Fisica do Corpo Humano (4300325)

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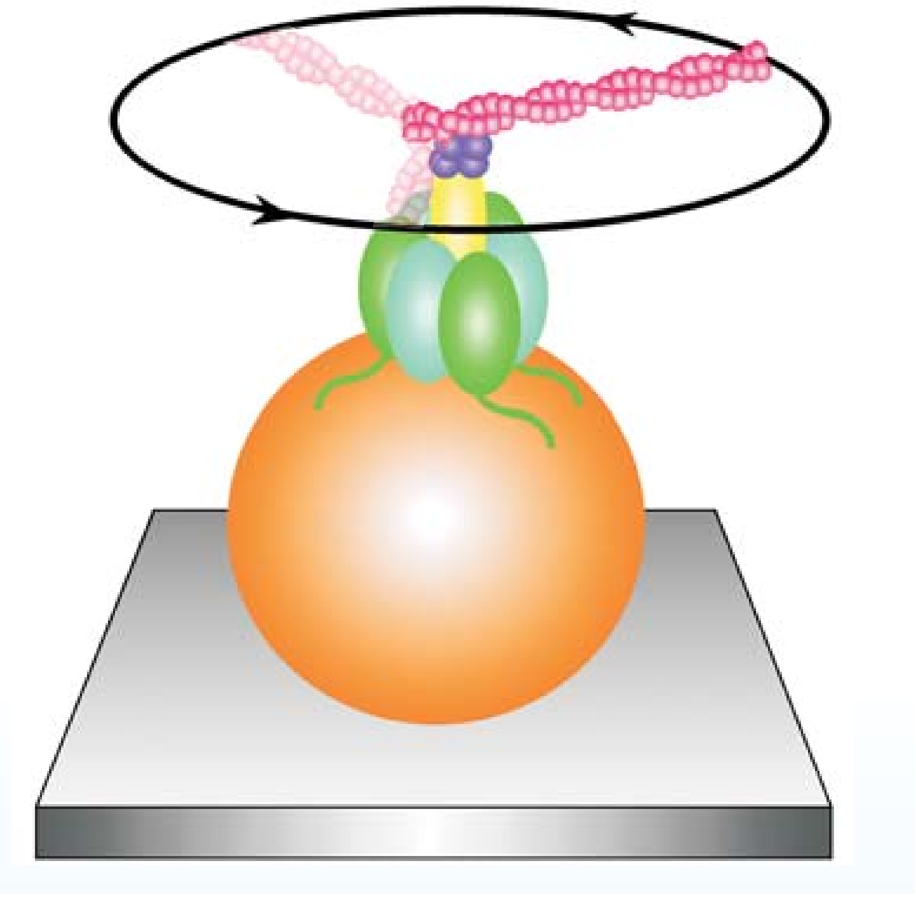
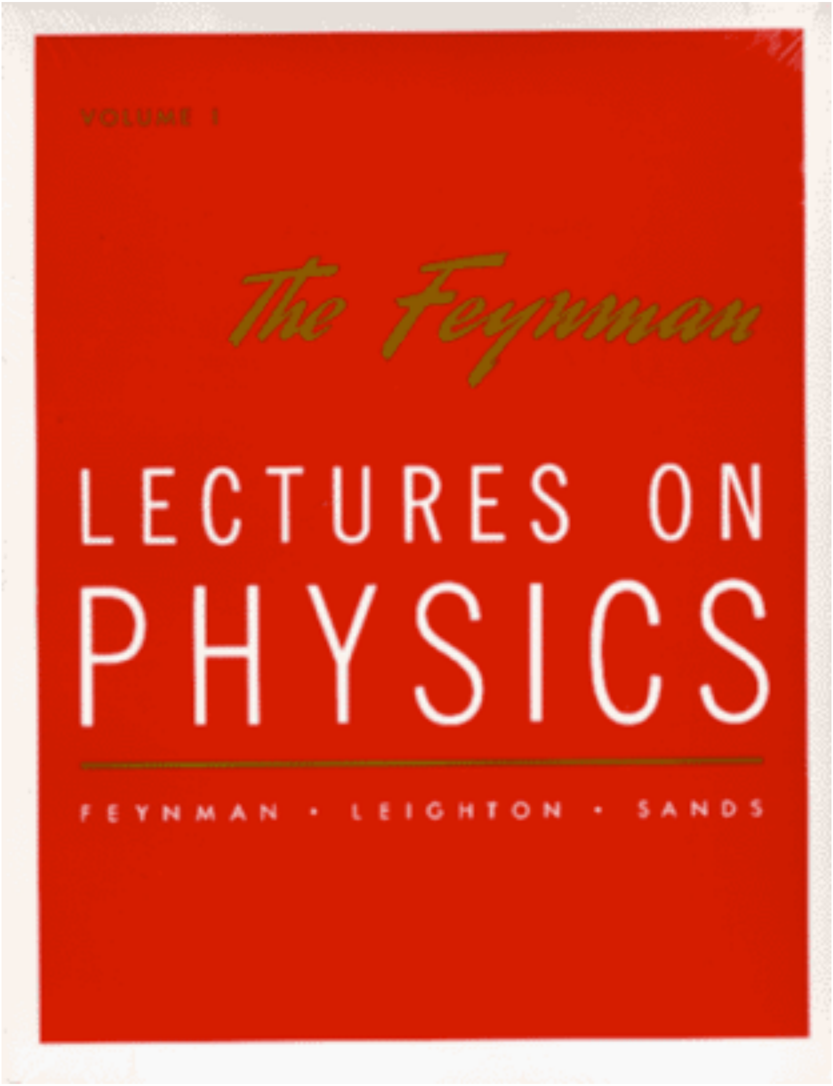
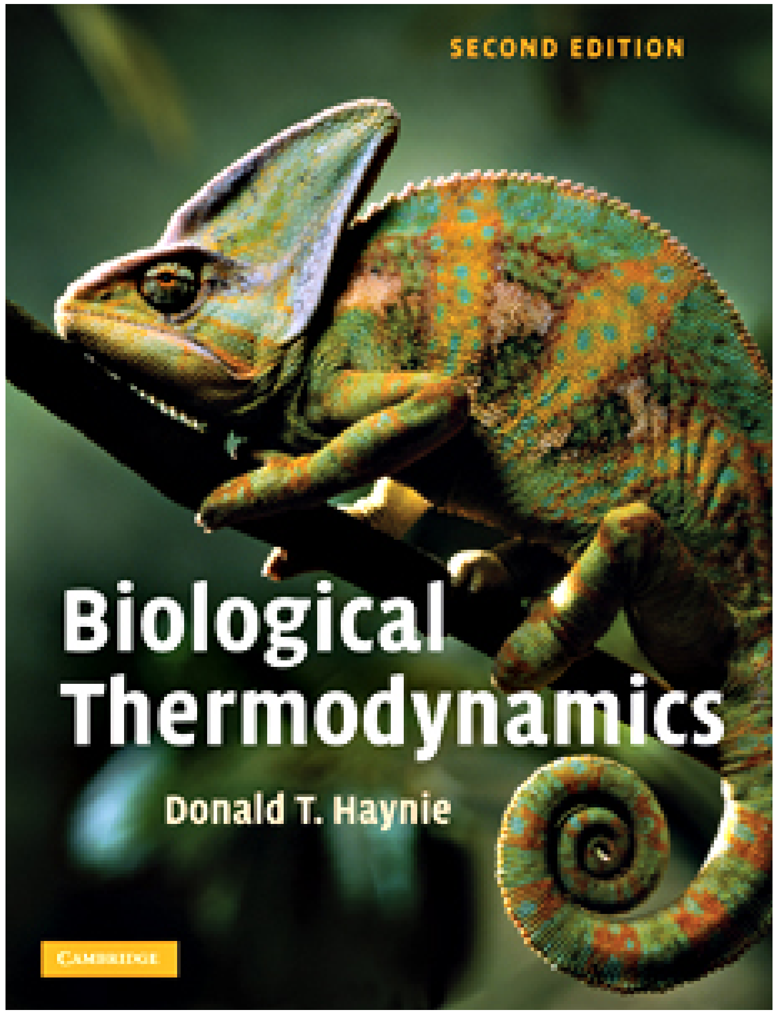
B05

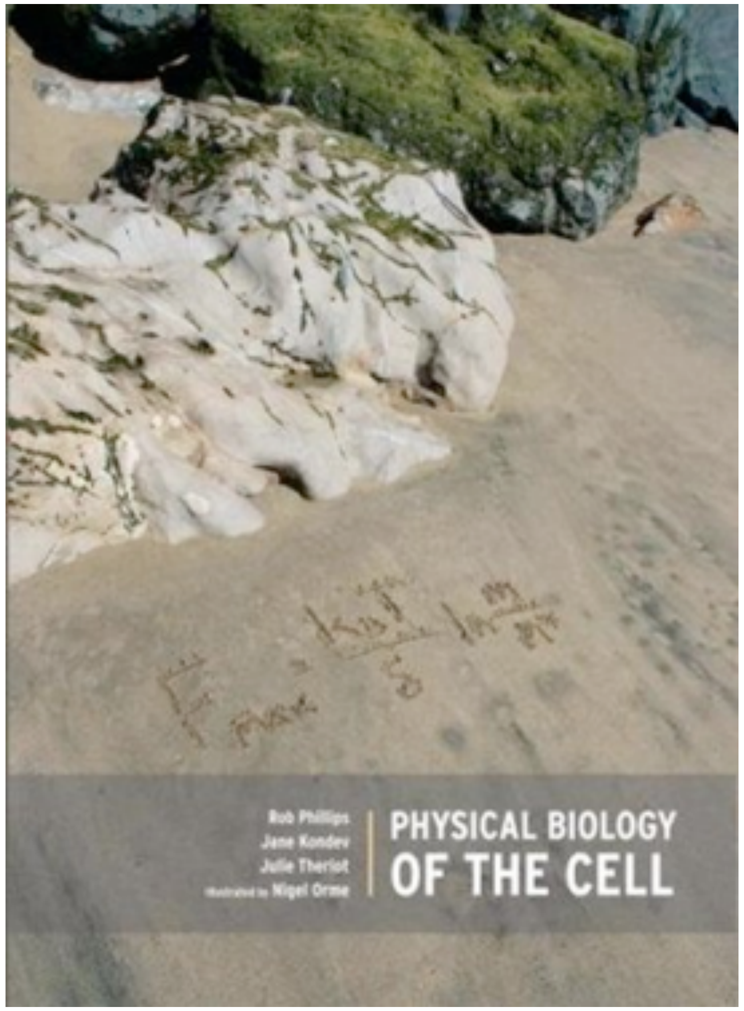
Fibras e Motores
Aula 9



Princípios Físicos Aplicados à Fisiologia (PGF5306-1)







Distribuição de Boltzmann

Figure 6.3a Physical Biology of the Cell, 2ed. (© Garland Science 2013)

