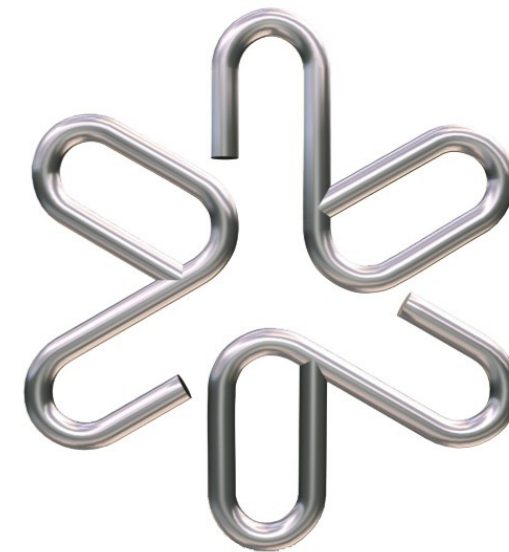


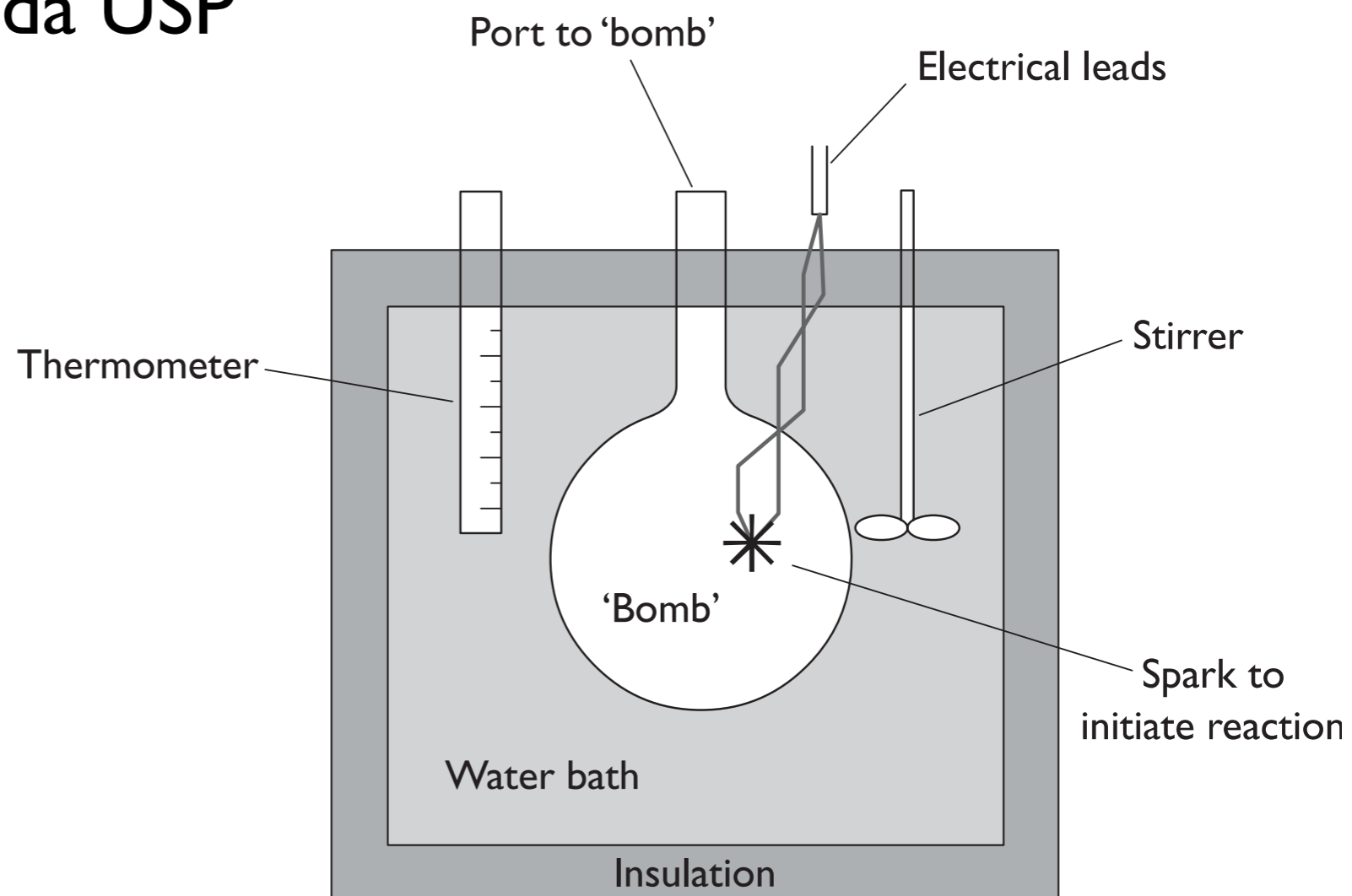
Física do Corpo Humano (4300325)



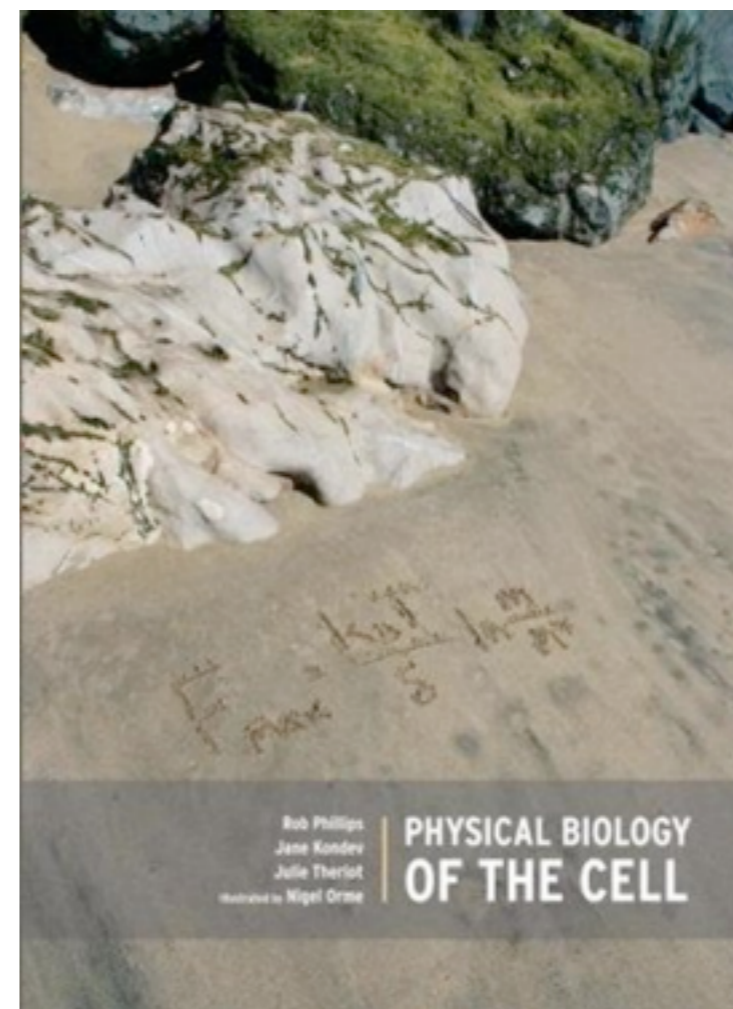
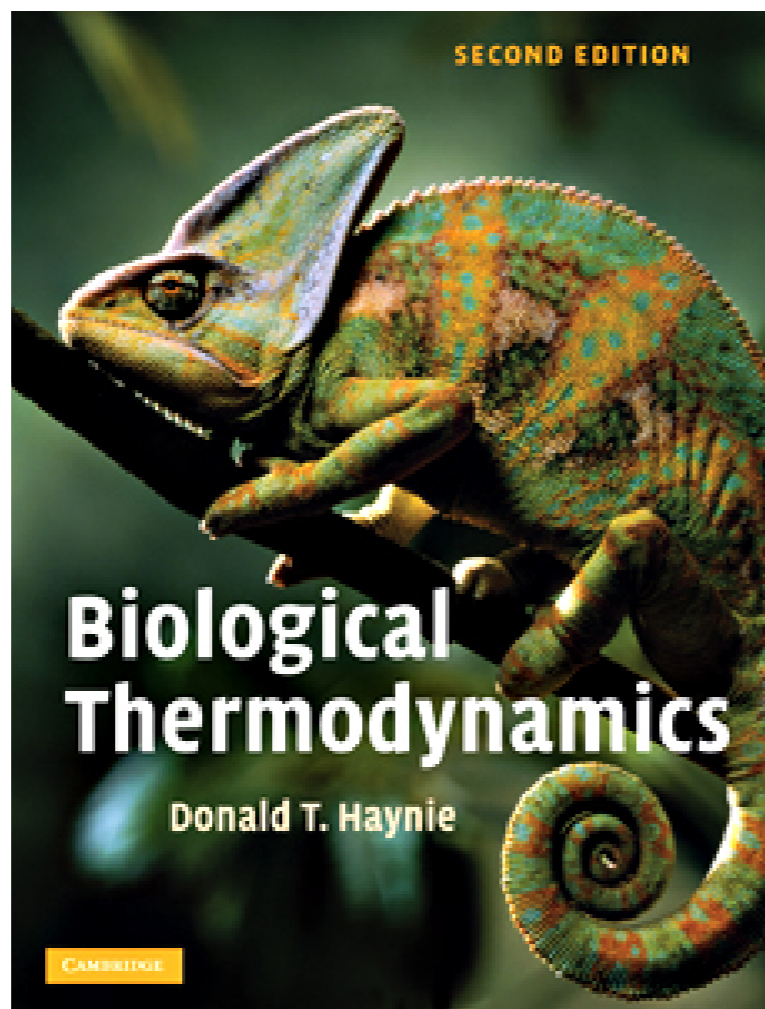
Prof. Adriano Mesquita Alencar
Dep. Física Geral
Instituto de Física da USP

