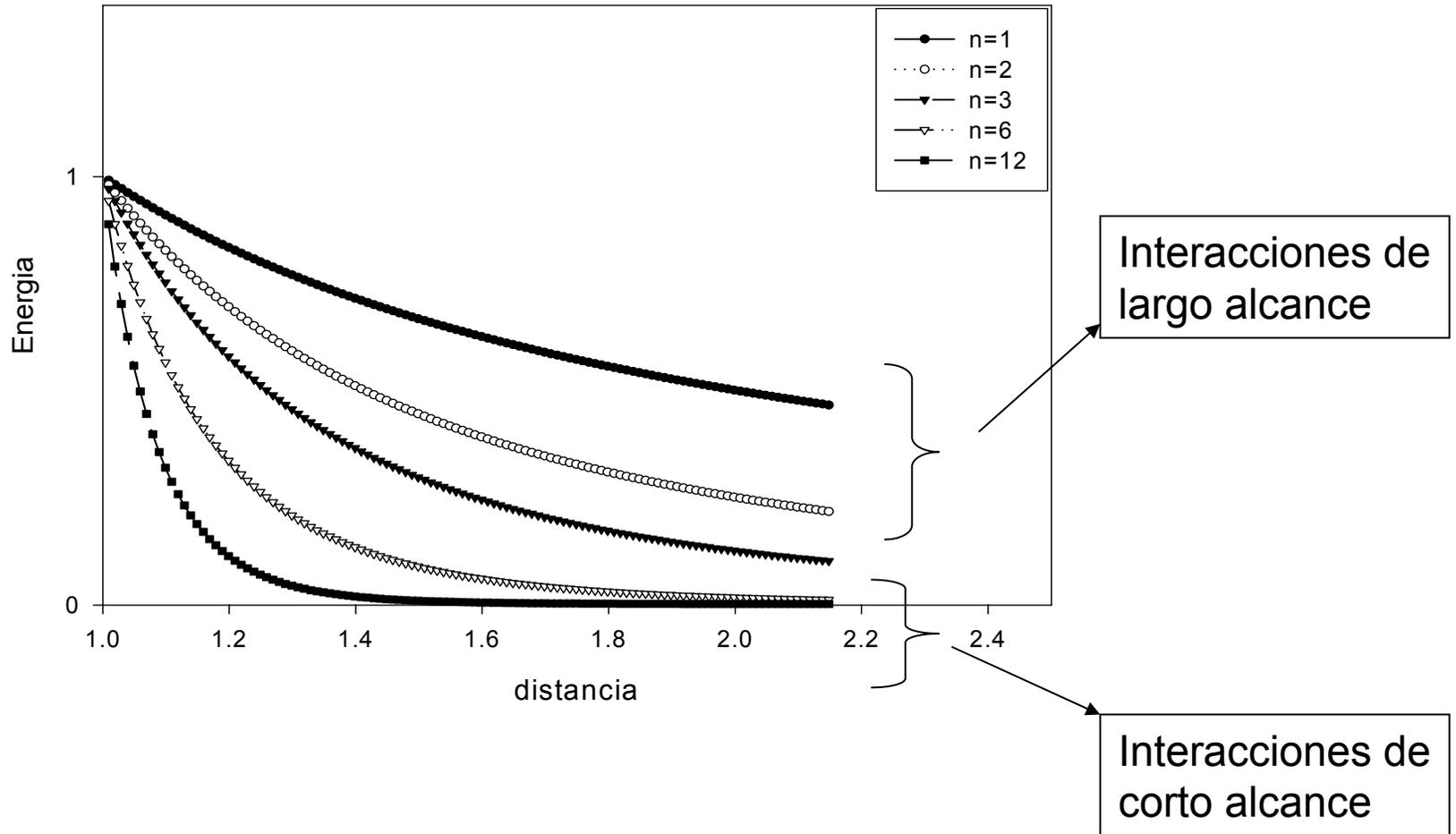
*Intermoleculares*

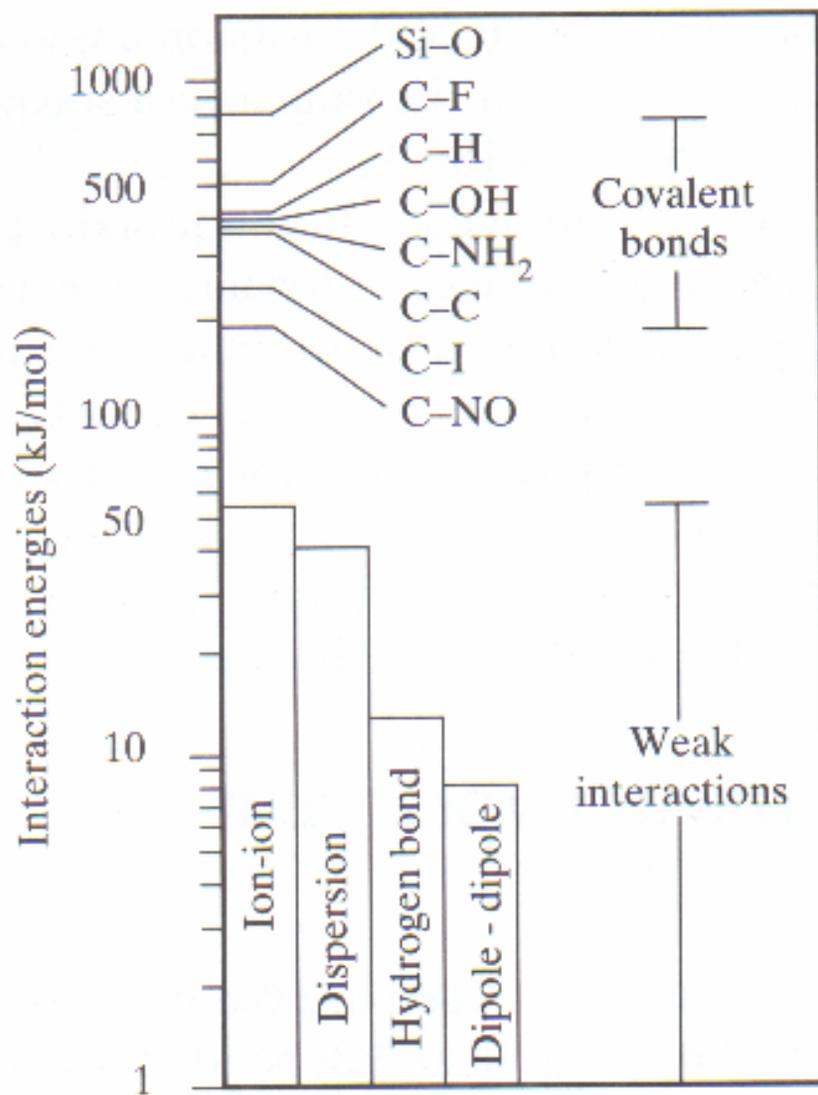
## $V_{\text{bonding}}$

- Incluyen a todas las interacciones entre átomos covalentemente unidos
- Por los valores de energía que tienen los enlaces, son los términos que dominan la energía total de una molécula
- La energía de enlace se define como la cantidad de energía que debo entregar a mi sistema para romper ese enlace

## V Non-bonding

- Las interacciones débiles son las que definen en gran medida la conformación de una molécula
- En conjunto hacen un aporte mínimo a la energía total de la molécula
- La mayoría de las interacciones débiles muestran una dependencia de la distancia entre átomos de  $1/r^n$
- Tienen fundamental importancia en los procesos biológicos ya que median la interacción entre moléculas





**Figure 1.6** Energies of molecular interactions. The interactions that define the structure of a molecule range from the strong interactions of covalent bonds (200 to 800 kJ/mol) to the weak ion-ion, dipole-dipole, dispersion, and hydrogen-bonding interactions (0 to 60 kJ/mol).

# Interacciones electrostáticas

$$V_e = \frac{q_1 q_2 e^2}{Dr^n}$$

- Incluyen a las carga-carga (n=1) y carga-dipolo (n=2)
- Son no-direccionales
- Son interacciones de largo alcance
- En general son interacciones de “superficies” ( puentes salinos)
- Si se las encuentran en ambientes no-polares generalmente están asociadas a una función biológica
- Dan “rigidez” a la estructura molecular

# Interacciones dipolo-dipolo

$$V_{dd} = \frac{\mu_1 \mu_2}{Dr^3}$$

- Se generan por una asimetría permanente en la distribución de cargas de una molécula.
- La carga puede ser parcial o neta.
- Son interacciones de corto alcance
- Son vectoriales ( $\mu = \delta r$ ) por lo tanto altamente direccionales