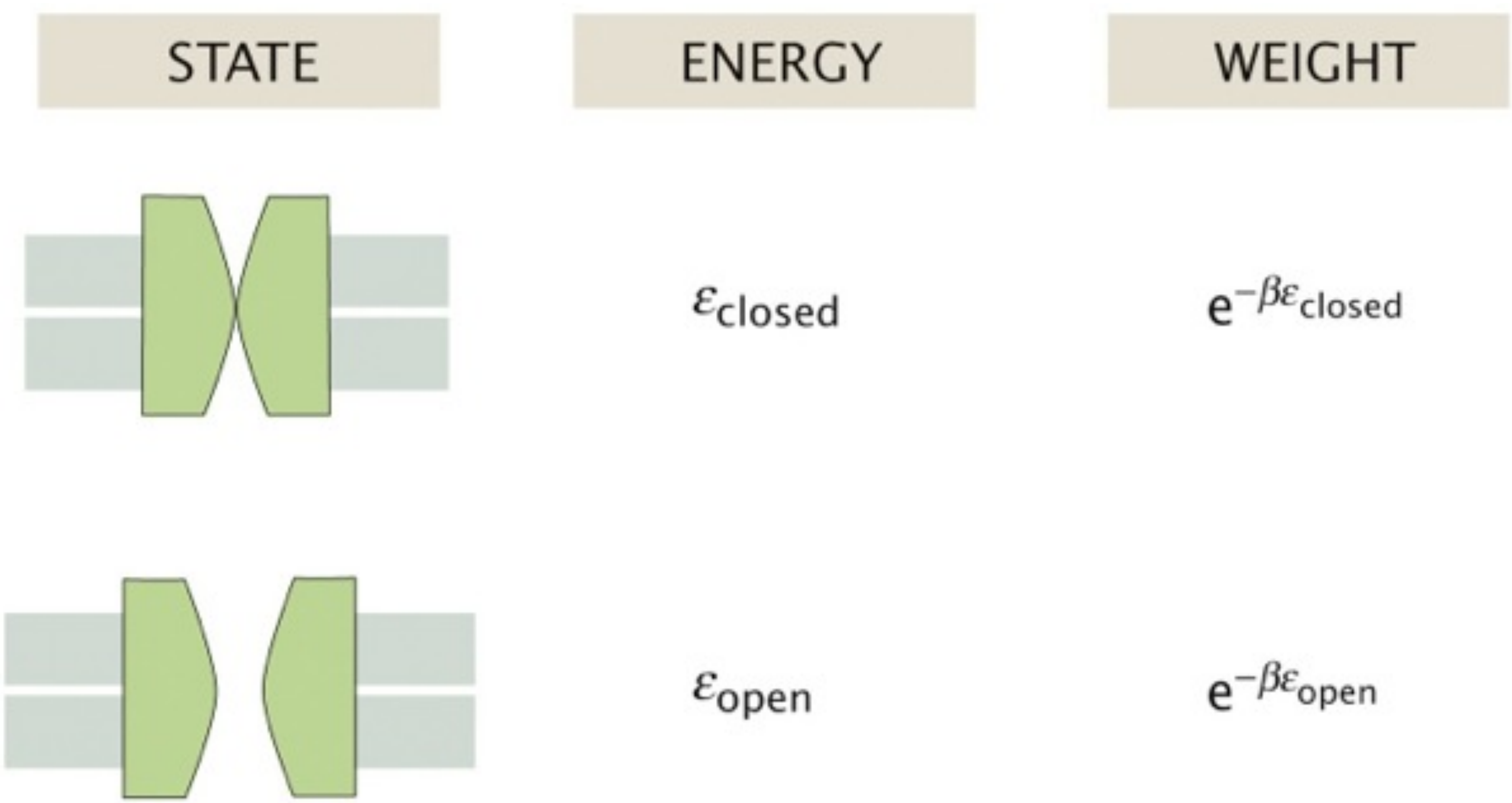


Figure 6.3b Physical Biology of the Cell, 2ed. (© Garland Science 2013)

$$p(E_i) \propto e^{-E_i/k_BT}$$

$$\sum_i^N p(E_i) = 1$$

$$p(E_i) = \frac{1}{Z} e^{-E_i/k_BT}$$

$$Z = \sum_{i=1}^N e^{-E_i/k_BT}$$

Distribuição de Boltzmann

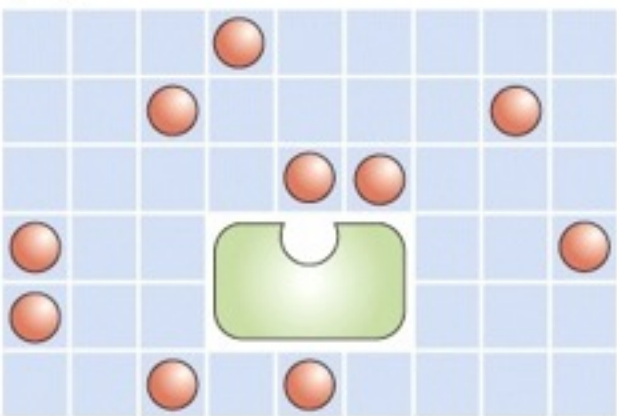
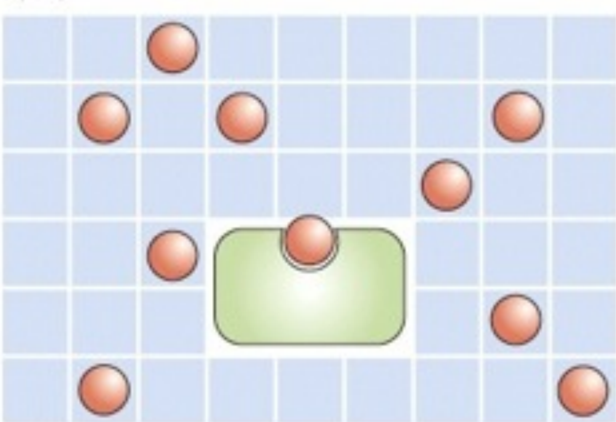
STATE	ENERGY	MULTIPLICITY	WEIGHT
(A) 	$L\varepsilon_{\text{sol}}$	$\dfrac{\Omega!}{L!(\Omega-L)!} \approx \dfrac{\Omega^L}{L!}$	$\dfrac{\Omega^L}{L!}\, e^{-\beta L\varepsilon_{\text{sol}}}$
(B) 	$(L-1)\varepsilon_{\text{sol}} + \varepsilon_{\text{b}}$	$\dfrac{\Omega!}{(L-1)!(\Omega-L+1)!} \approx \dfrac{\Omega^{L-1}}{(L-1)!}$	$\dfrac{\Omega^{L-1}}{(L-1)!}\, e^{-\beta[(L-1)\varepsilon_{\text{sol}} + \varepsilon_{\text{b}}]}$

Figure 6.4 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

$$p(E_i) \propto e^{-E_i/k_B T}$$

Estrutura Atômica

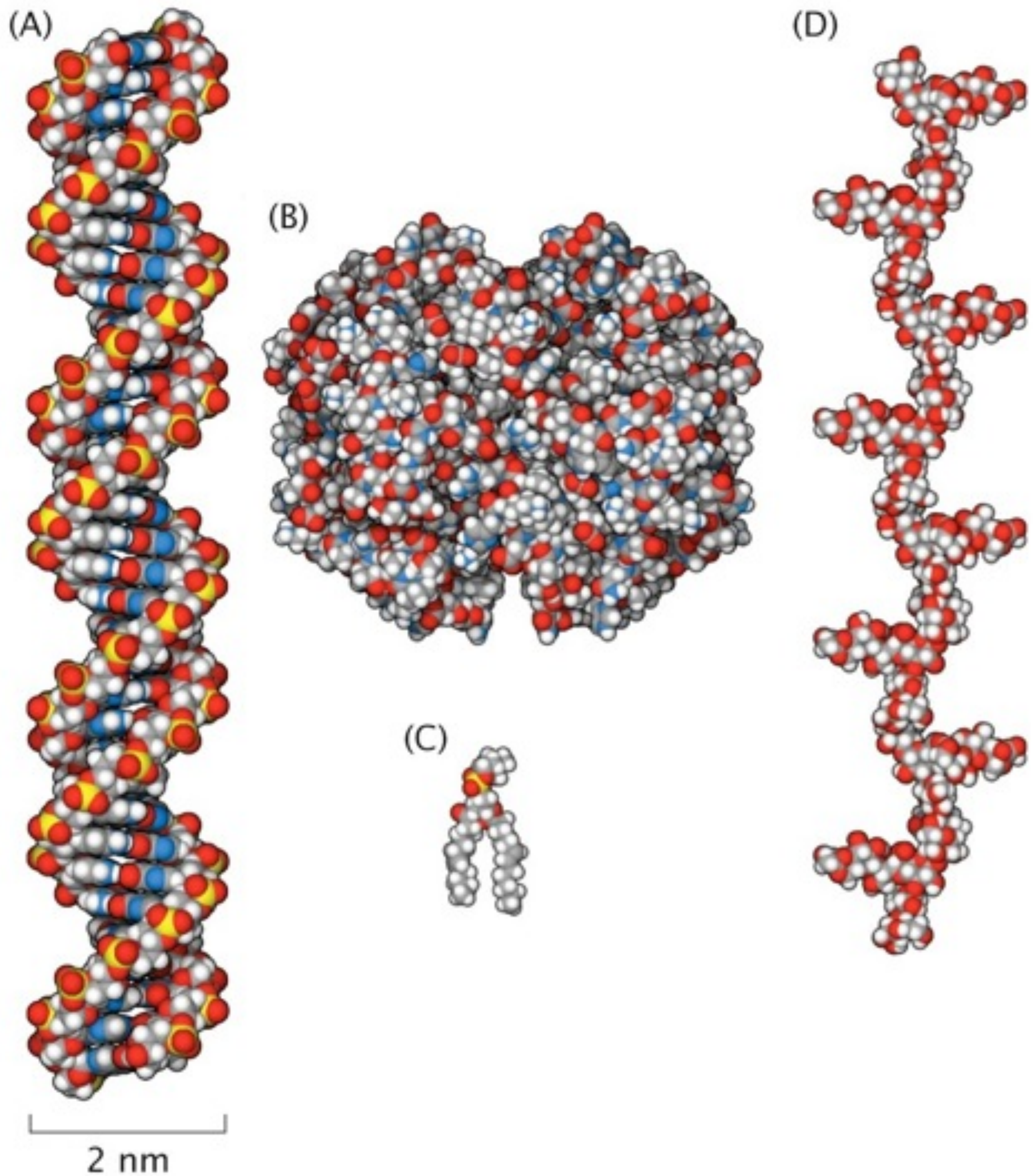


Figure 1.1 Atomic-level structural representation of members of each of the major classes of macromolecules, all drawn at the same scale. Charged nitrogen, oxygen, and phosphorus atoms, and the hydrogen atoms that are directly bonded to them, are colored black. Polar nitrogen, oxygen, and sulfur atoms, and the hydrogen atoms that are directly bonded to them, are colored gray. Carbon atoms and the hydrogen atoms that are directly bonded to them are colored light gray. (A) Atomic structure of a small fragment of the nucleic acid DNA in the B form, (B) atomic structure of the oxygen-carrying protein hemoglobin, (C) phosphatidylcholine lipid molecule from a cell membrane, and (D) branched complex carbohydrate (M41 capsular polysaccharide) from the surface of the bacterium *Escherichia coli*. (Illustrations courtesy of D. Goodsell.)

Figure 1.1 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Alfabeto

Figure 1.2 Illustration of Crick's "two great polymer languages." The left-hand column shows how nucleic acids can be thought of in terms of letters (nucleotides), words (codons), and sentences (genes). The right-hand column illustrates a similar idea for proteins, where the letters correspond to amino acids, the words to elements of secondary structure such as α helices and β strands, and the sentences to fully folded functional proteins.