B02

**Energia
Aula 6**



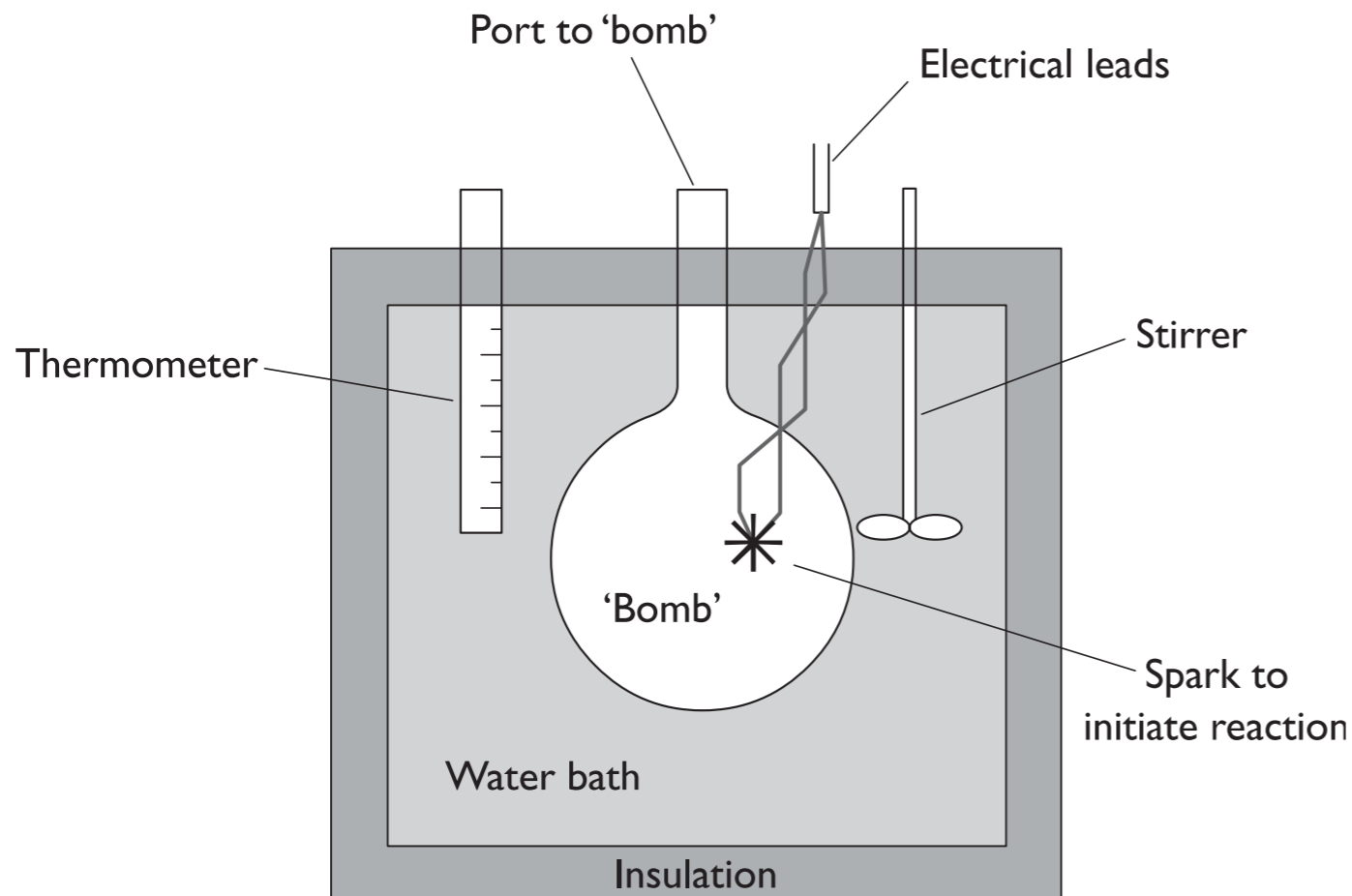
Princípios Físicos Aplicados à Fisiologia (PGF5306-I)



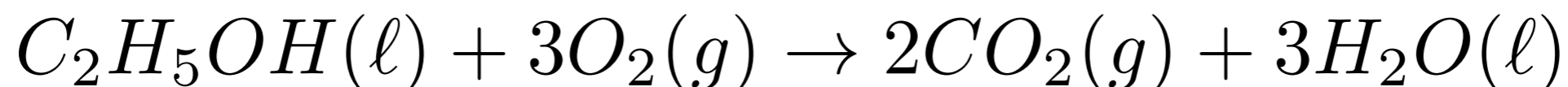
Entalpia, H

$$\Delta H = \Delta U + RT\Delta n$$

R , é uma constante universal, 8.3145 J/K mol



Em um experimento dessa bomba de calorímetro com Etanol, a 298K e volume constante, 1368 kJ/mol de calor é liberado

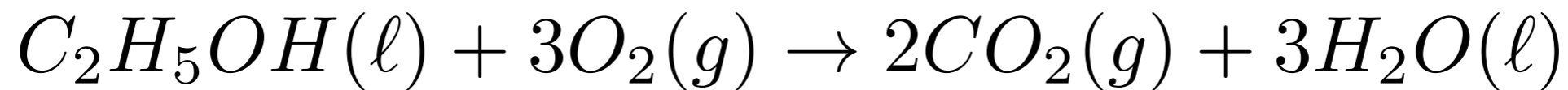


Entalpia, H

$$\Delta H = \Delta U + RT\Delta n$$

$$\Delta H = \Delta U + 298 \cdot 8.3145\Delta n$$

$$\Delta H = \Delta U + 2478\Delta n$$

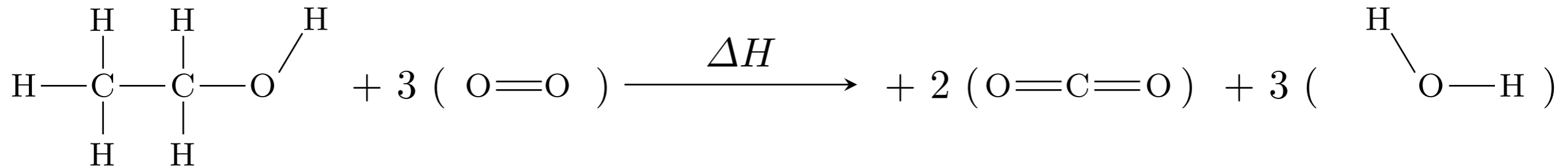
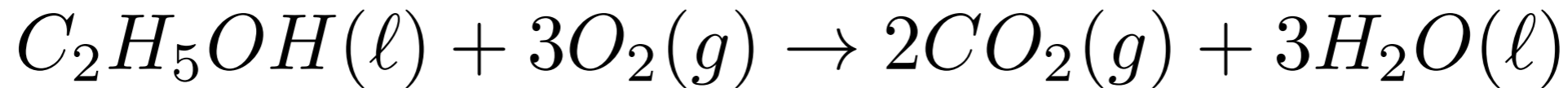


$$\Delta n = 2 - 3 = -1$$

$$\Delta H = -1368000 - 2478 \quad (\text{J/mol})$$

Se a variação de entalpia é negativo o processo é **exotérmico**. Caso contrario o processo é **endotérmico**