# Interacciones de Van der Waals

- Incluyen interacciones que implican dipolos inducidos
- Son interacciones de corto alcance
- Atractivas: Fuerzas de dispersión de London

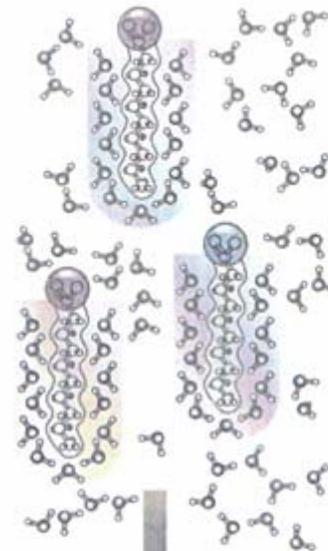
$$V_L = \frac{-3\alpha_1\alpha_2}{4r^6}$$

- Repulsivas:

$$V_R = \frac{k}{r^m}$$

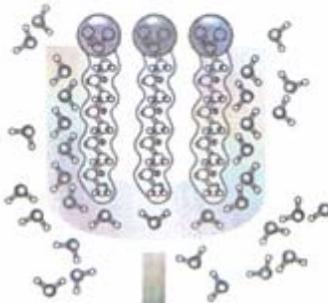
# Efecto Hidrofóbico

- Es el único en donde no existe una interacción atractiva mutua entre las partículas
- Está dominado por el aumento en el desorden de las moléculas de solvente
- Es proporcional al área hidrofóbica de la molécula expuesta al solvente



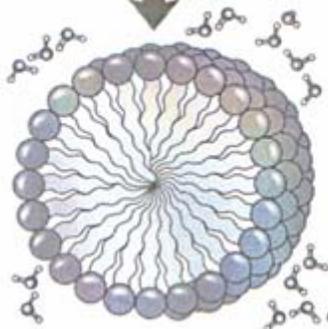
### Dispersion of lipids in H<sub>2</sub>O

Each lipid molecule forces surrounding H<sub>2</sub>O molecules to become highly ordered.



### Clusters of lipid molecules

Only lipid portions at the edge of the cluster force the ordering of water. Fewer H<sub>2</sub>O molecules are ordered, and entropy is increased.



### Micelles

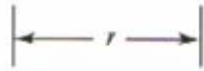
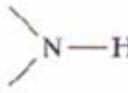
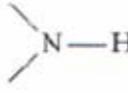
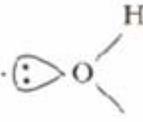
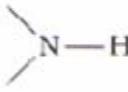
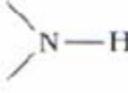
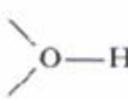
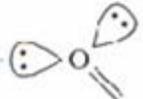
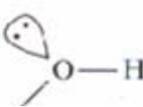
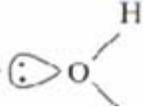
All hydrophobic groups are sequestered from water; ordered shell of H<sub>2</sub>O molecules is minimized, and entropy is further increased.

(b)

# Puentes de Hidrógeno

- Implican un donador de H (D) y un aceptor de H (A)
- El donador tiene que poder polarizar el enlace D-H
- El aceptor tiene que ser un átomo muy electronegativo con un par electrónico no-enlazante polarizable
- Es altamente direccional
- Es una interacción dipolo-dipolo
- Buenos donores son FH, OH, NH, SH
- Buenos aceptores son el F el O y el N.