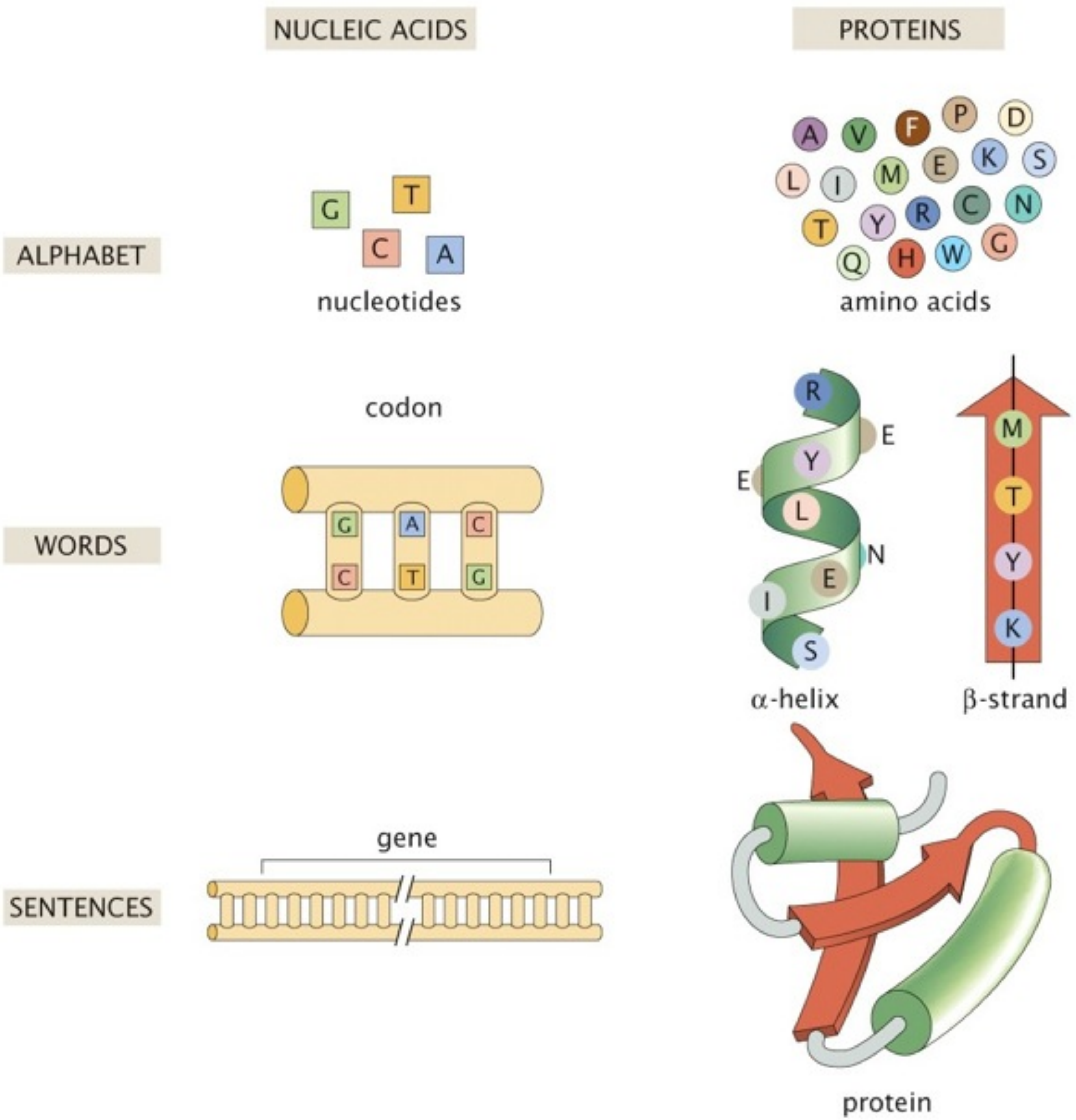


Figure 1.2 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

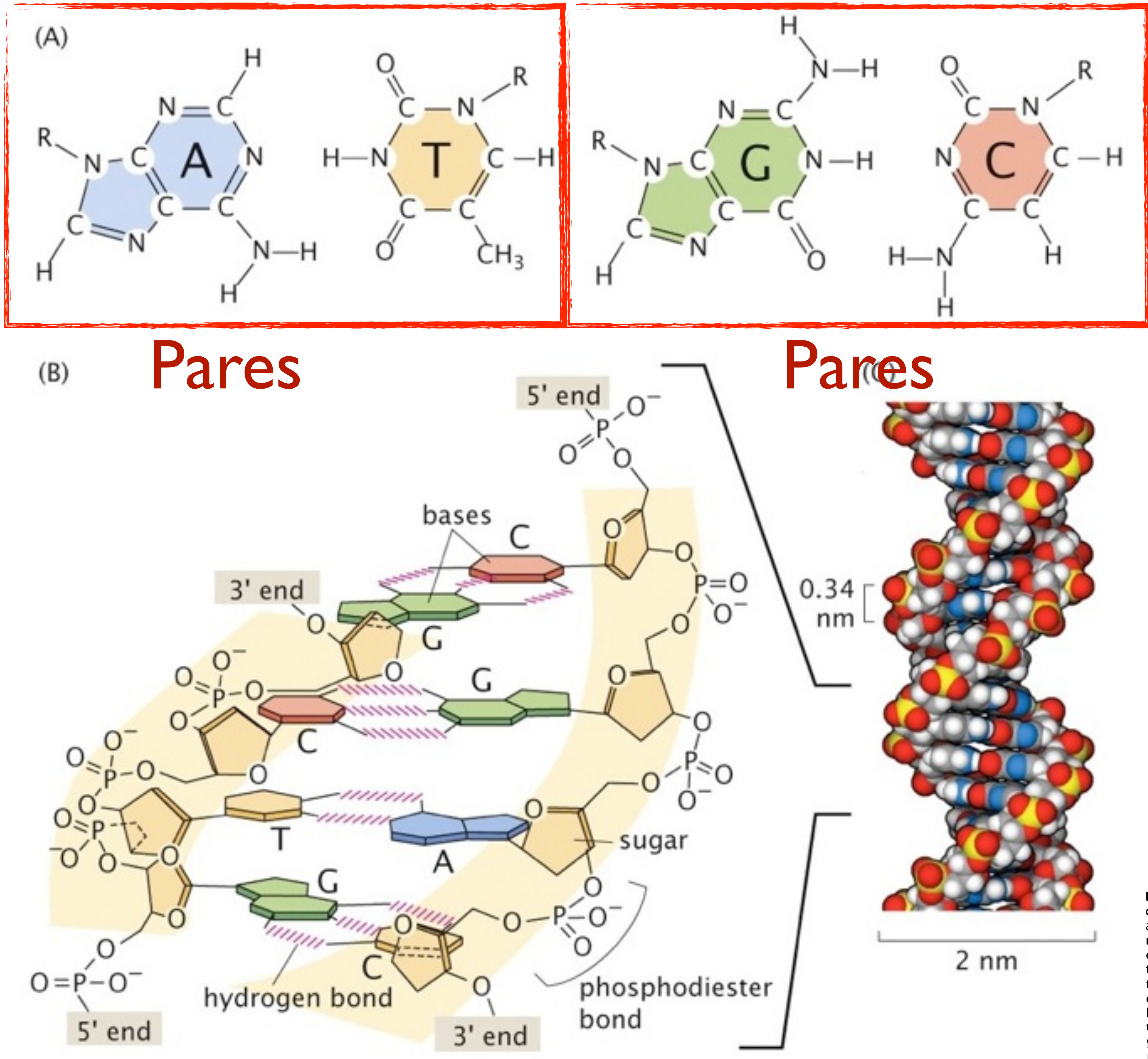


Figure 1.3 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Figure 1.3 The chemical structure of nucleotides and DNA. (A) In DNA, the four distinct subunits or bases are abbreviated: A (adenine), T (thymine), G (guanine), and C (cytosine). In these diagrams, carbon is represented by C, oxygen by O, nitrogen by N and hydrogen by H. The letter R indicates attachment to a larger chemical group (the rest of the molecule); for nucleotides, the R group consists of the pentose sugar deoxyribose attached to phosphate. A single line connecting two atoms indicates a single covalent bond and a double line indicates a double covalent bond. The two large bases, A and G, are called purines and the two small bases, C and T, are called pyrimidines. (B) Illustration of how bases are assembled to form DNA, a double helix with two "backbones" made of the deoxyribose and phosphate groups. The four bases are able to form stable hydrogen bonds uniquely with one partner such that A pairs only with T and G pairs only with C. The structural complementarity of the bases enables the faithful copying of the nucleotide sequence when DNA is replicated or when RNA is transcribed. (C) Space-filling atomic model approximating the structure of DNA. The spacing between neighboring base pairs is 0.34 nm. (Adapted from B. Alberts et al., Molecular Biology of the Cell, 5th ed. New York, Garland Science, 2008.)

Código Proteico

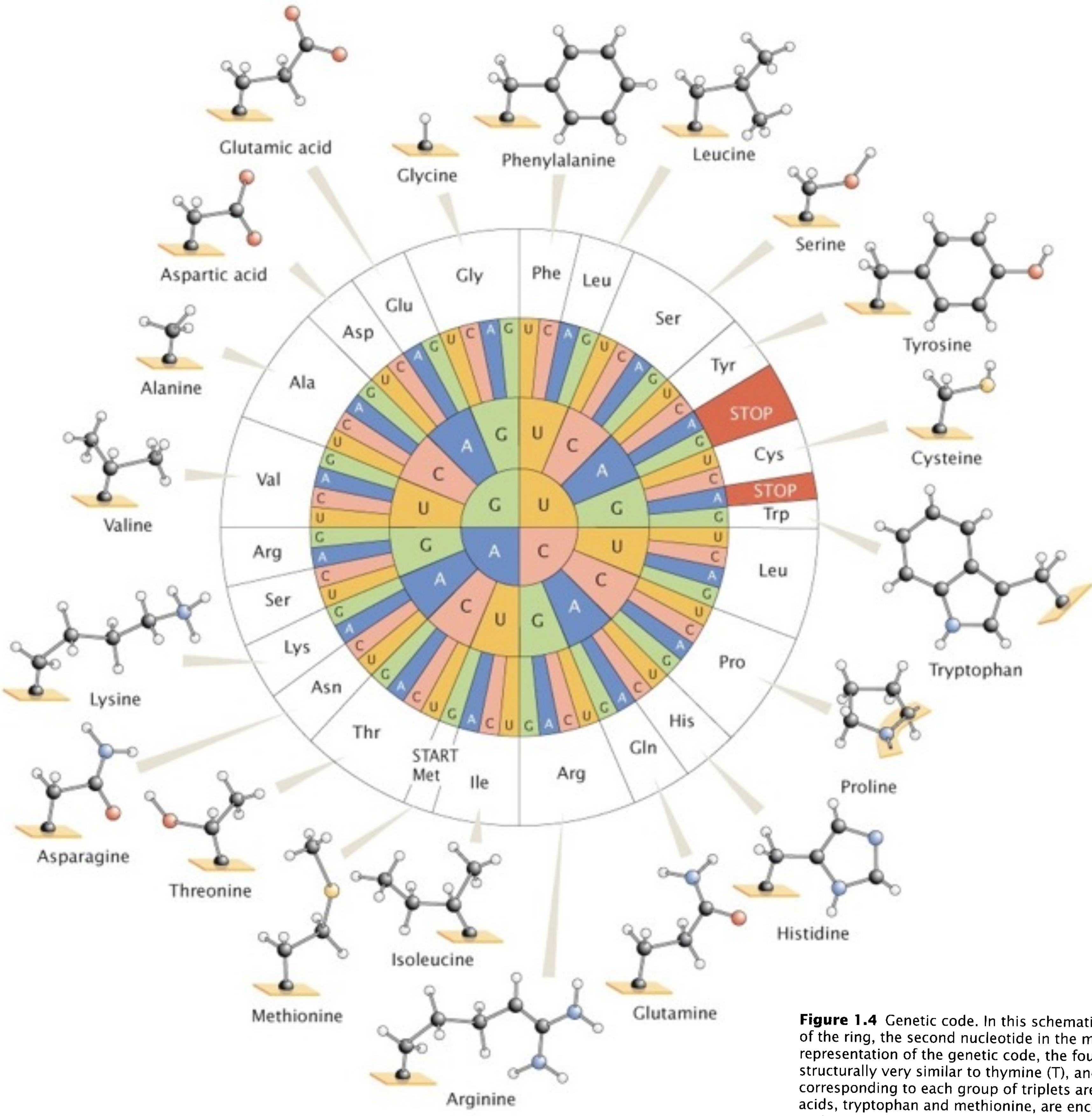


Figure 1.4 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Figure 1.4 Genetic code. In this schematic representation, the first nucleotide in a coding triplet is shown at the center of the ring, the second nucleotide in the middle shaded ring and the third nucleotide in the outer shaded ring. In this representation of the genetic code, the four bases are adenine (A), cytosine (C), guanine (G) and uracil (U). Uracil is structurally very similar to thymine (T), and is used instead of thymine in messenger RNA. The amino acids corresponding to each group of triplets are illustrated with their names (outer ring) and atomic structures. Two amino acids, tryptophan and methionine, are encoded by only a single triplet, whereas others including serine, leucine, and arginine are encoded by up to six. Three codons do not code for any amino acid and are recognized as stop signals. The unique codon for methionine, AUG, is always used to initiate protein synthesis.