Entalpia, H



Liquido para Gas = 277

$$((5*415+346+358+464)+277)+3*498$$

Liquido para Gas = 41

$$(2*2*805+6*464+(3*41))$$

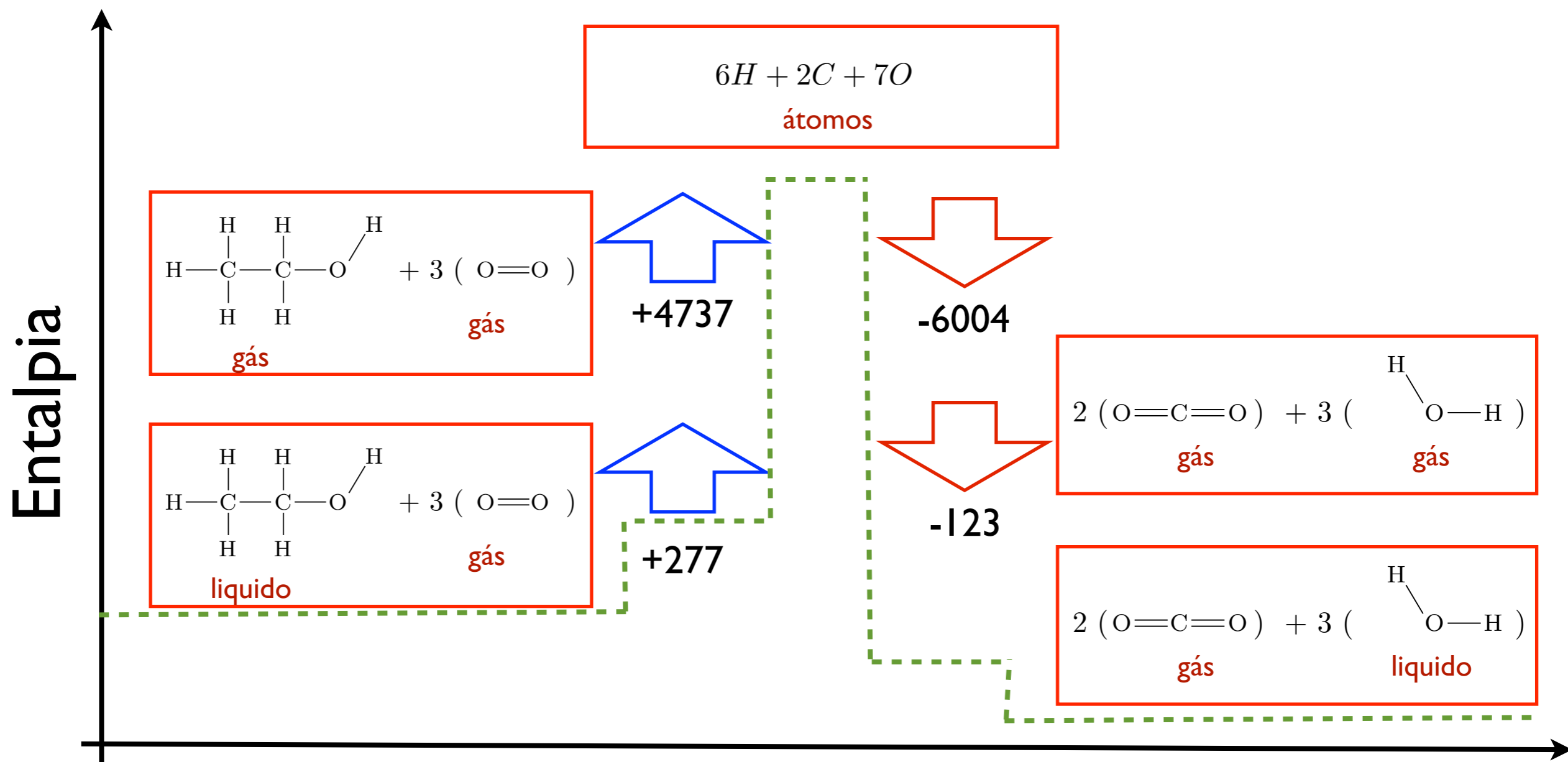
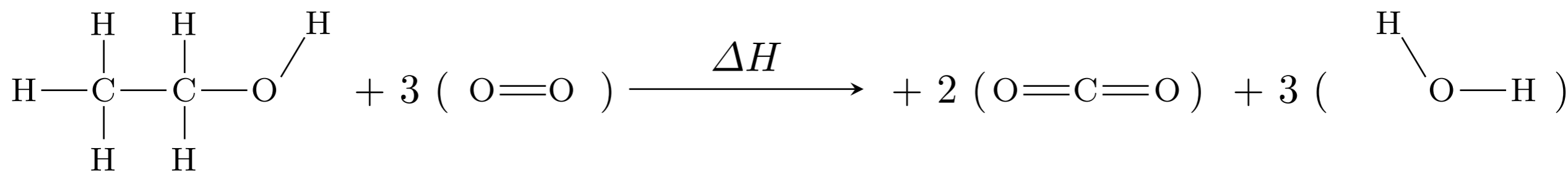
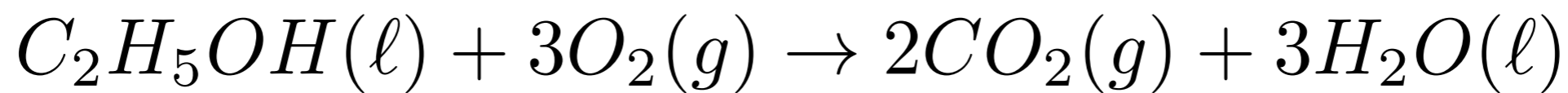
$$\Delta H^{\circ} = -1113 \text{ (saindo do estado liquido)}$$

$$\Delta H^{\circ} = -1267 \text{ (estado gasoso para todos)}$$

$$\Delta H^{\circ} = -1368 \text{ kJ/mol}$$

(Valor de Tabela)