**TABLE 1.3** HYDROGEN-BOND DONORS AND ACCEPTORS IN MACROMOLECULES

Donor	Acceptor	$r$ (nm)
		
		0.29
		0.29
		0.31
		0.37
		0.28
		0.28

# Interacciones cation- $\pi$ y $\pi$ - $\pi$

- $\pi$ - $\pi$  Implica la interacción de orbitales  $\pi$  entre anillos aromáticos (de origen electrostático y de Van der Waals)
- Cation- $\pi$  Implica la interacción entre orbitales  $\pi$  y un catión (netamente electrostática)

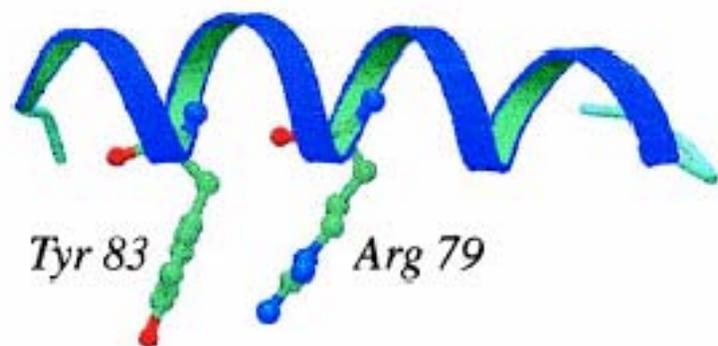


FIG. 3. An example of a strong cation- $\pi$  interaction in an  $\alpha$ -helix ( $E_{\text{res}} = -4.2$  kcal/mol). The plot was created by using MOLSCRIPT and RASTER3D (36, 37).

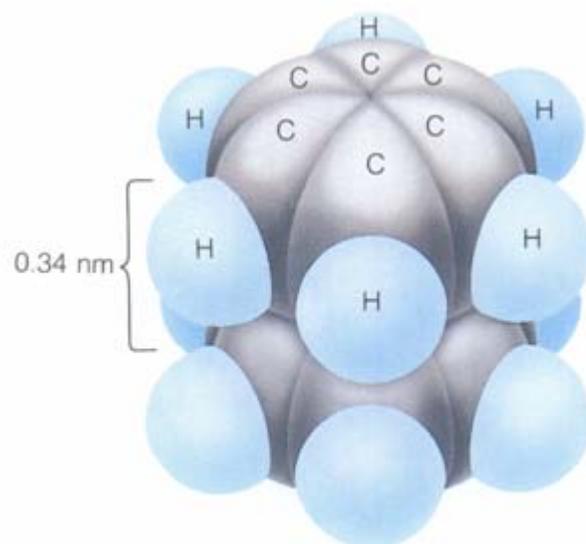


Figure 2 4

# **Cómo medimos la tendencia de distintos procesos a ocurrir de una cierta manera?**

$$\Delta G = \Delta H - T \Delta S$$

$\Delta G$  = cambio en la energía libre de Gibbs

$\Delta H$  = cambio en la entalpía

T = temperatura

$\Delta S$  = cambio en la entropía del sistema

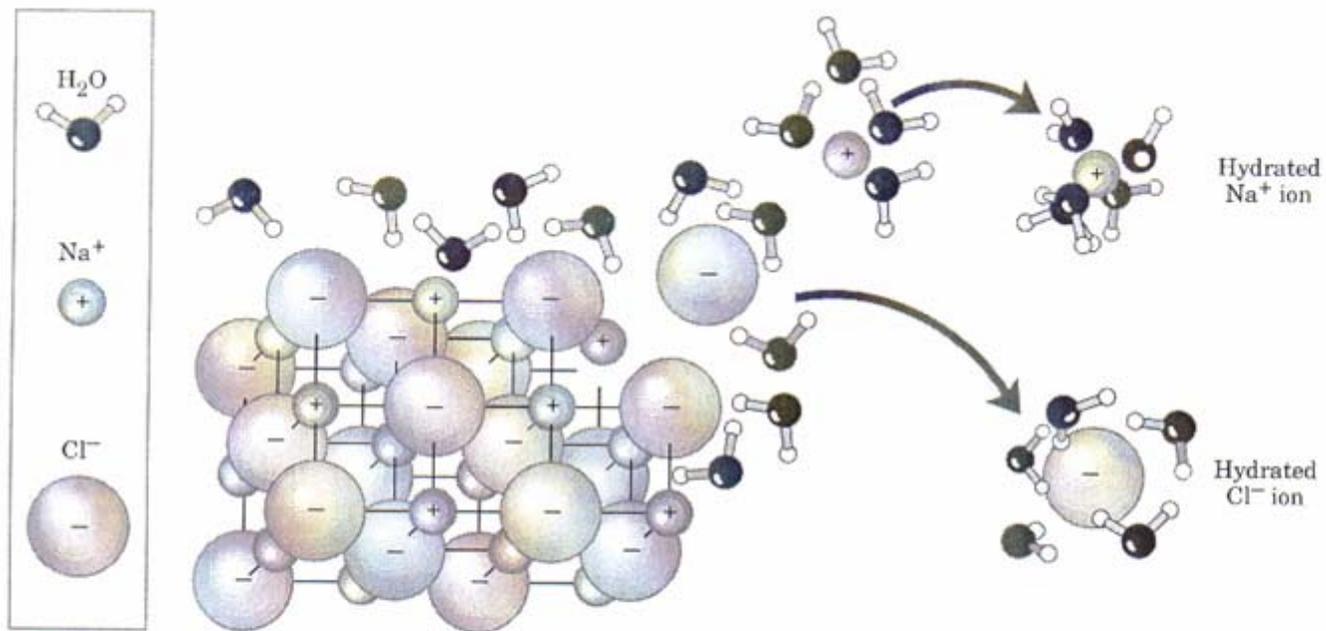
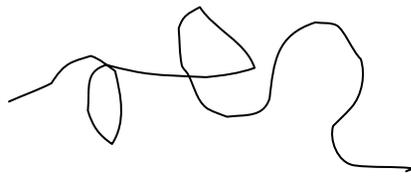
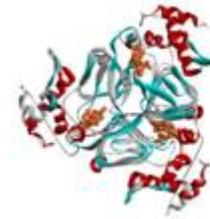