Aminoácidos

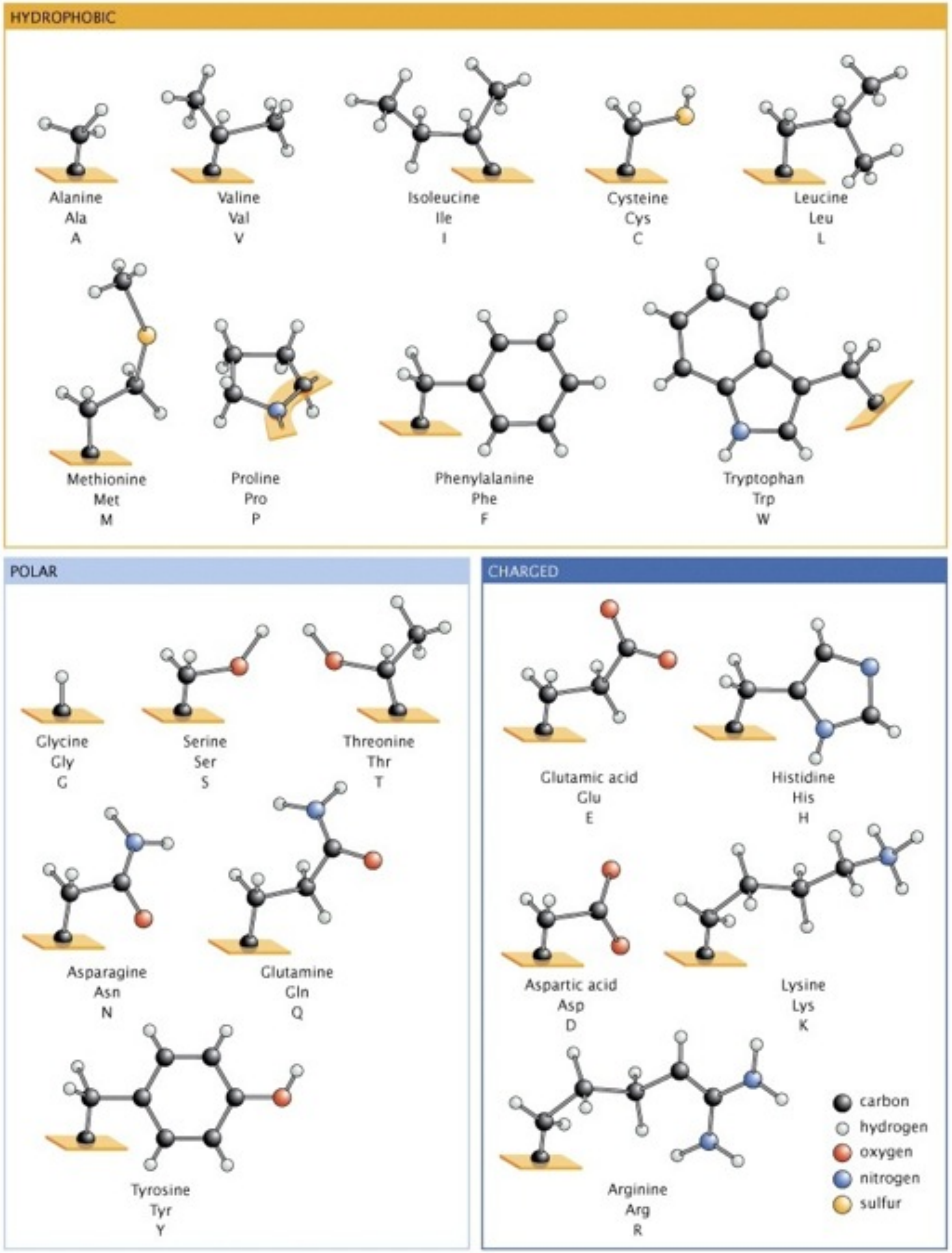


Figure 2.33 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Idealizações

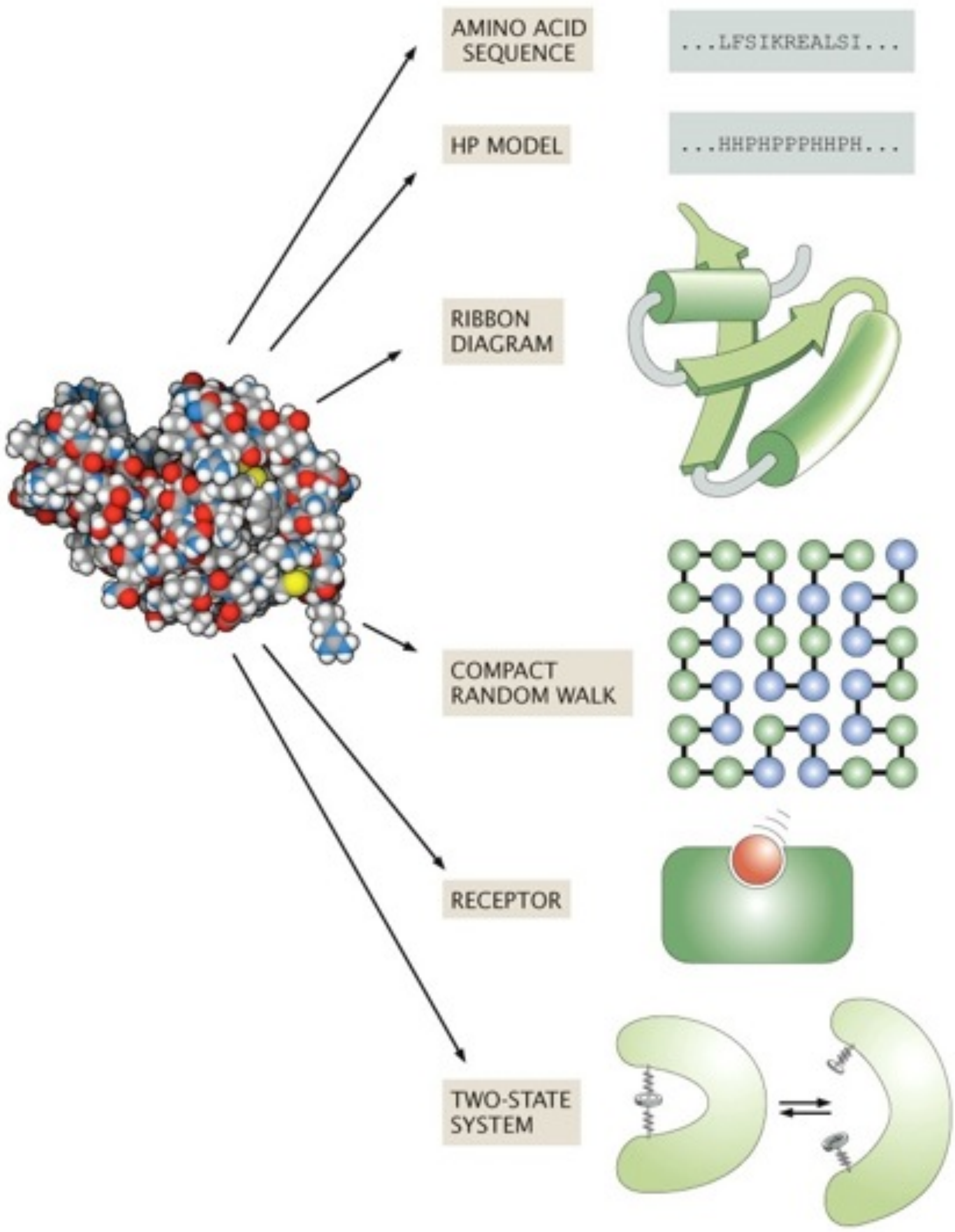


Figure 1.6 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

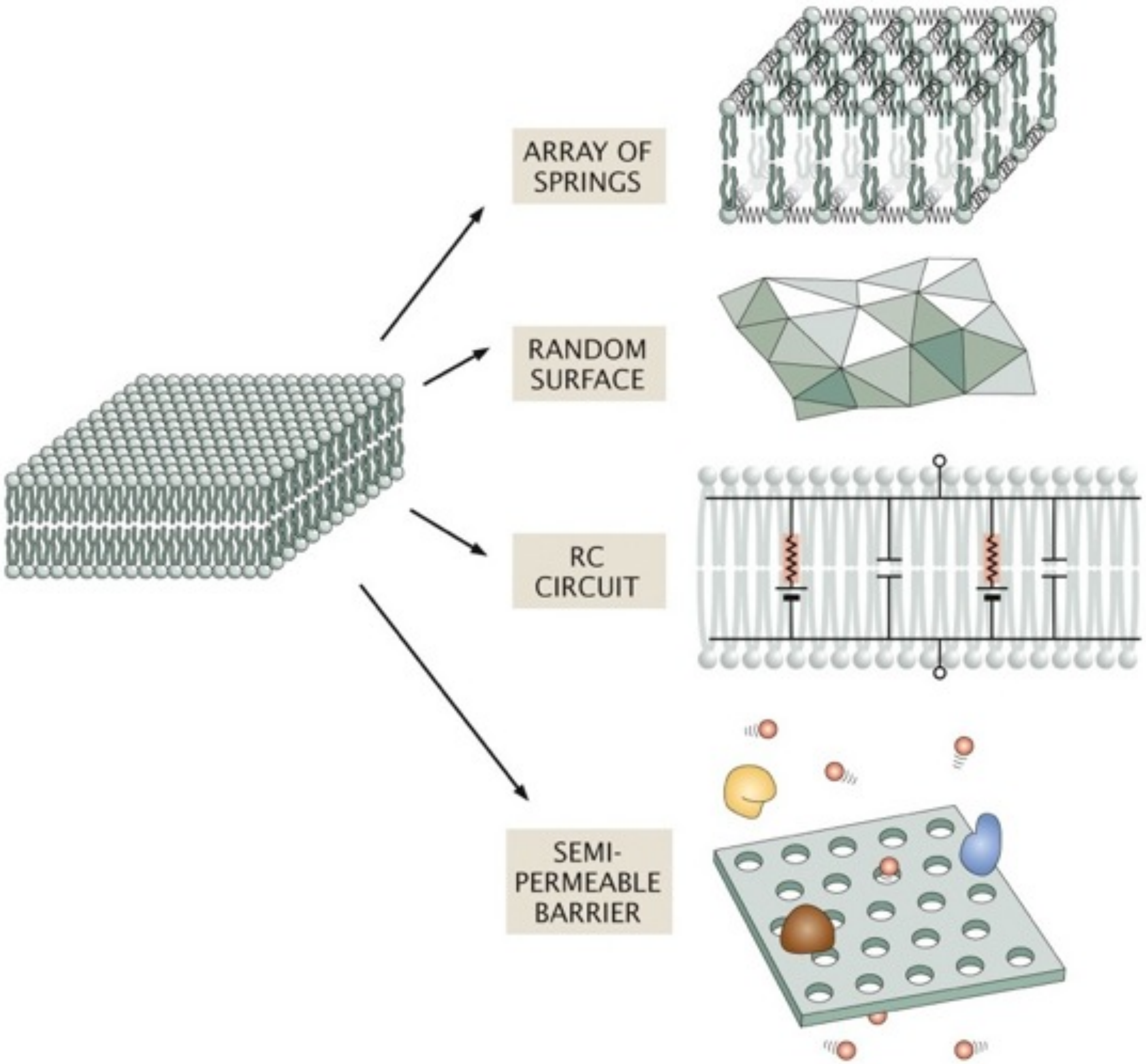
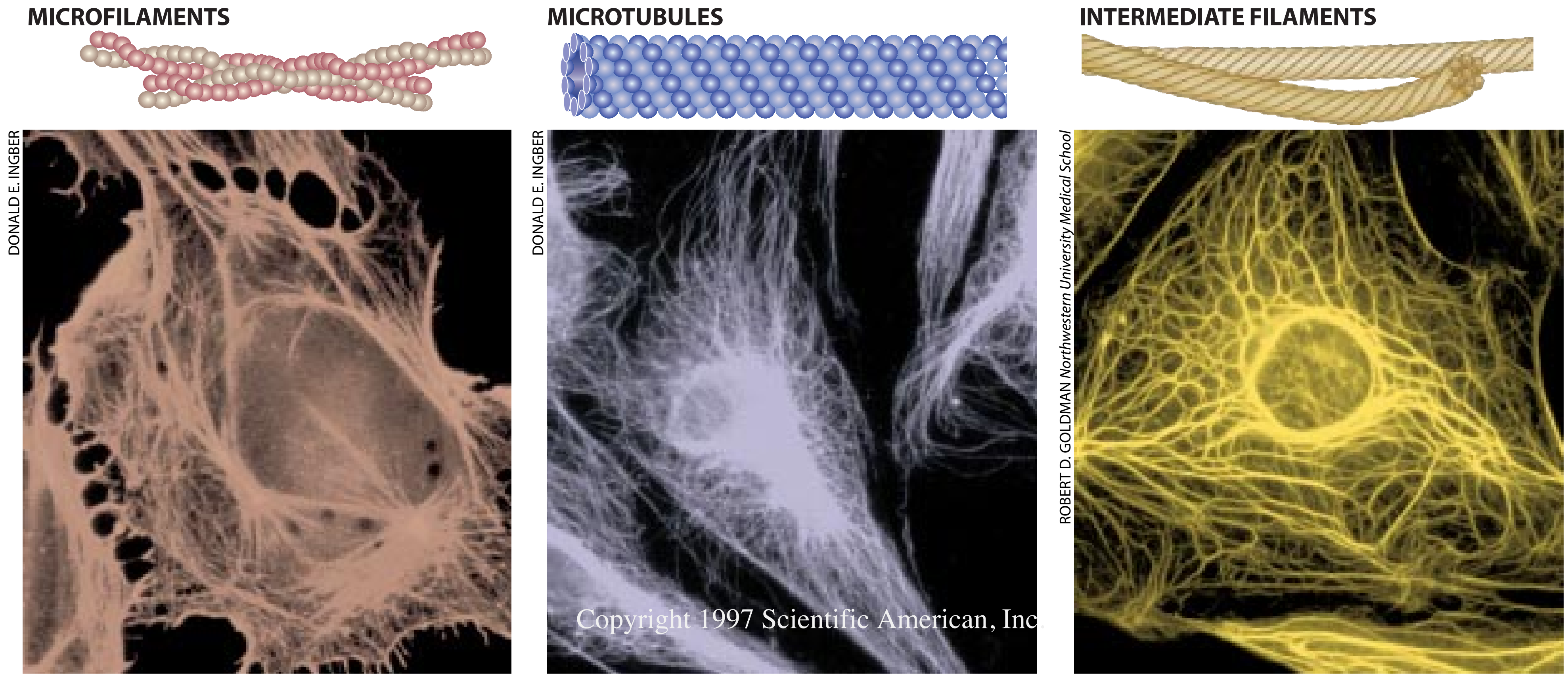
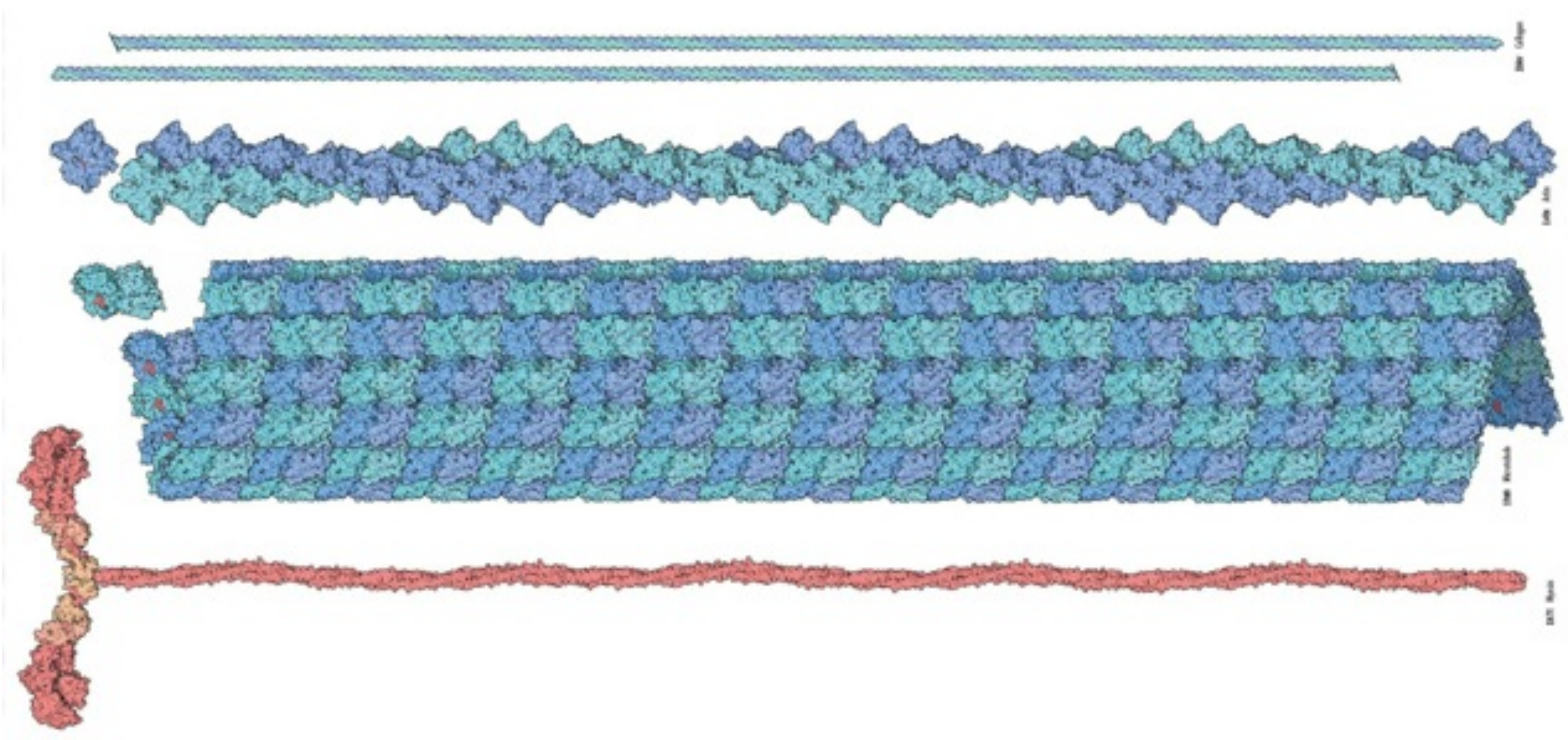