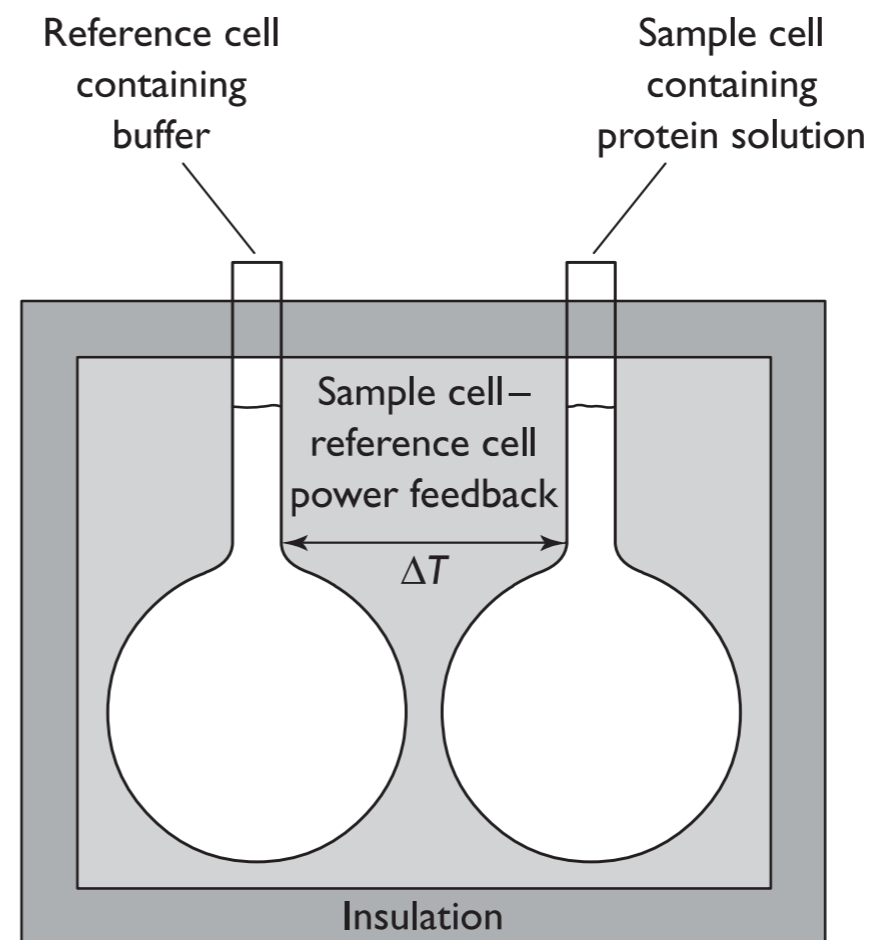
$C - C \rightarrow 346$	$C = O \rightarrow 1077$ em Monoxido
$C = C \rightarrow 602$	$C = O \rightarrow 805$ em Dioxido
$C - H \rightarrow 415$	$C - O \rightarrow 358$
$H - H \rightarrow 436$	$O - H \rightarrow 464$
$O = O \rightarrow 498$	$H - Cl \rightarrow 432$



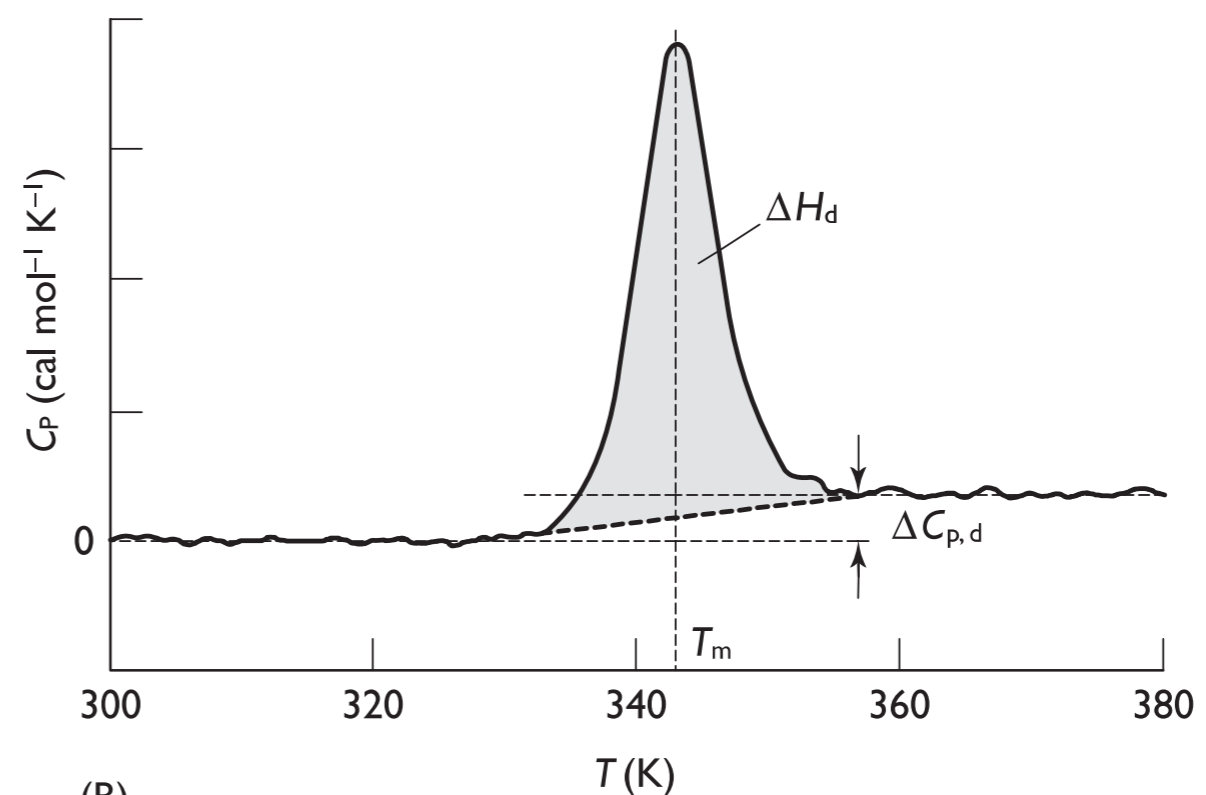
Bioquímica

- Aproximadamente 1/2 da massa seca do corpo humano é de proteínas
- O estado nativo das proteínas é “folded”, empacotado - uma espécie de cristal orgânico
- Mesmo nesse estado existe flutuação na estrutura do caroço central.
- Estado empacotado - parecido com sólido
- Estado desempacotado - parecido com líquido

Fig. 2.10 Differential scanning calorimetry. (A) Schematic diagram of the instrument. In this case the reference cell contains buffer only, and the sample cell contains the macromolecule dissolved in buffer. Both cells are heated very slowly (e.g. $1\text{ }^{\circ}\text{C min}^{-1}$) in order to maintain equilibrium, and feedback electronic circuitry is used to add heat so that $\Delta T \approx 0$ throughout the experiment. Other types of DSC have been used for other purposes in biophysics, for example, to investigate the physiological limits of the freeze tolerance and freeze-avoidance strategies taken by different insect species to survive subzero temperatures. (B) Data. The heat added to keep $\Delta T \approx 0$ can be plotted as a function of temperature. The endothermic peak corresponds to heat absorbed, for example, on protein denaturation. The peak maximum corresponds roughly to the transition temperature, or melting temperature. The area below the peak is $\Delta H_d(T_m)$. The heat capacity of the unfolded state of a protein minus the heat capacity of the folded state is $\Delta C_{p,d}$. There is more about DSC in Chapter 5.



(A)



(B)