figure 4-6

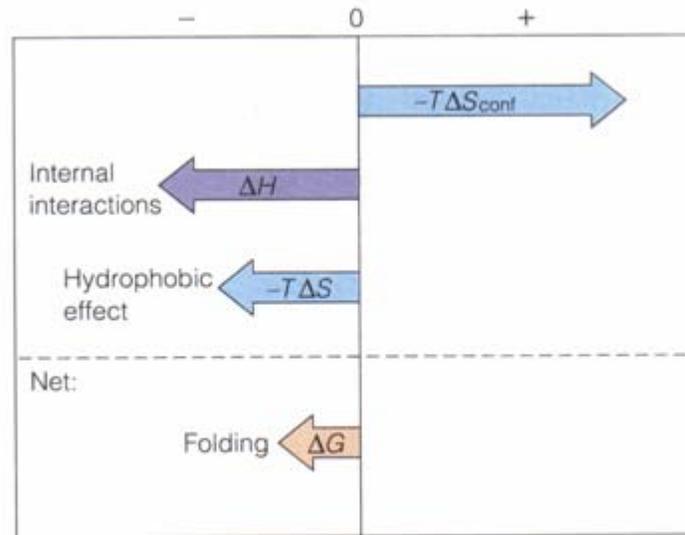
Water dissolves many crystalline salts by hydrating their component ions. The NaCl crystal lattice is disrupted as water molecules cluster about the Cl<sup>-</sup> and Na<sup>+</sup> ions. The ionic charges are partially neutralized, and the electrostatic attractions necessary for lattice formation are weakened.



U



N

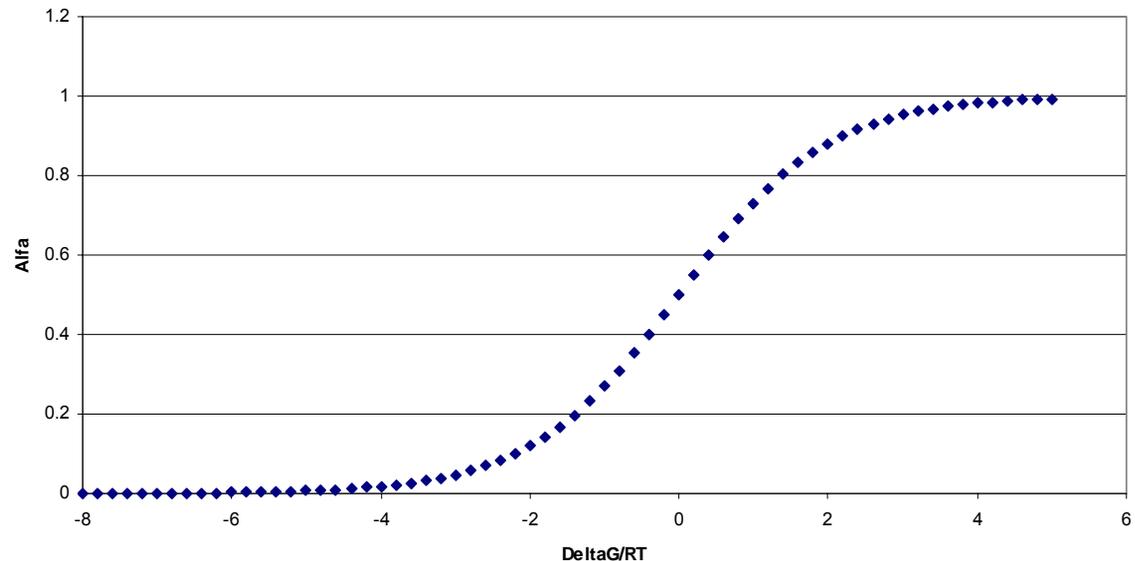


Proteína	$\Delta G$ (kJ/mol)	$\Delta H$ (kJ/mol)	$\Delta S$ (kJ/mol °)
Ribonucleasa	-7.3	-238	-0.774
Quimotripsinógeno	-32	-163	-0.439
Mioglobina	-57	-175	-0.397

$$K = U/N = \alpha/1-\alpha$$

$$\alpha = K / (1+K)$$

$$K = \exp(-(\Delta G^\circ/RT))$$



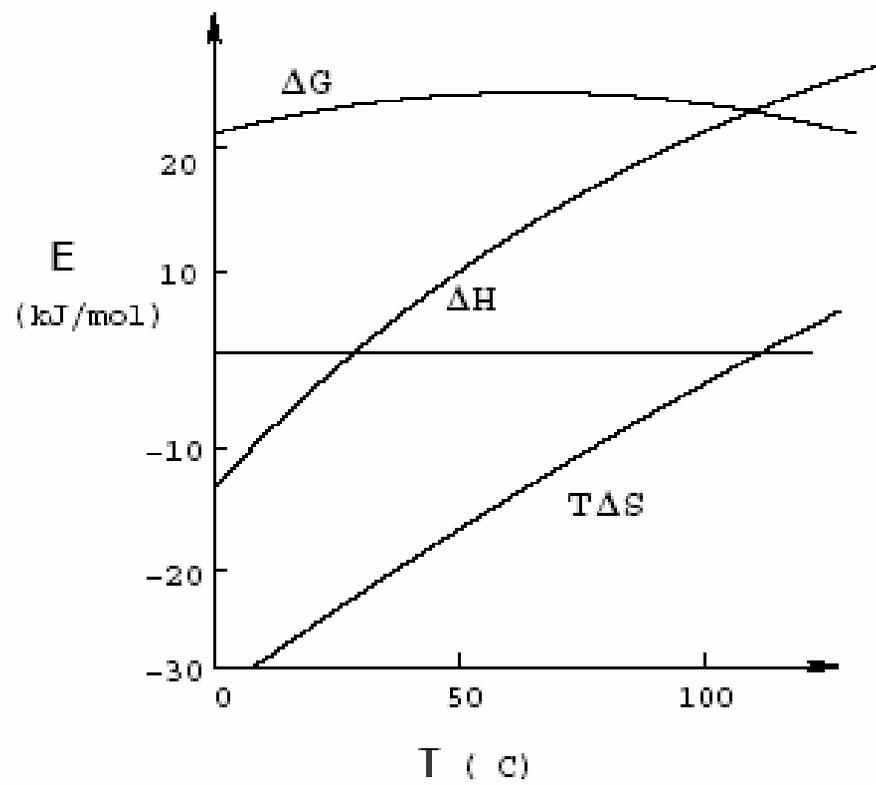
El cambio en  $\Delta G^\circ$  de solo 6 RT (15.45kJ/mol) produce un cambio de alfa de un 5 a un 95%

Tener en cuenta que los puentes de hidrógeno tienen una energía promedio de unos 30kJ/mol

## Efecto de la temperatura sobre el efecto hidrofóbico

At 300 K and partial pressure of 1 atm.