Figure 1.7 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Somos Feitos Disso





Colágeno, F-actina, microtúbulo e filamento de miosina

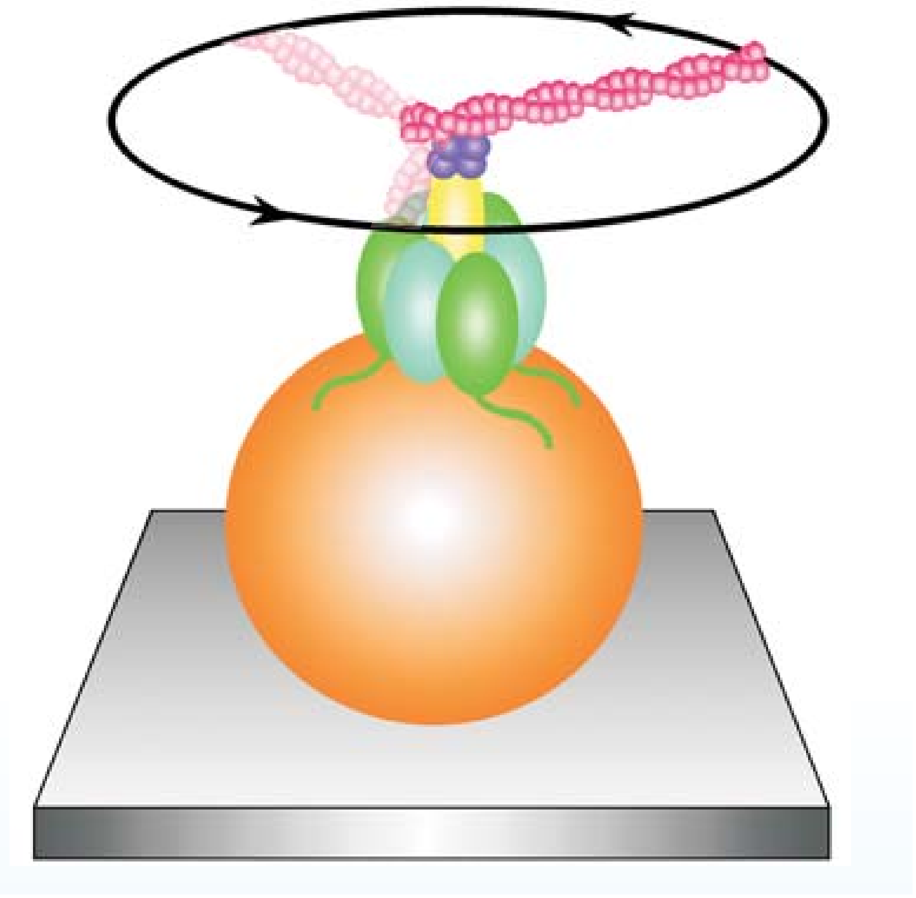
Somos Feitos Assim

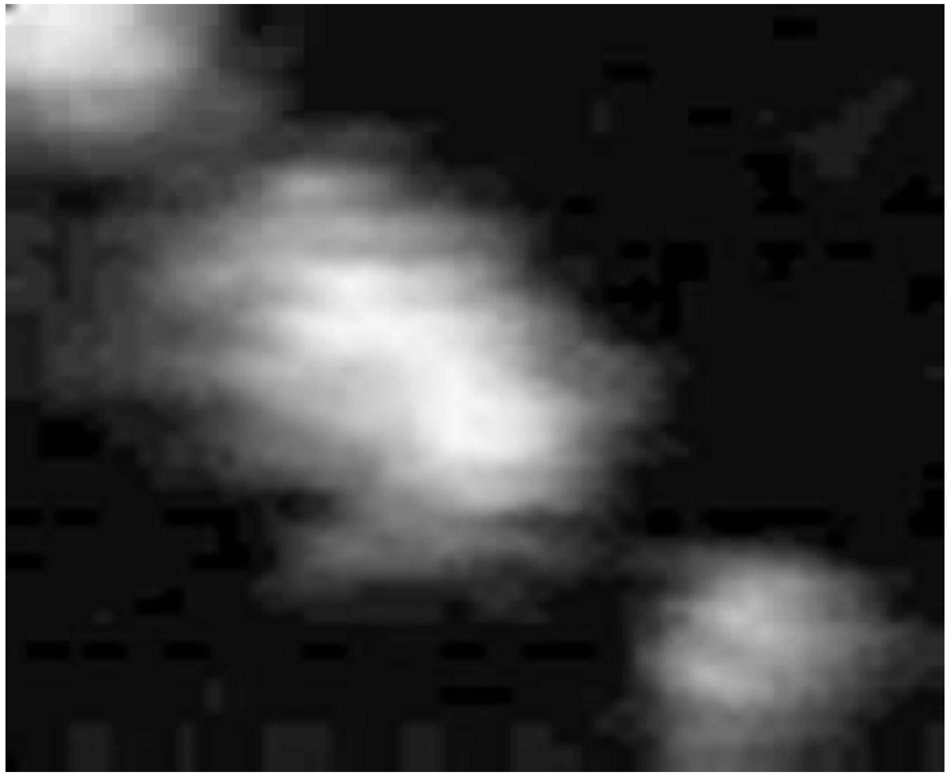
Tensegrity

Ou Assim?

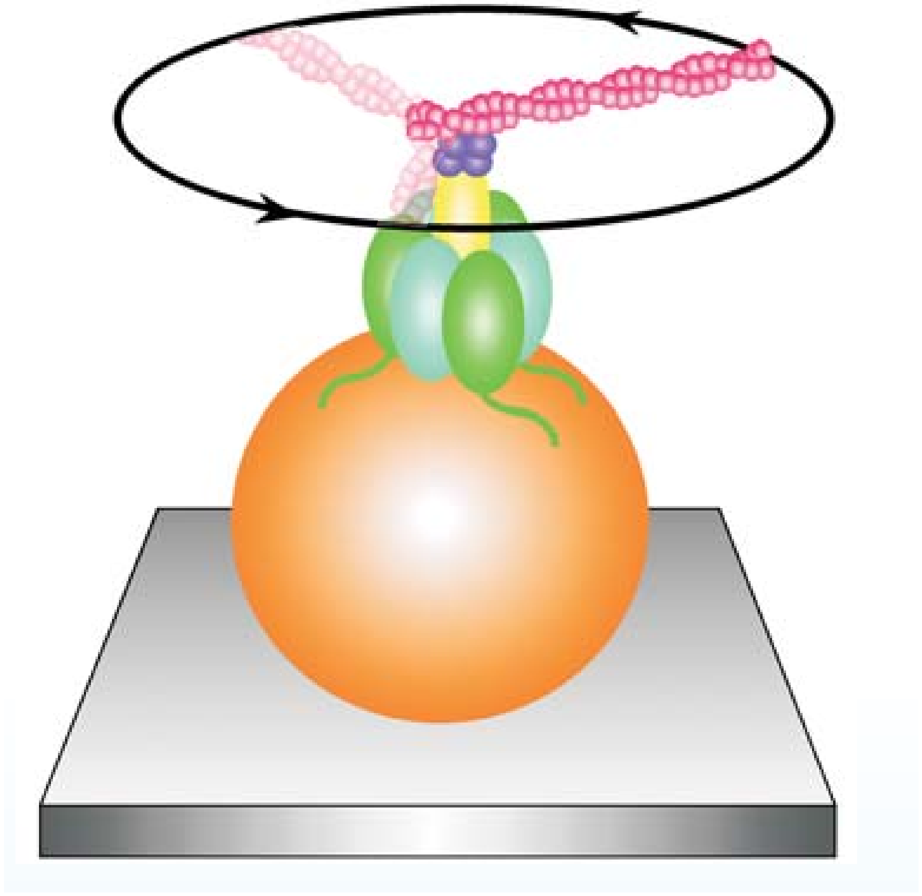
Células se comportam, do ponto de vista mecânico, como um vidro mole…