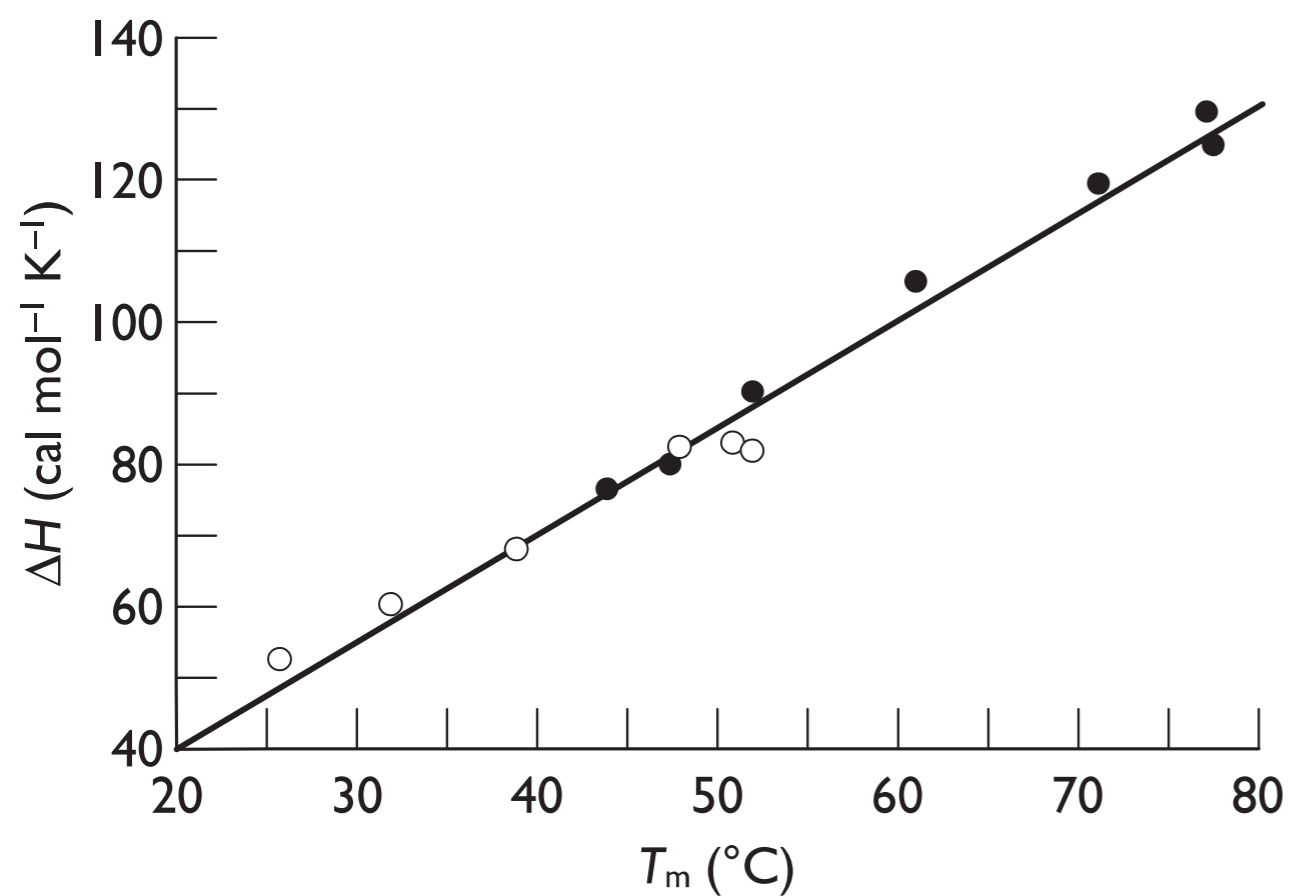


Fig. 2.7 Enthalpy of unfolding of hen egg white lysozyme as a function of transition temperature. Filled symbols: intact lysozyme. Open symbols: lysozyme in which one of the four native disulfide bonds has been removed. When folded, 3-SS lysozyme closely resembles the native state of intact lysozyme. Change in transition temperature was induced by a change of pH. Note that ΔH is approximately linear in T_m . The data are from Cooper *et al.* (1991).

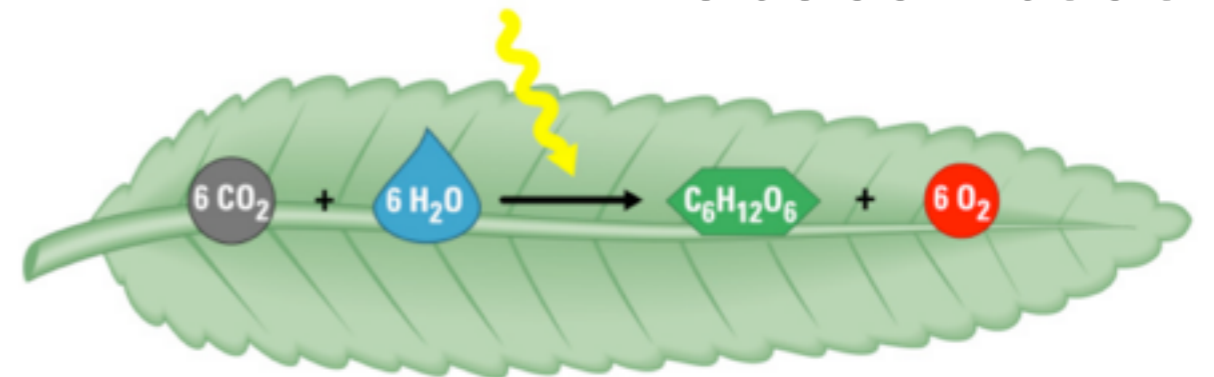
Energias

Energias mais relevantes para sistemas biológicos:

1. Energia Química
2. Energia Mecânica
3. Energia Eletromagnética
4. Energia Térmica



Fotossíntese

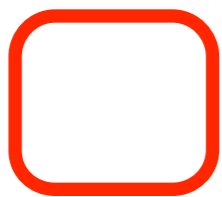


Energias

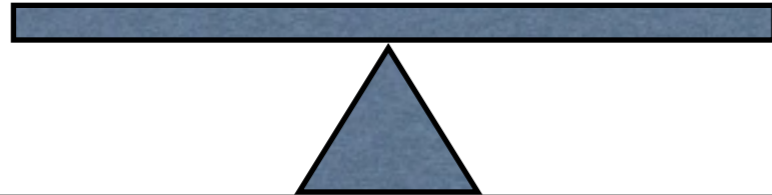
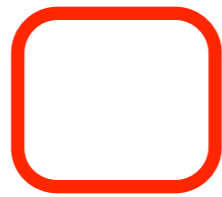
Energias mais relevantes para sistemas biológicos:

1. Energia Química
2. Energia Mecânica
3. Energia Eletromagnética
4. Energia Térmica

Determinísticas



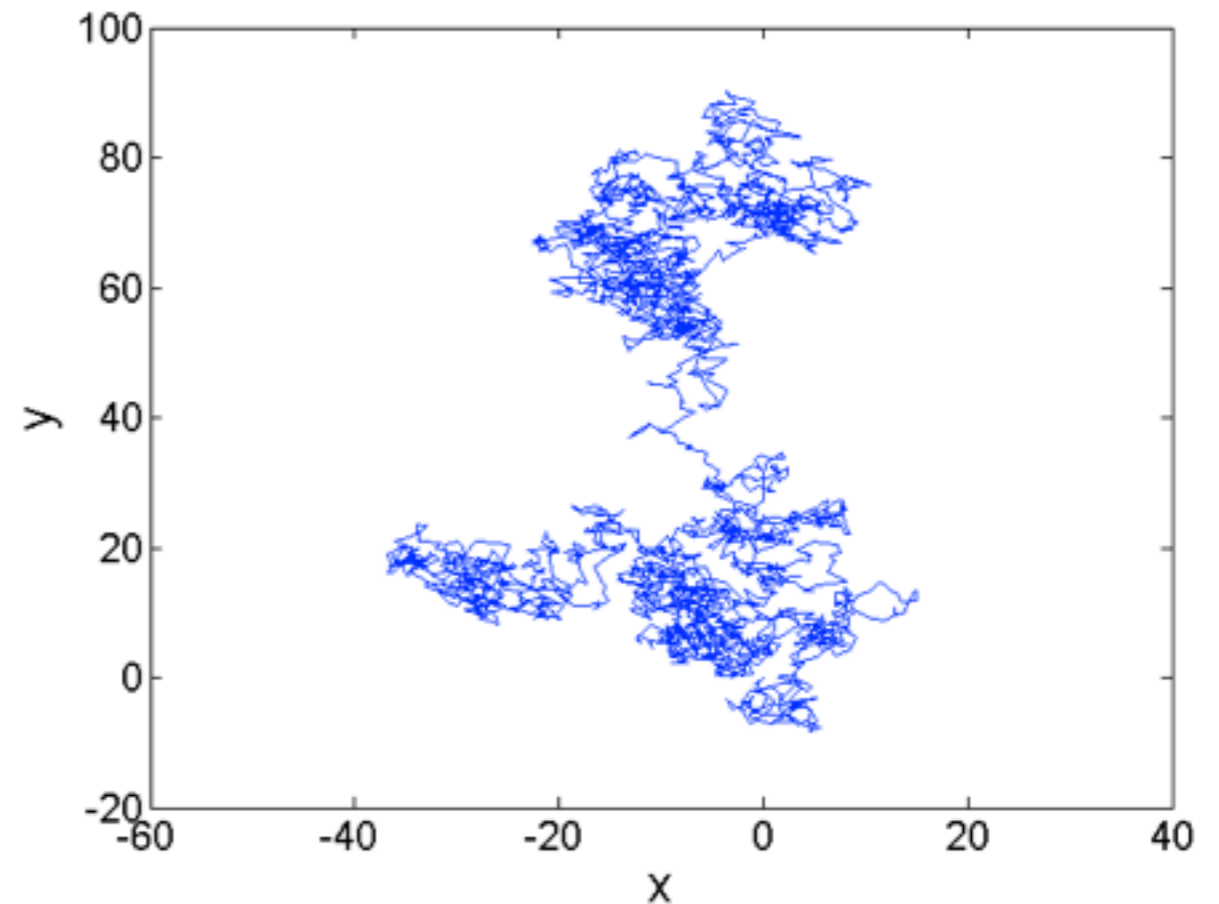
Térmicas



Forças no interior da célula

Movimento Browniano

MB difusivo



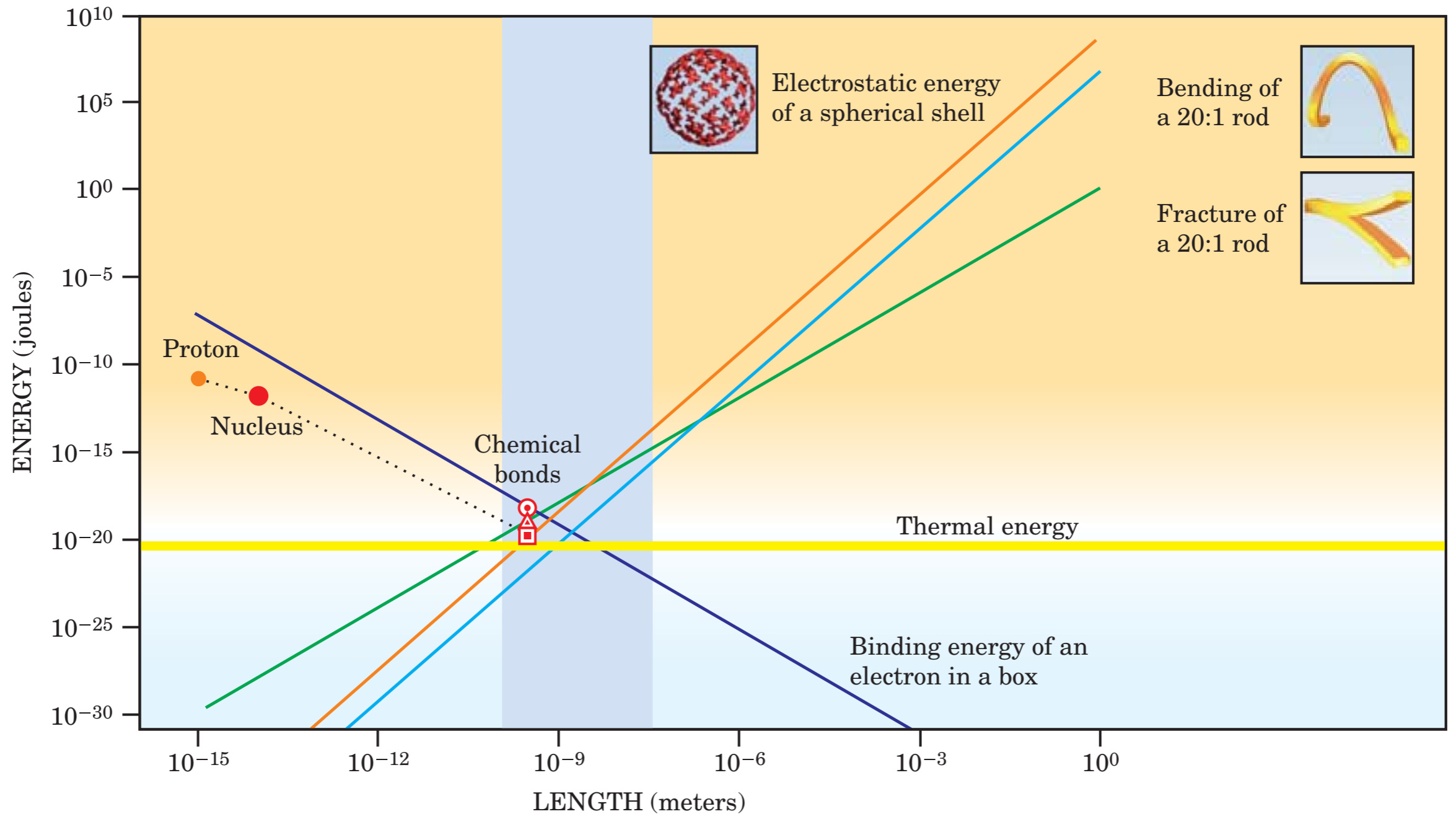
A razão entre as escalas determinísticas e térmicas é:

$$E_{\text{det}}/k_B T$$

A razão entre a escalas determinísticas e térmicas é:

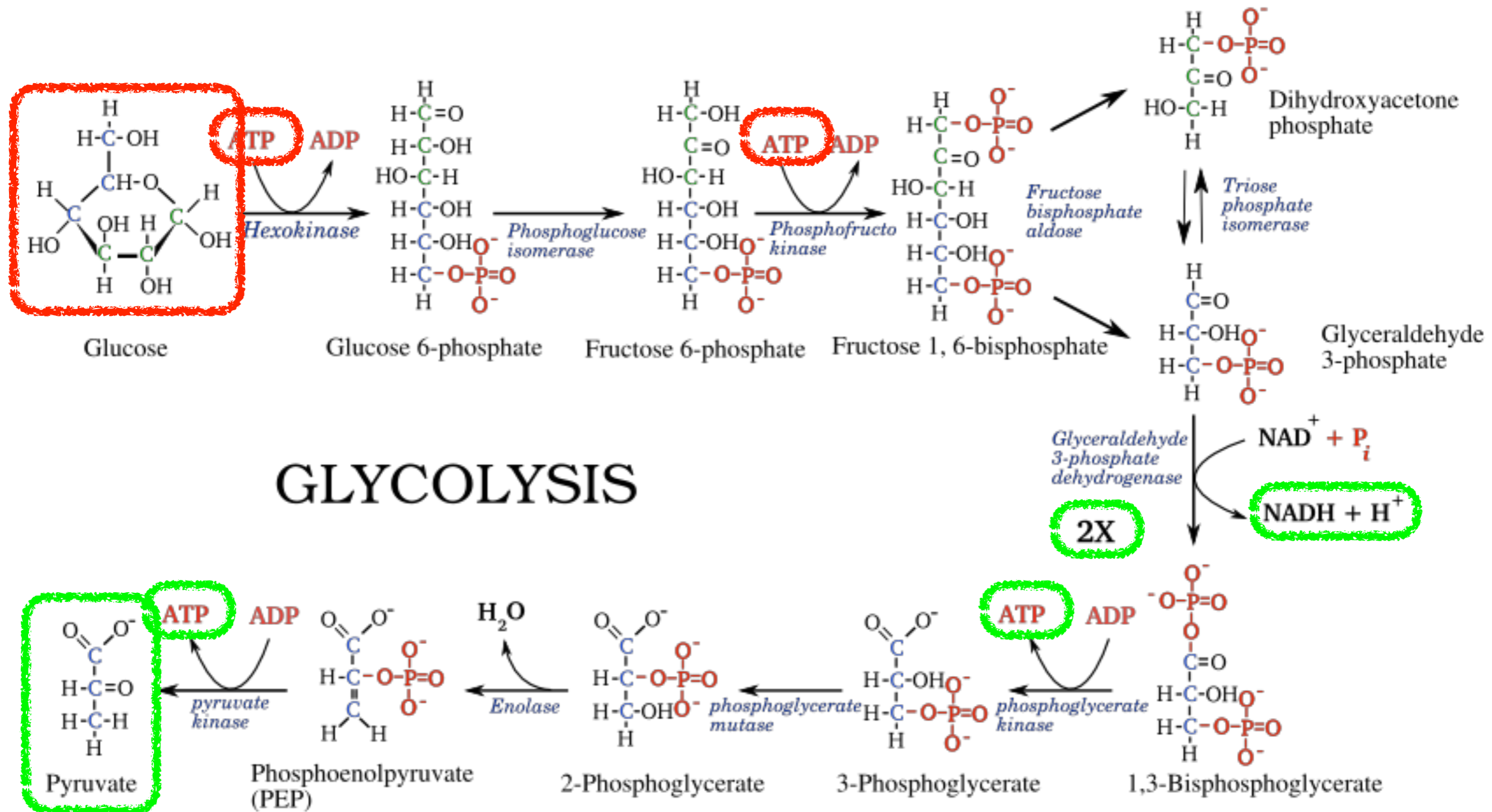
$$E_{\text{det}}/k_{\text{B}}T$$

$$\begin{aligned} k_{\text{B}}T &= 4.1 \text{ pN nm} \\ &= 0.6 \text{ kcal/mol} \\ &= 2.5 \text{ kJ/mol} \\ &= 25 \text{ meV} \end{aligned}$$