	$\frac{\Delta G_p^*}{kT}$	$\frac{\Delta S_p^*}{k}$	$\frac{\Delta H_p}{kT}$	$\frac{(\Delta C_p)_p}{k}$
CH <sub>4</sub>	3.4	- 8.4	-5.0	29
C <sub>2</sub> H <sub>6</sub>	3.1	-10.6	-7.5	36
C <sub>3</sub> H <sub>8</sub>	3.4	-11.9	-8.5	41
n-C <sub>4</sub> H <sub>10</sub>	3.6	-13.4	-9.8	40



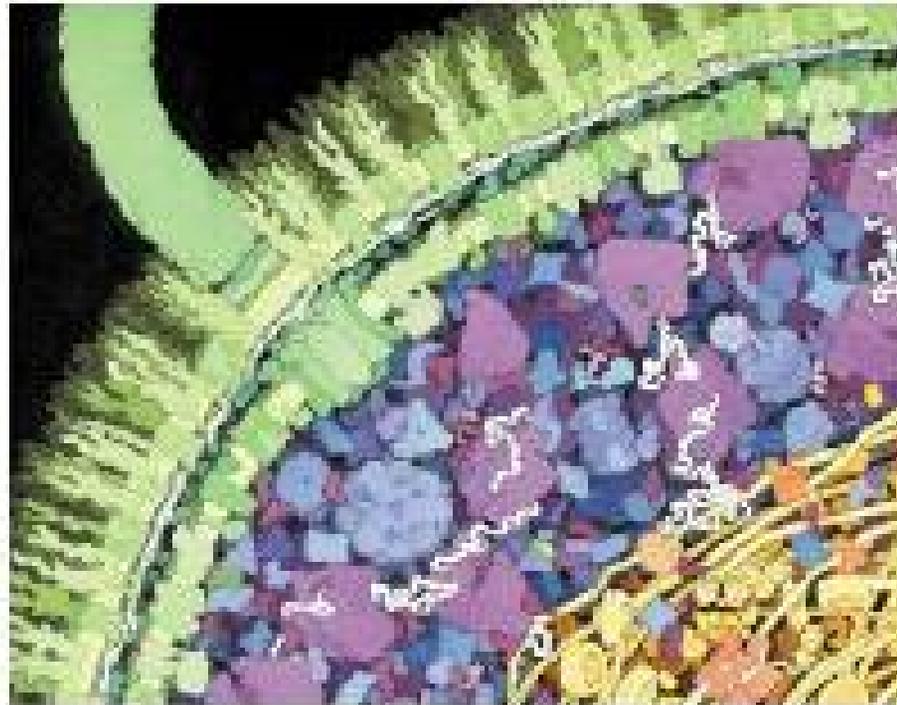
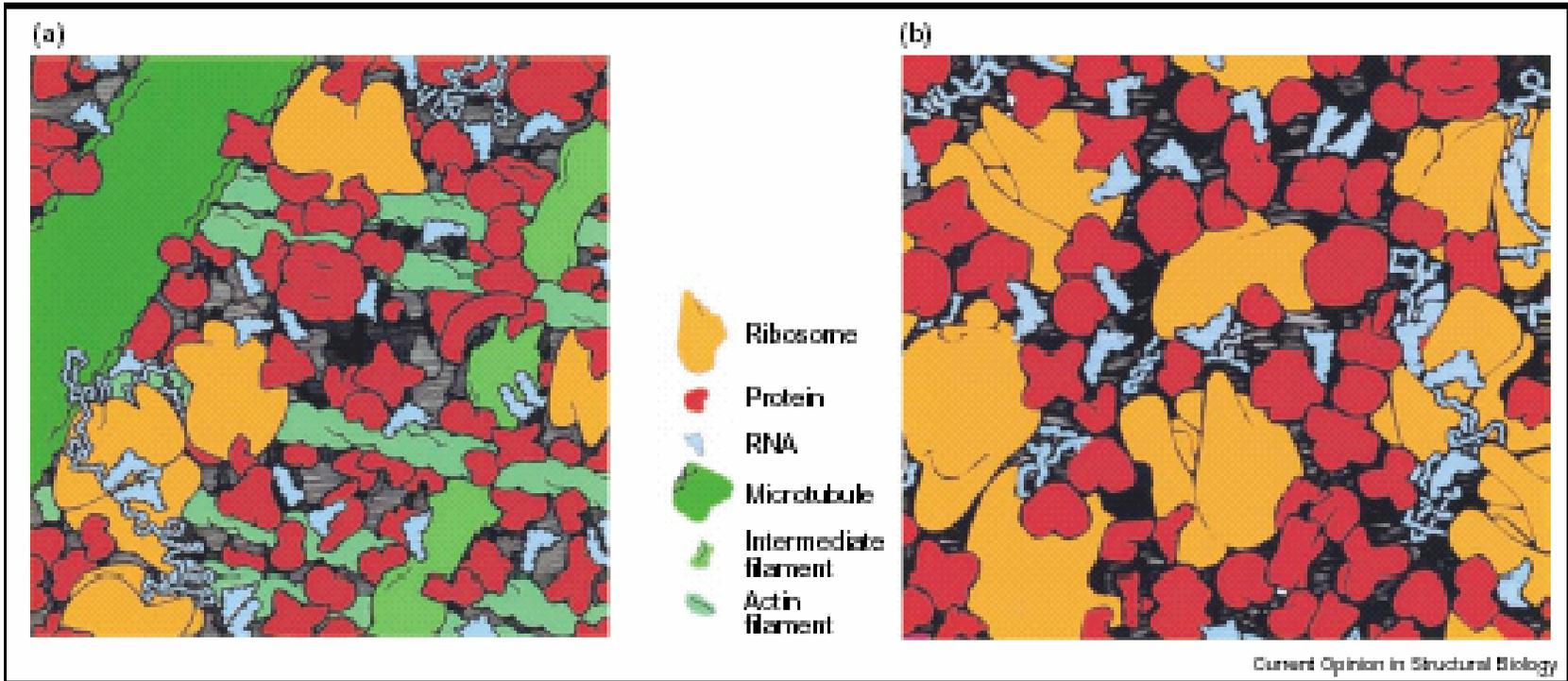