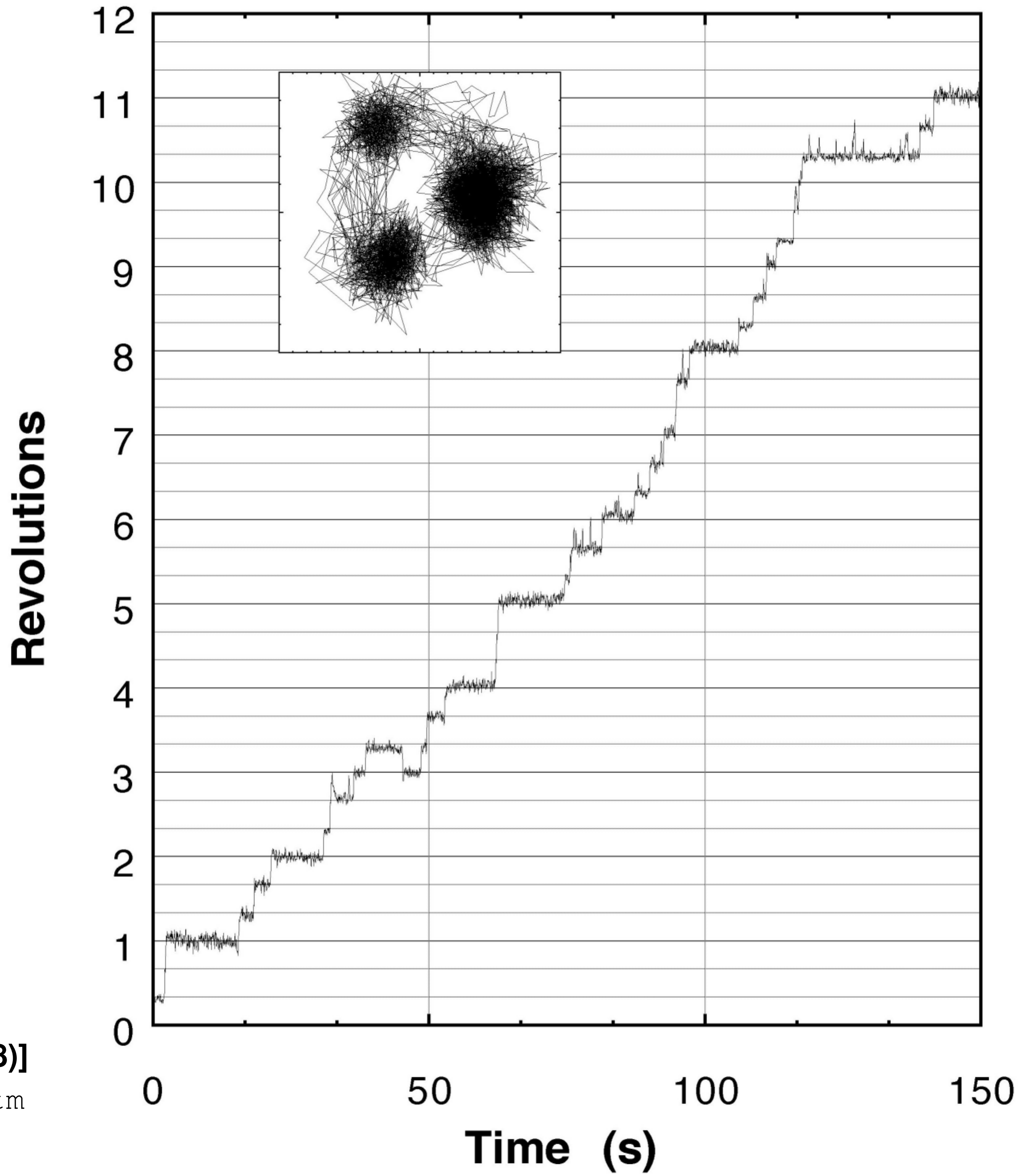
Motores Celulares





Distribuição de Boltzmann



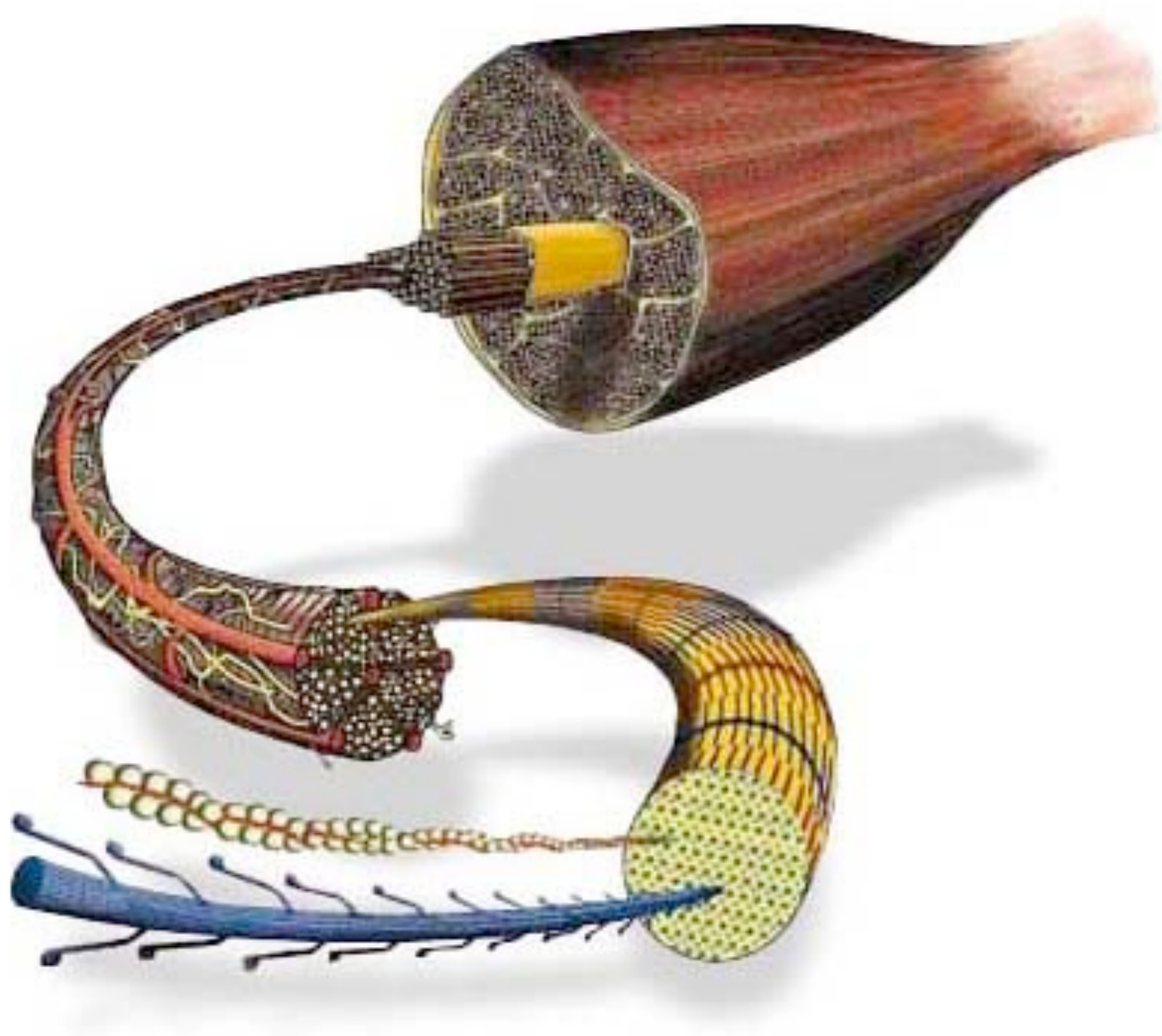


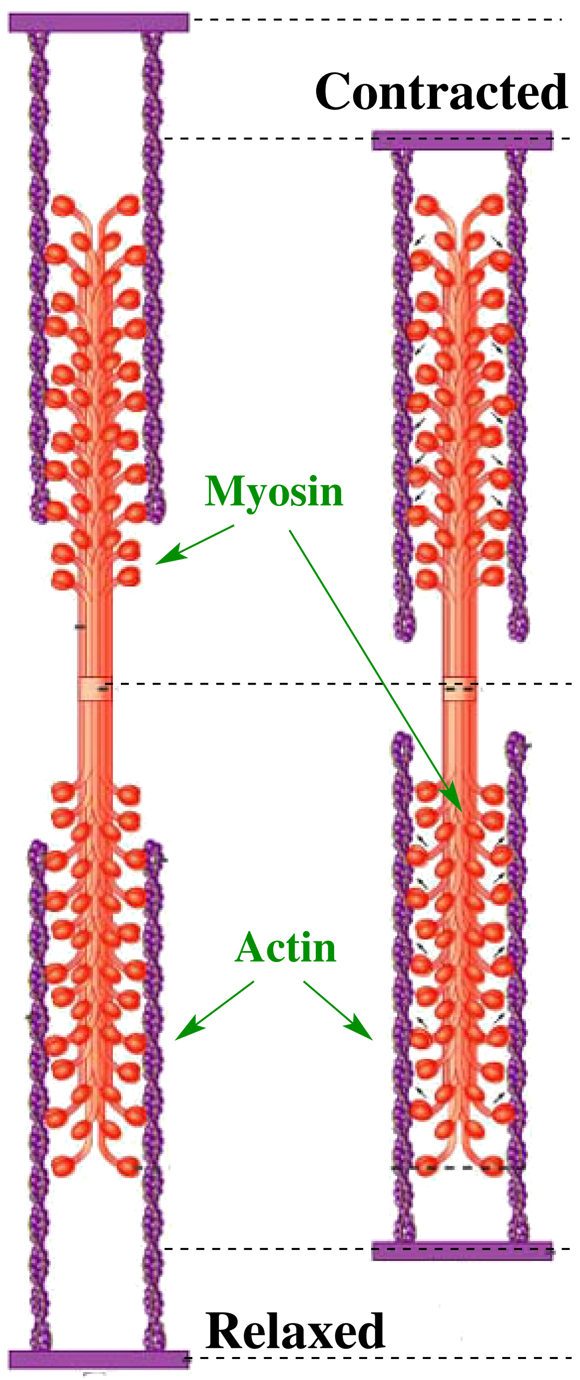
[R. Yasuda et al., Cell 93, 1117 (1998)]

http://www.k2.phys.waseda.ac.jp/F1movies/F1Step.htm

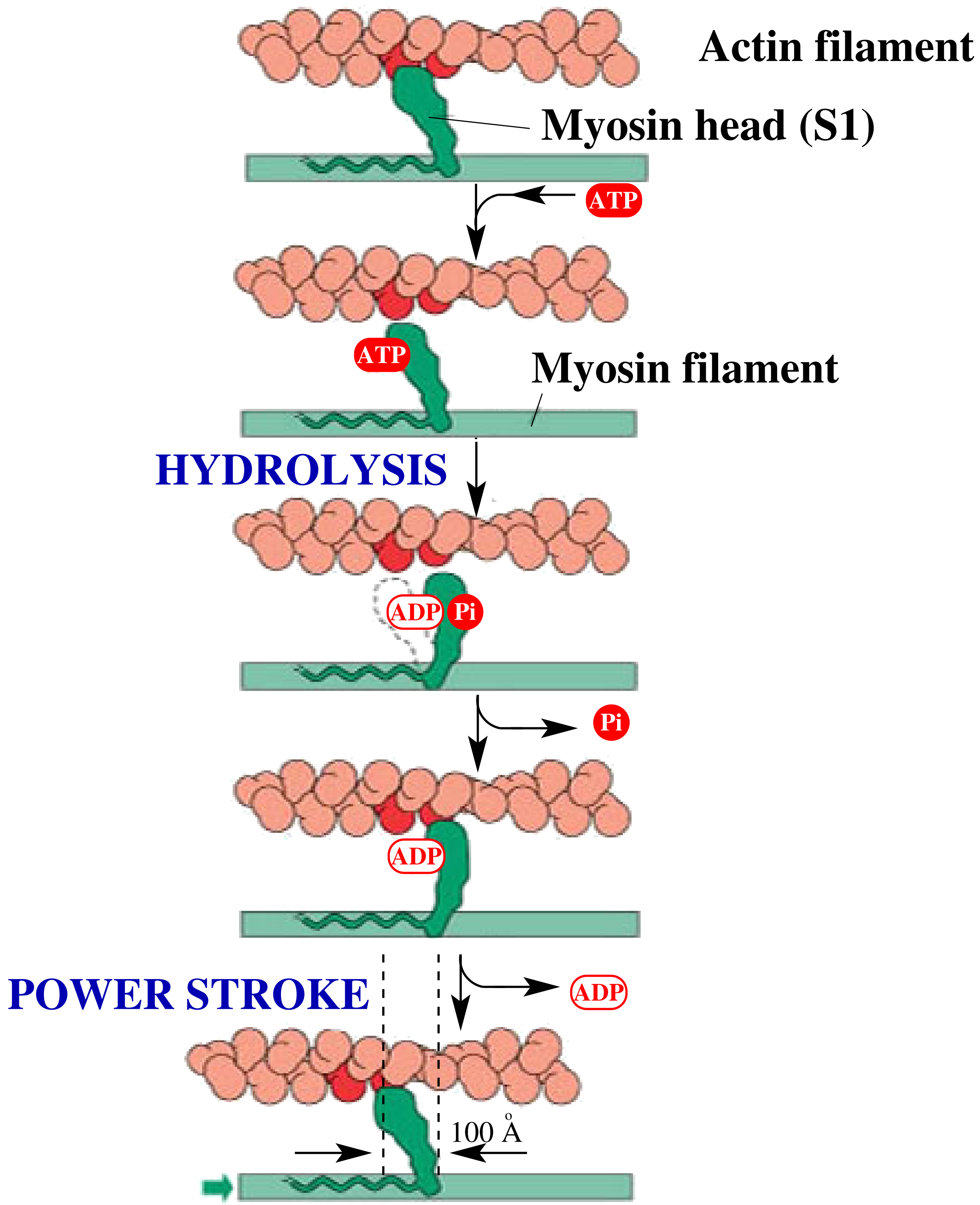
Motores Celulares

O Sistema Acto-Miosina é presente em praticamente todas as celulas eucariontes (com núcleo)