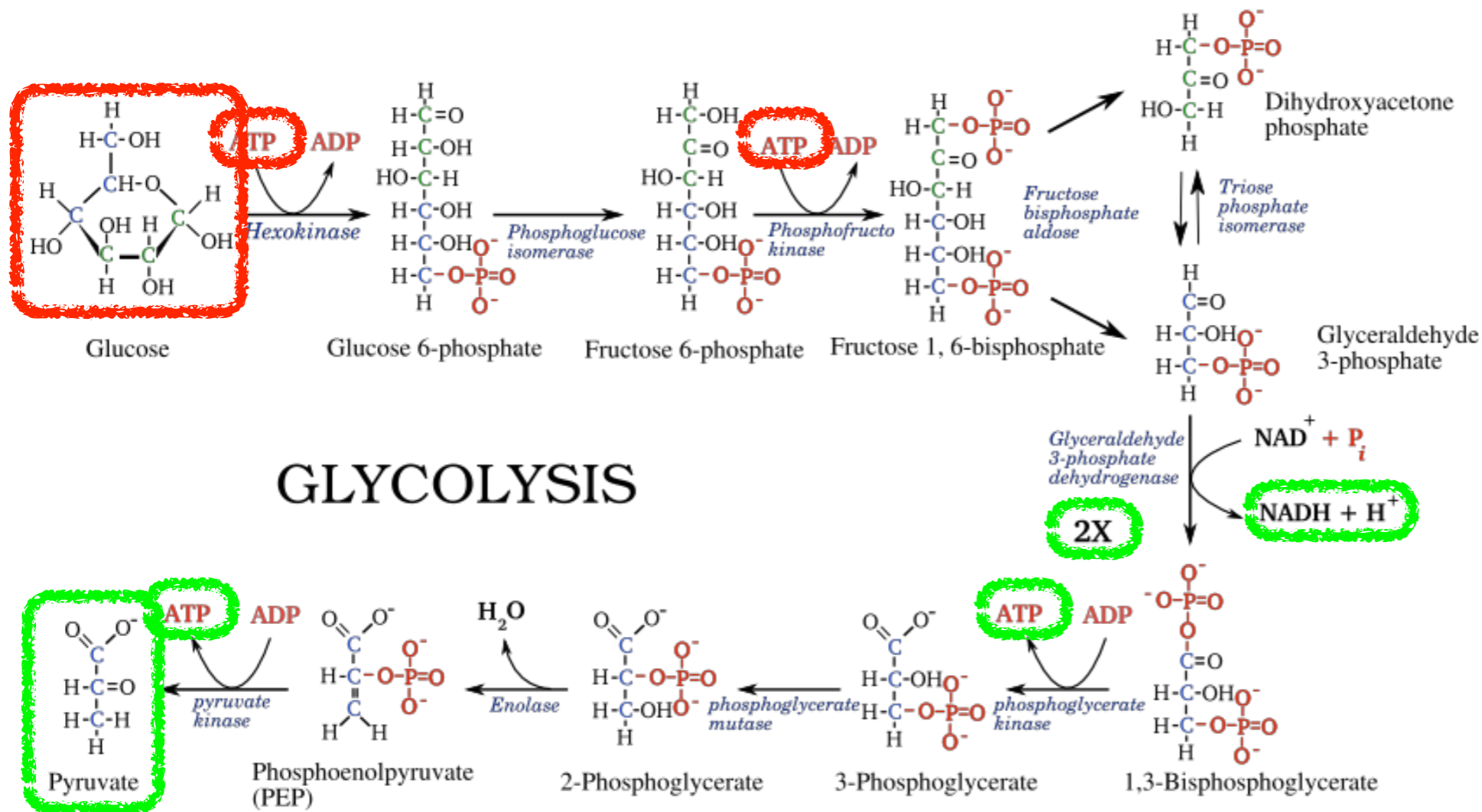


Maquinaria molecular: Ligação de Hidrogênio (quadrado), grupos de fosfato em ATP (triângulo), ligações covalentes (círculo), energia de torção (azul), energia de fratura (verde), energia eletrostática (laranja). [Rob Phillips and Stephen R. Quake, *Physics Today* (2006)]

Geração de Energias



Geração de Energias

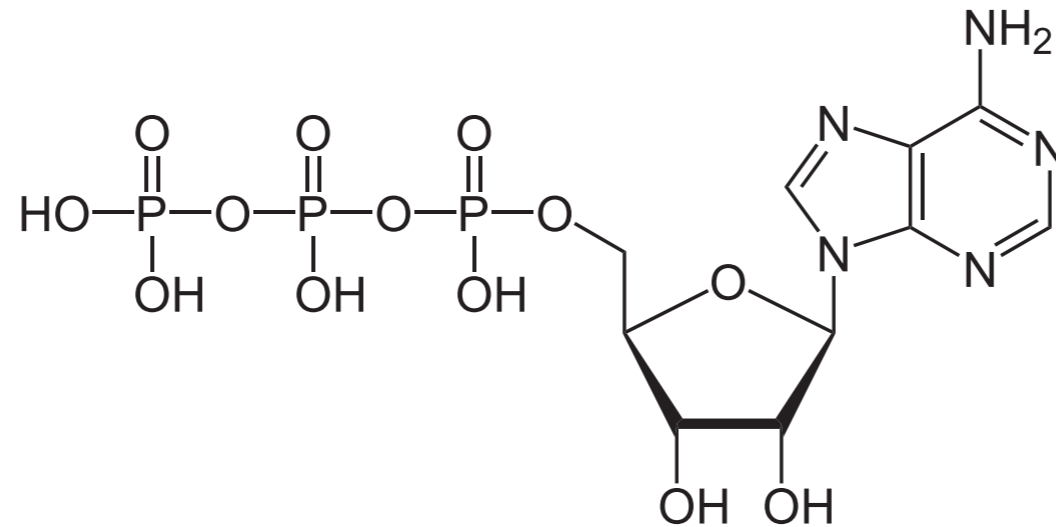


Pyruvate possui grande valor energético e pode ser utilizado para produzir mais ATP.

Assim, uma molécula de glicose pode gerar até 30 ATPs.

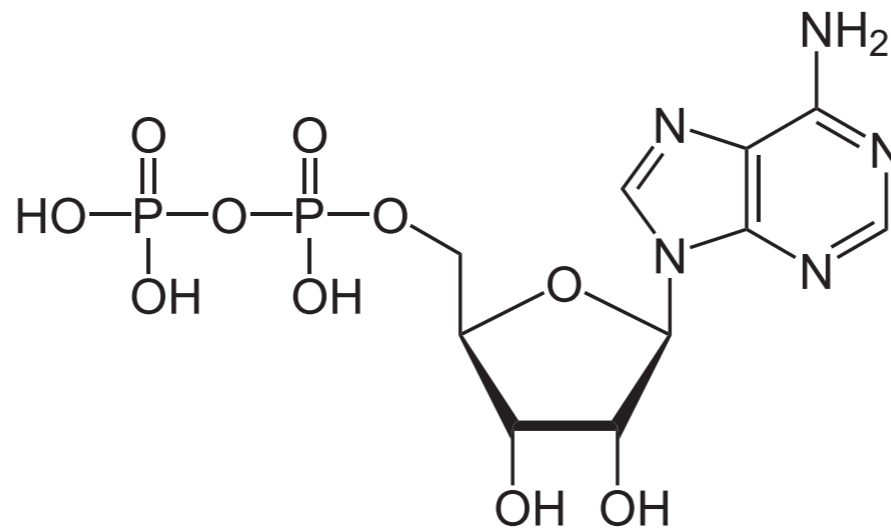
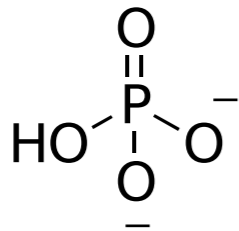
Armazenamento de Energias

$$\begin{aligned}k_B T &= 4.1 \text{ pN nm} \\ &= 0.6 \text{ kcal/mol} \\ &= 2.5 \text{ kJ/mol} \\ &= 25 \text{ meV}\end{aligned}$$
$$\begin{aligned}C - C &\rightarrow 346 \text{ kJ/mol} \\ C = C &\rightarrow 602 \\ C - H &\rightarrow 415 \\ H - H &\rightarrow 436 \\ O = O &\rightarrow 498\end{aligned}$$