Fig. 1. Representation of the approximate numbers, shapes and density of packing of macromolecules inside a cell of *Escherichia coli*. Small molecules are not shown. Reproduced, with permission, from Ref. 47.



The crowded state of the cytoplasm in (a) eukaryotic and (b) *E. coli* cells. Each square illustrates the face of a cube of cytoplasm with an edge 100 nm in length. The sizes, shapes and numbers of macromolecules are approximately correct. Small molecules are not shown. Adapted with permission from [21]

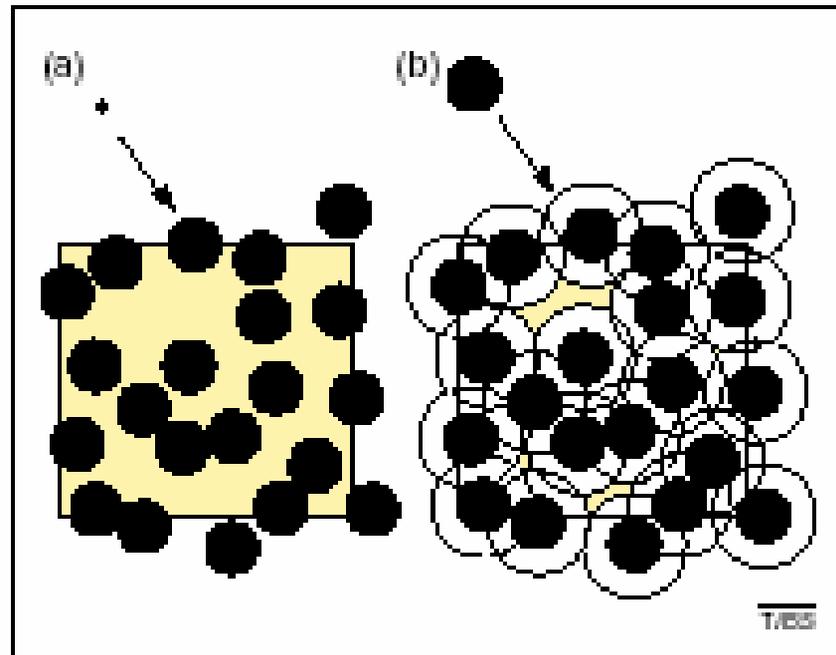


Fig. 2. The importance of size in volume exclusion. The squares define volumes containing spherical macromolecules occupying ~30% of the available space. (a) The centre of an introduced small molecule has access to virtually all of the remaining 70% of the space, indicated in yellow. (b) The centre of an introduced molecule similar in size to the macromolecules is excluded from most of this 70% as it cannot approach these macromolecules to a distance less than that indicated by the open circles. Reproduced, with permission, from Ref. 9.

## Potencial químico

$$\mu_i = \mu^0 + RT \ln (a_i)$$

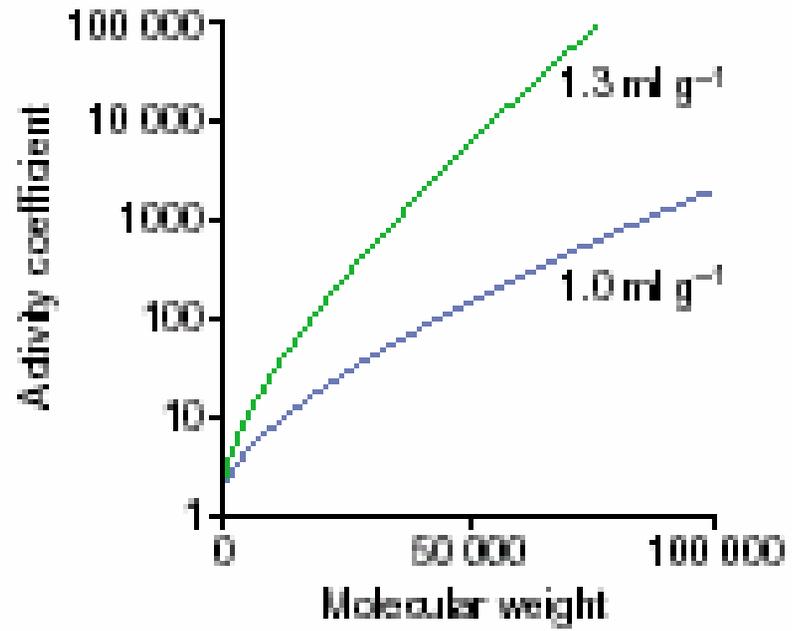
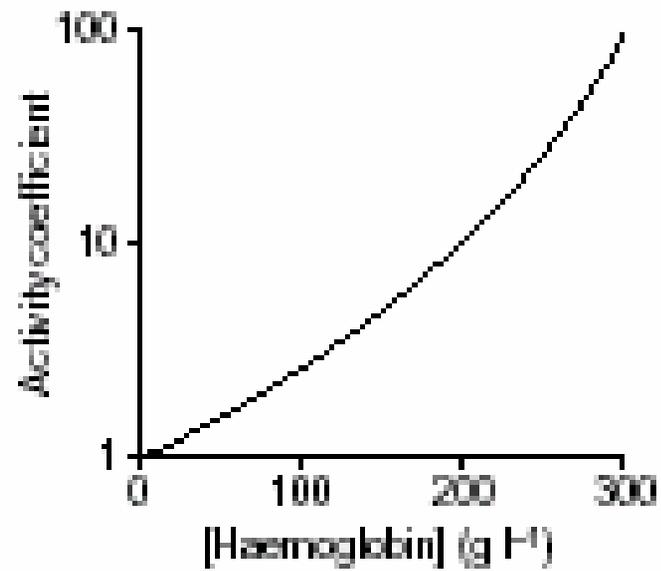
Donde  $a_i$  es la actividad de la sustancia  $i$ .