Motores Celulares



1 - Rigor (mortis)

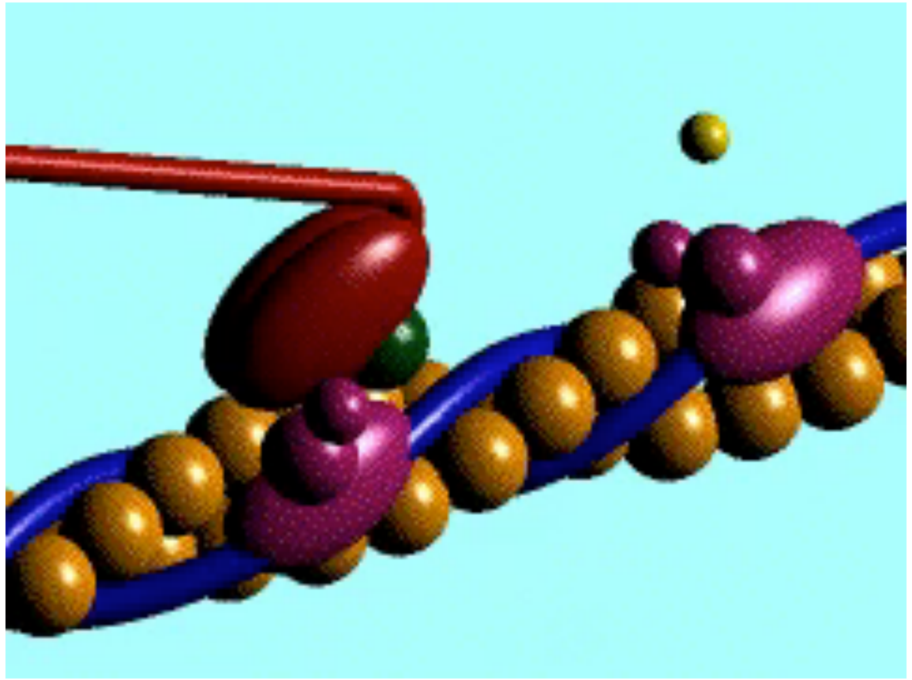
short-lived during contraction

2 - Released

ATP reduces the affinity of S1 for the actin filament

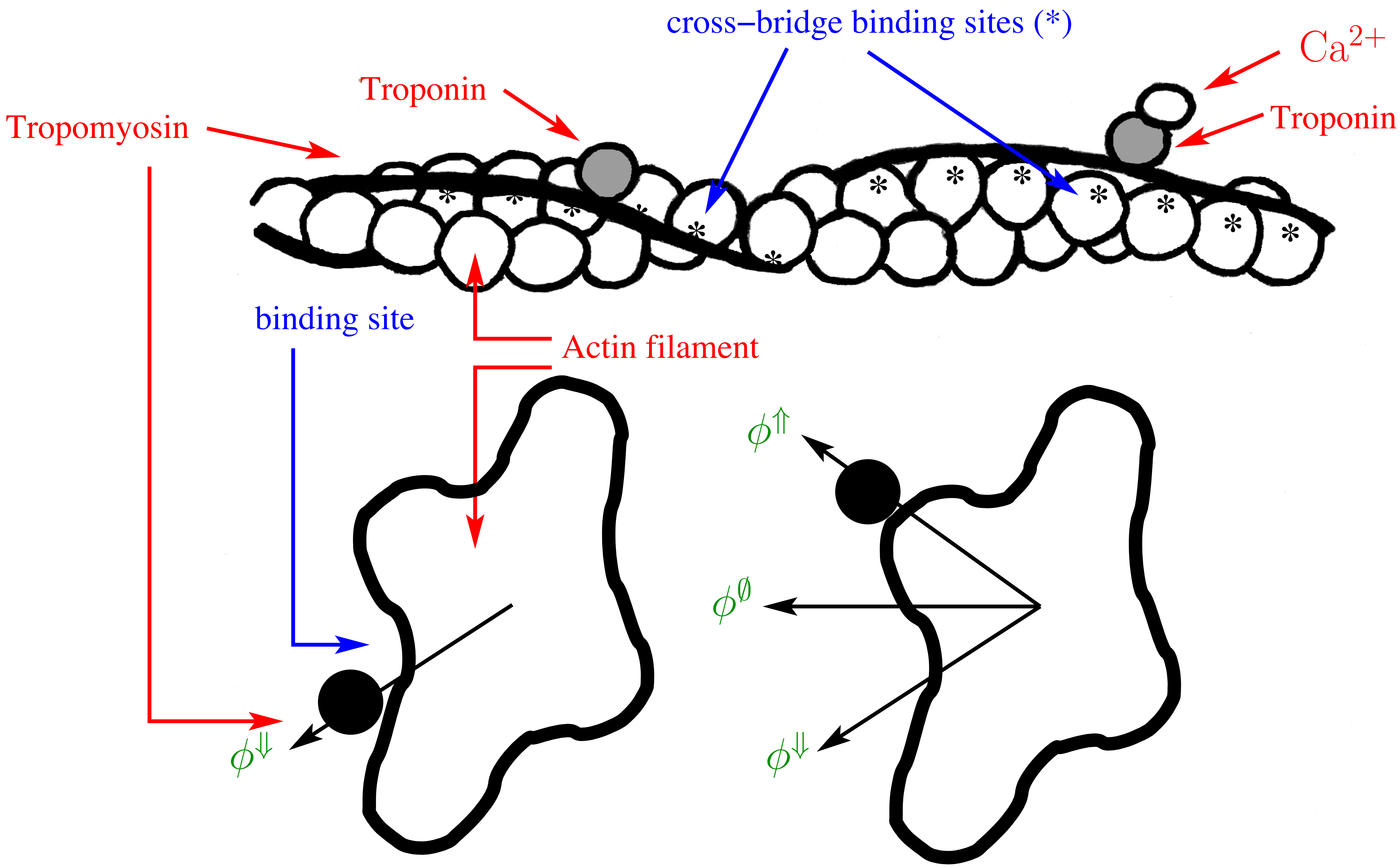
3 - ATP Hydrolysis

S1 binds to actin and releases Pi triggering the power stroke



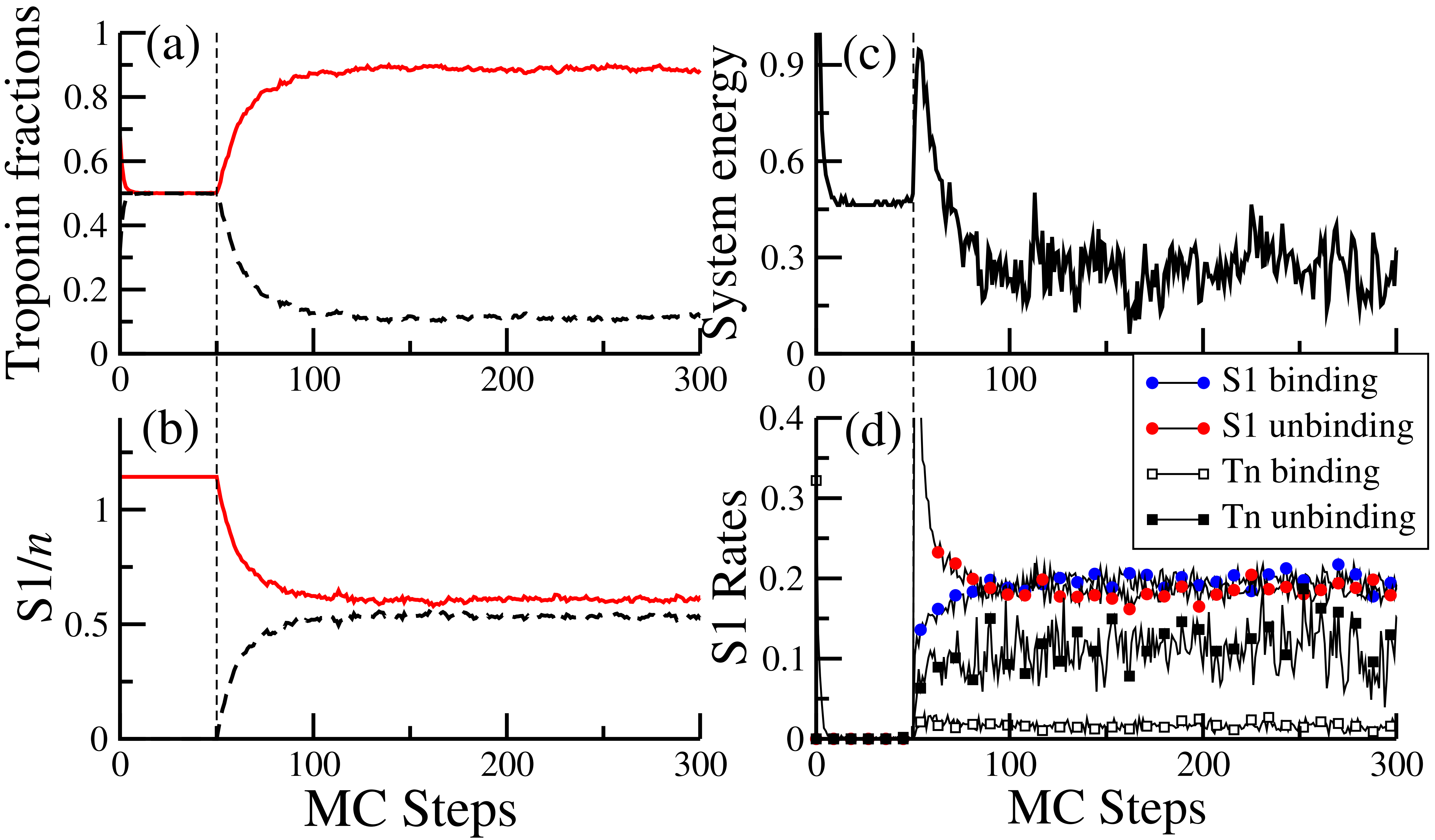
Motores Celulares

Fibra de Tropomiosina

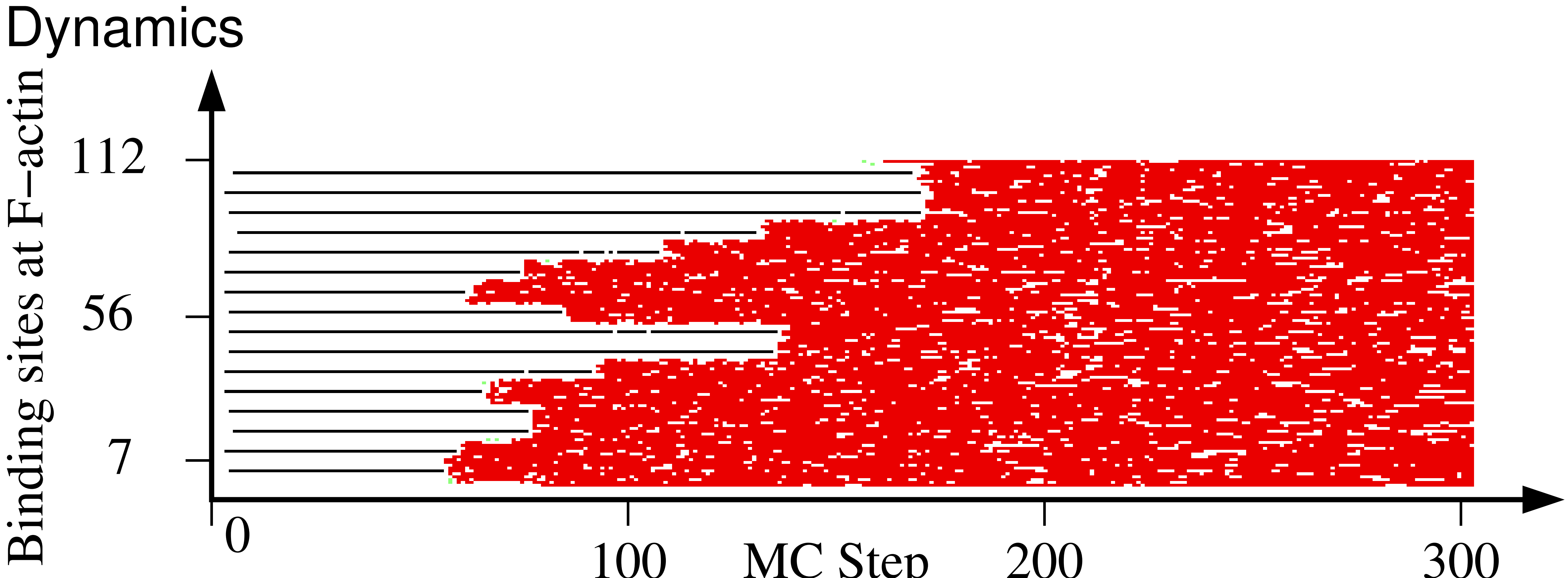


Motores Celulares

Dynamics

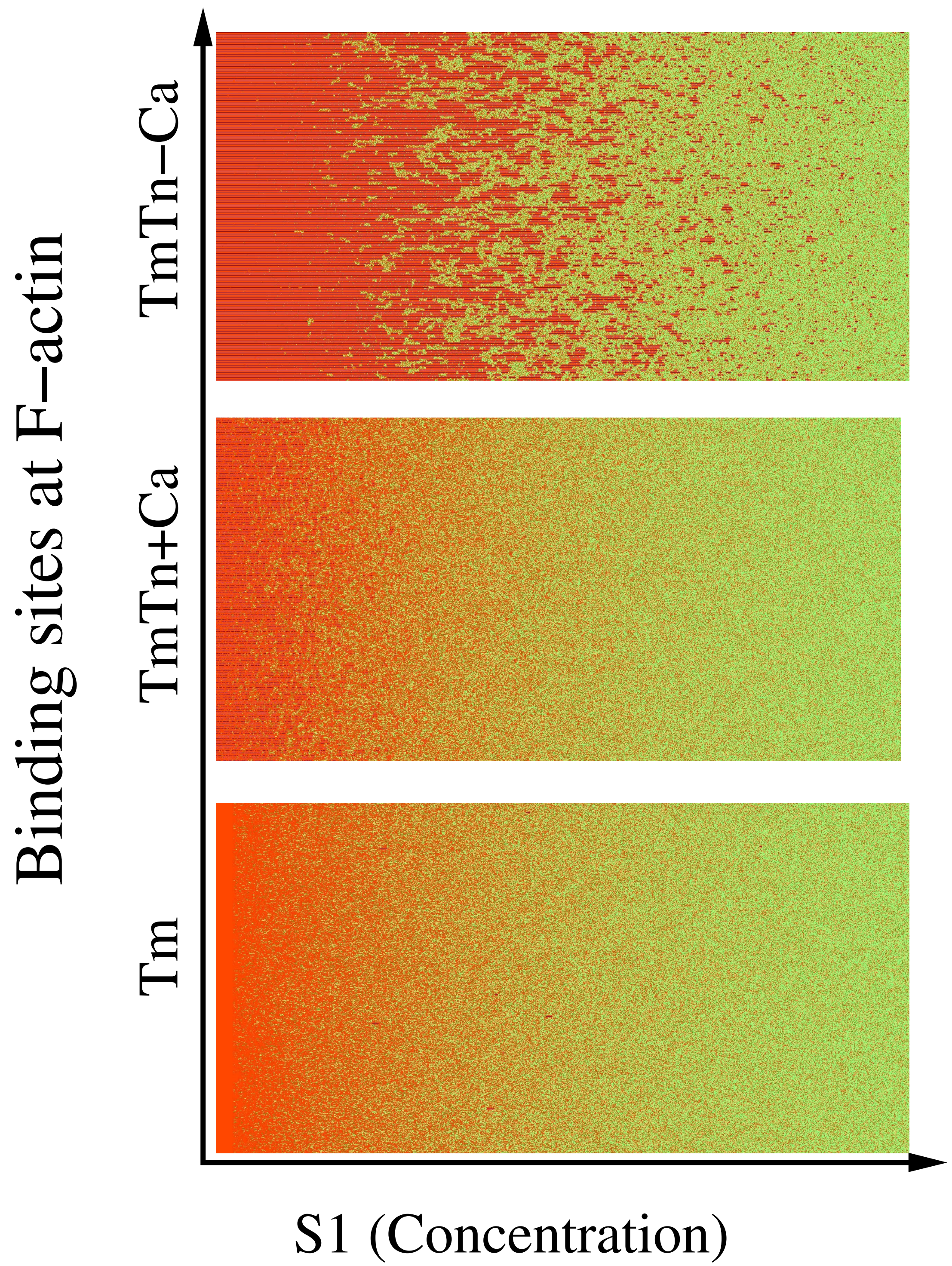


Motores Celulares

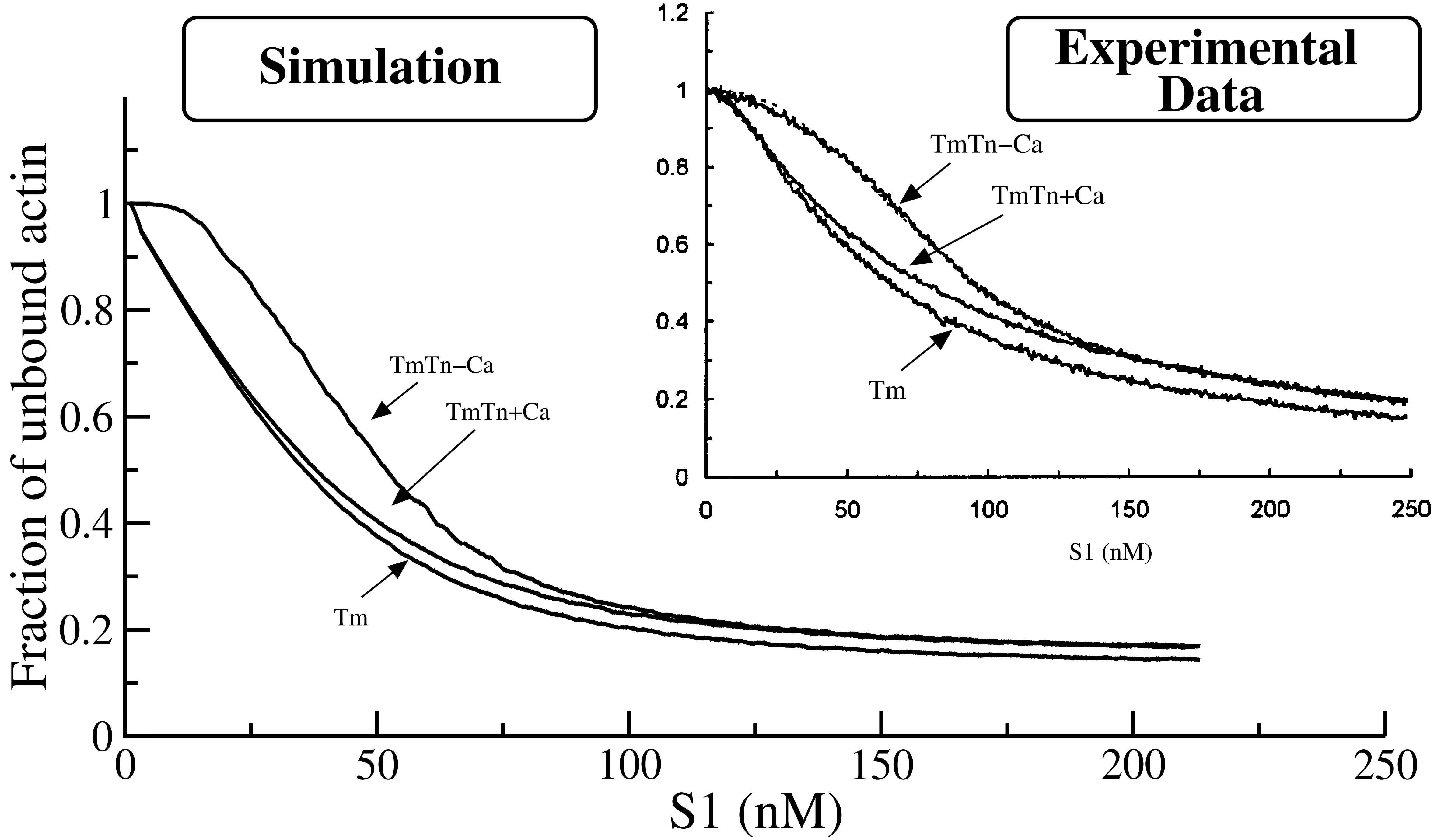


Motores Celulares

Modelo



Modelo versus Dados Experimentais



[Alencar, Butler and Mijailovich, PRE 2009]

Deformação

$$\epsilon = \frac{\Delta L}{L}$$

Para uma mola (modelo de Hooke)

$$F = -k\Delta x \qquad \text{(Microscopicamente)}$$