ATP

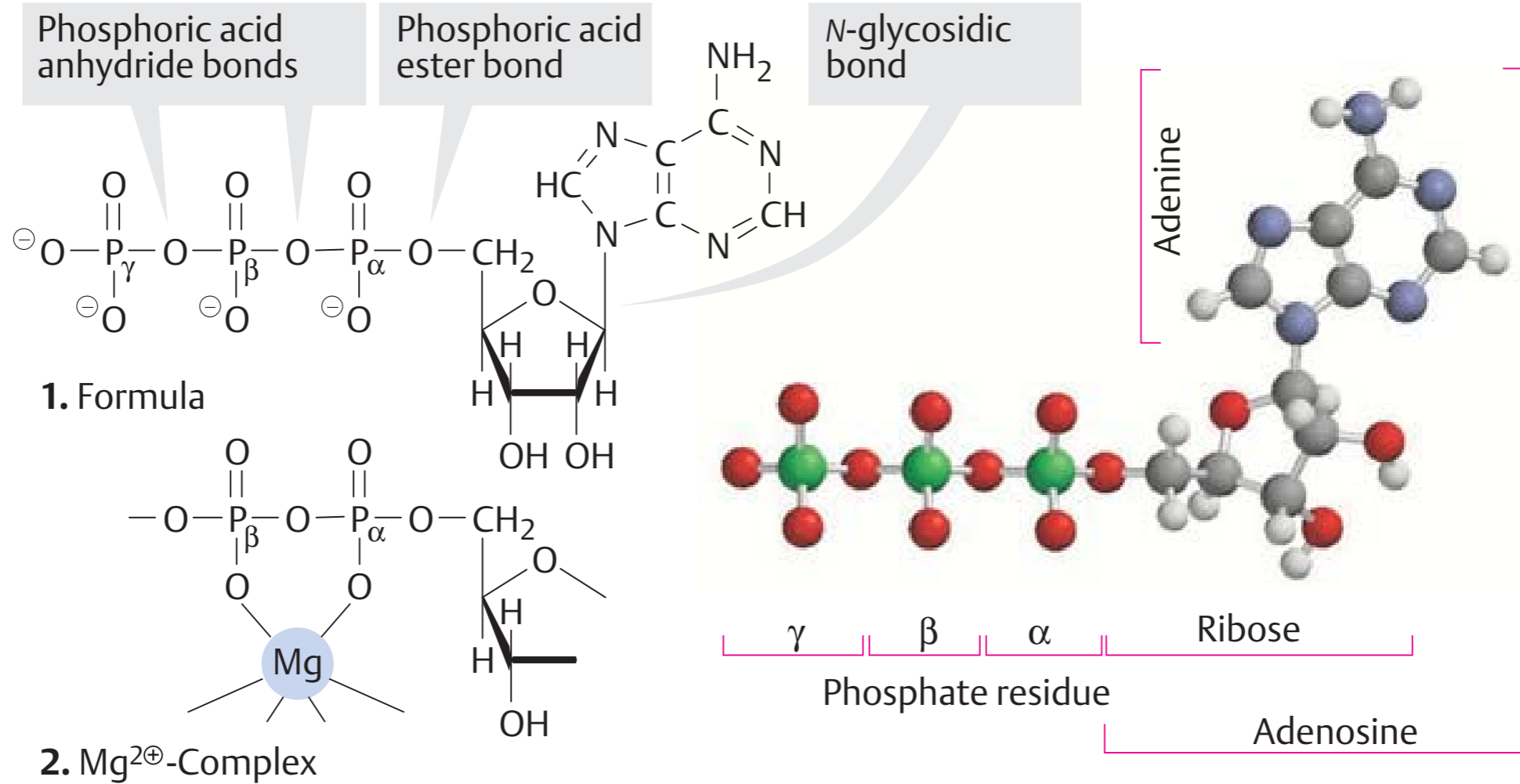
P_i



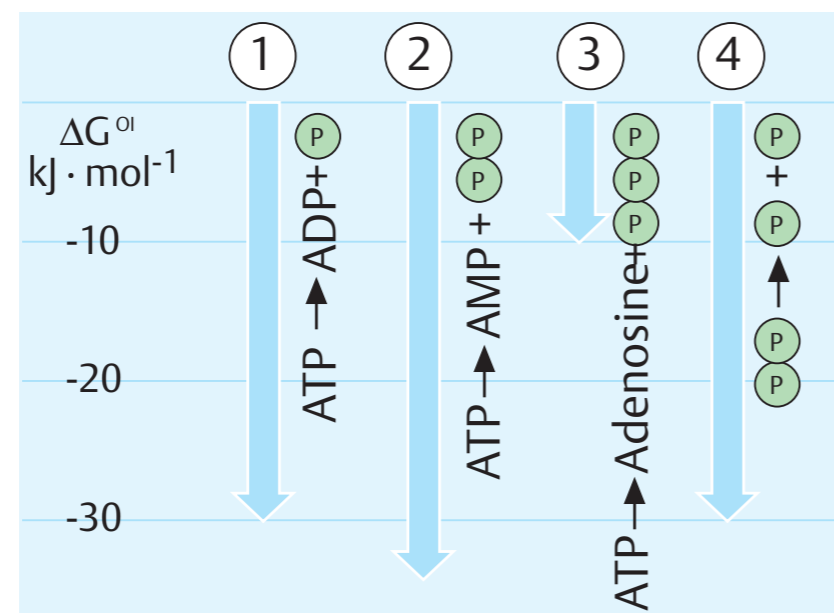
ADP



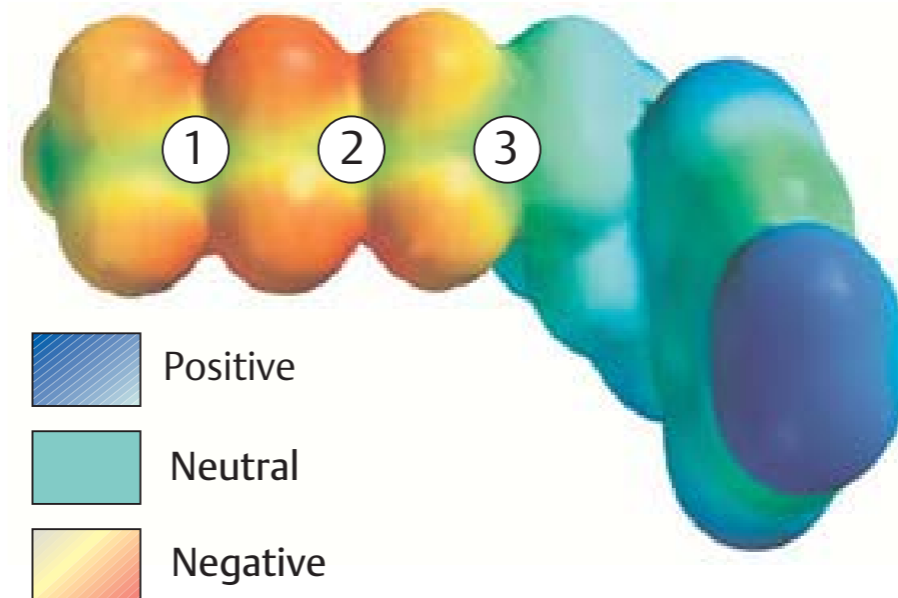
A. ATP: structure



B. Hydrolysis energies



1. Hydrolysis energies



2. ATP: charge density

ATP-ADP ~ varias tipos de reações bioquímicas

ATP-ADP ~ 20 kBT

Ligação covalente típica ~ 150 kBT

NADH ~ 2 ATP

NADPH ~ 2 ATP