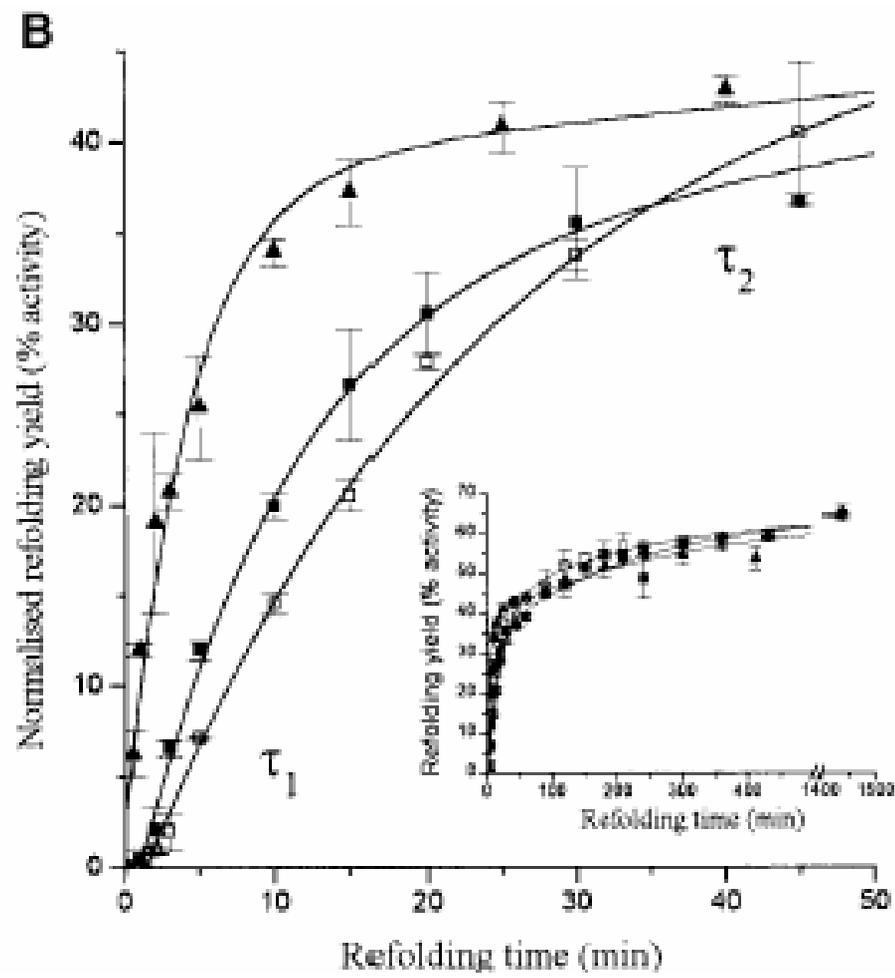
El potencial químico mide la tendencia al cambio de la sustancia  $i$

La relación entre actividad y concentración sólo es igual a 1 para soluciones ideales o muy diluidas

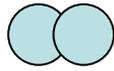
Coeficiente de actividad =  $\gamma_i = a_i/c_i$  donde  $c_i$  es la concentración.

$$\gamma_i = a_i/c_i = v_{\text{tot}}/v_{\text{avail}}$$



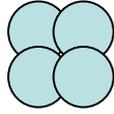
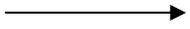


2 ○

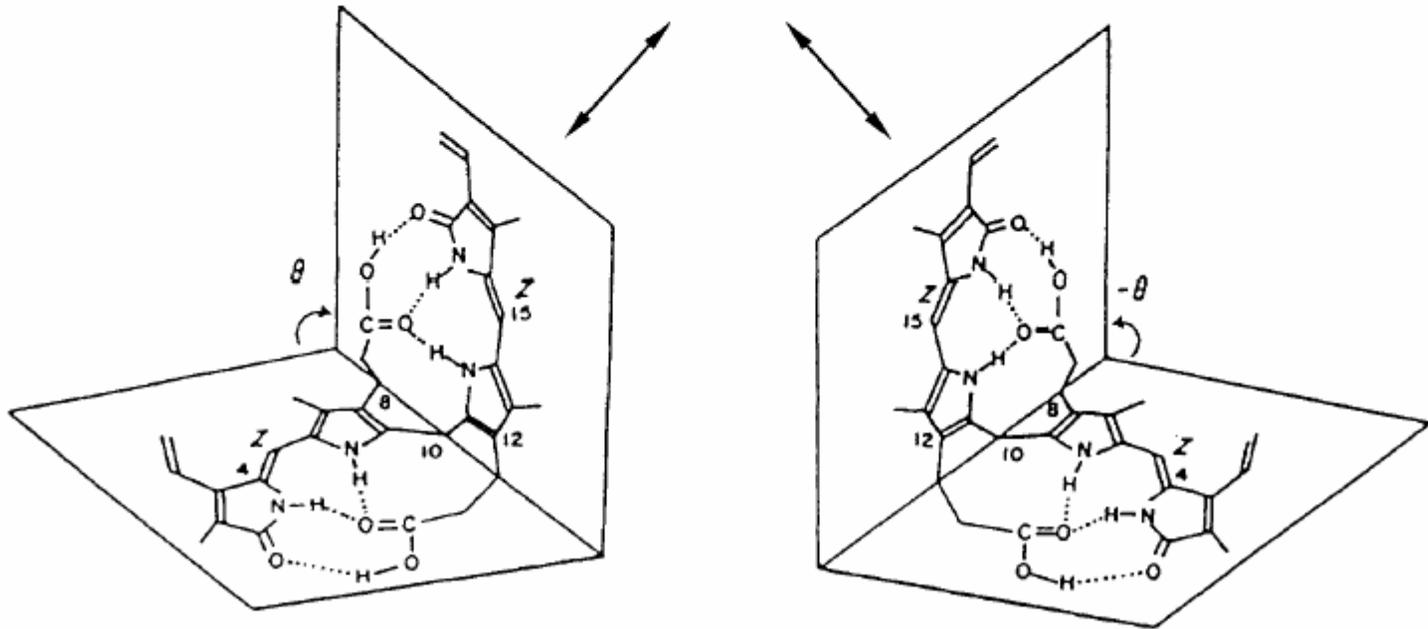
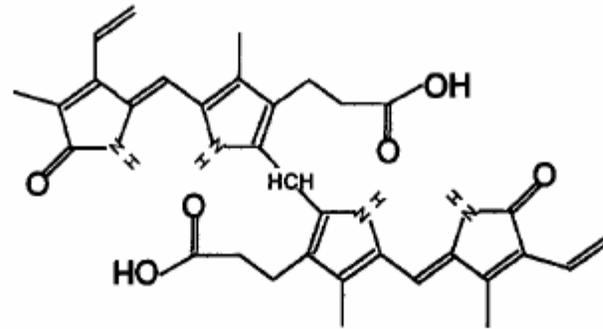


$K_{\text{crow}}/K_w = 10^{-40}$

4 ○



$K_{\text{crow}}/K_w = 10^3-10^5$



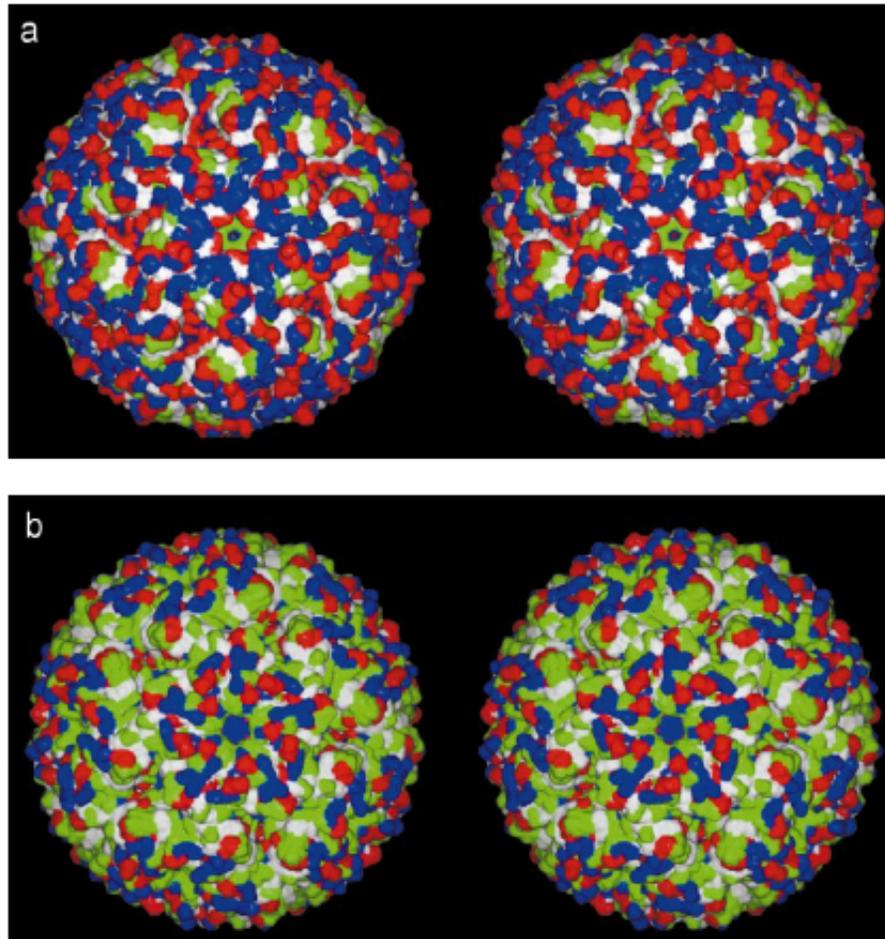
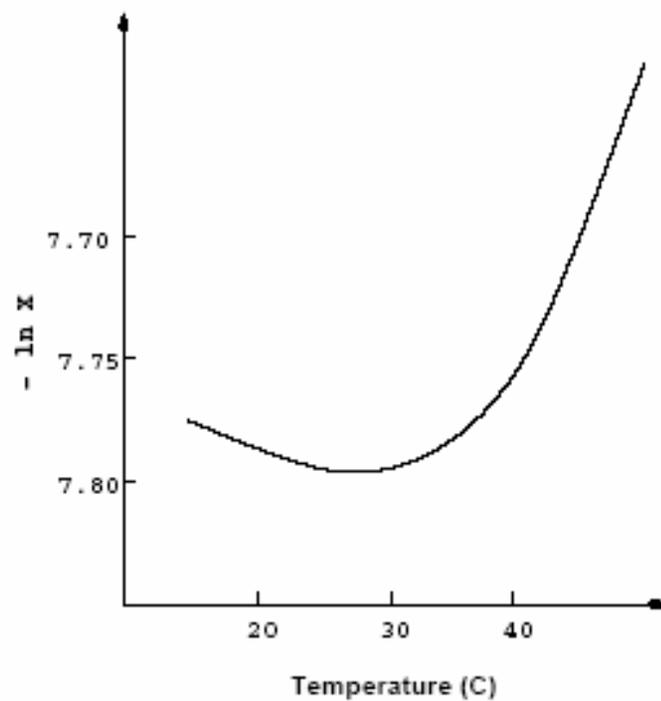


Figure 4. Accessible surface comparison of LS from (a) *A. aeolicus* and (b) *B. subtilis*. Color codes are: red for Asp and Glu; blue for Lys, His and Arg; green for Asn, Gln, Ser, Thr, Cys, Tyr and Gly; white for Ala, Val, Leu, Ile, Met, Pro, Phe and Trp. The image was generated by SPOCK (J. A. Christopher, The Center for Macromolecular Design, Texas A&M University).



Solubility of a typical hydrocarbon  
in water.