$$\frac{F}{A} = -E\frac{\Delta L}{L} \qquad \text{(Macroscopicamente)}$$

$$E \rightarrow \text{ Modulo de Young (Força/Area)}$$

Deformação

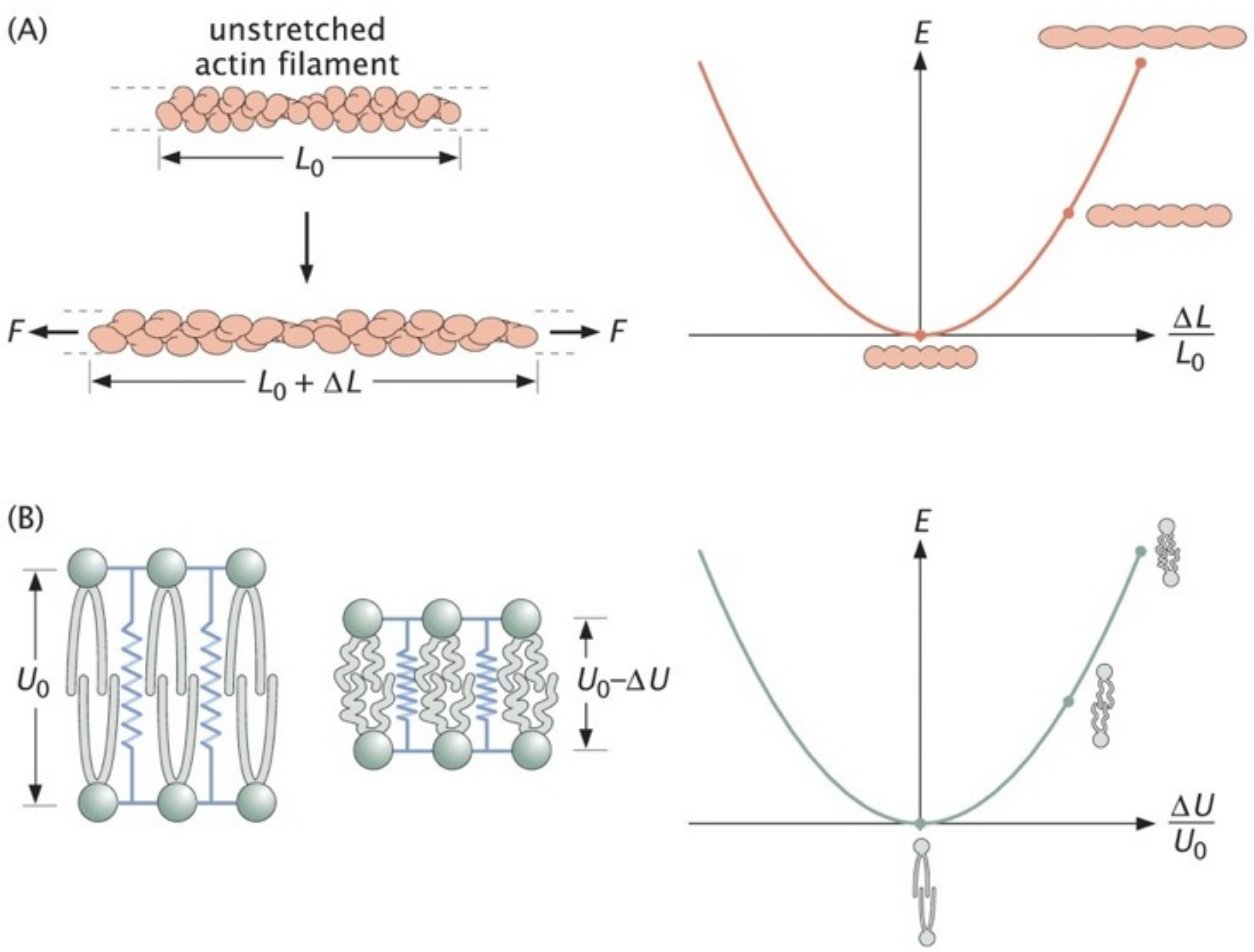


Figure 5.22 Deformation of macromolecular assemblies and the corresponding elastic energy cost associated with these deformations. (A) Schematic of F-actin stretching in response to a force applied along the filament axis. The energy curve shows a quadratic cost to either elongate or shrink the filament relative to its equilibrium length. (B) Schematic of deformation in which the thickness of the lipid bilayer is changed relative to its equilibrium value. The energy curve shows the elastic energy cost to change the thickness of a lipid bilayer from its equilibrium thickness.

Figure 5.24 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Deformação

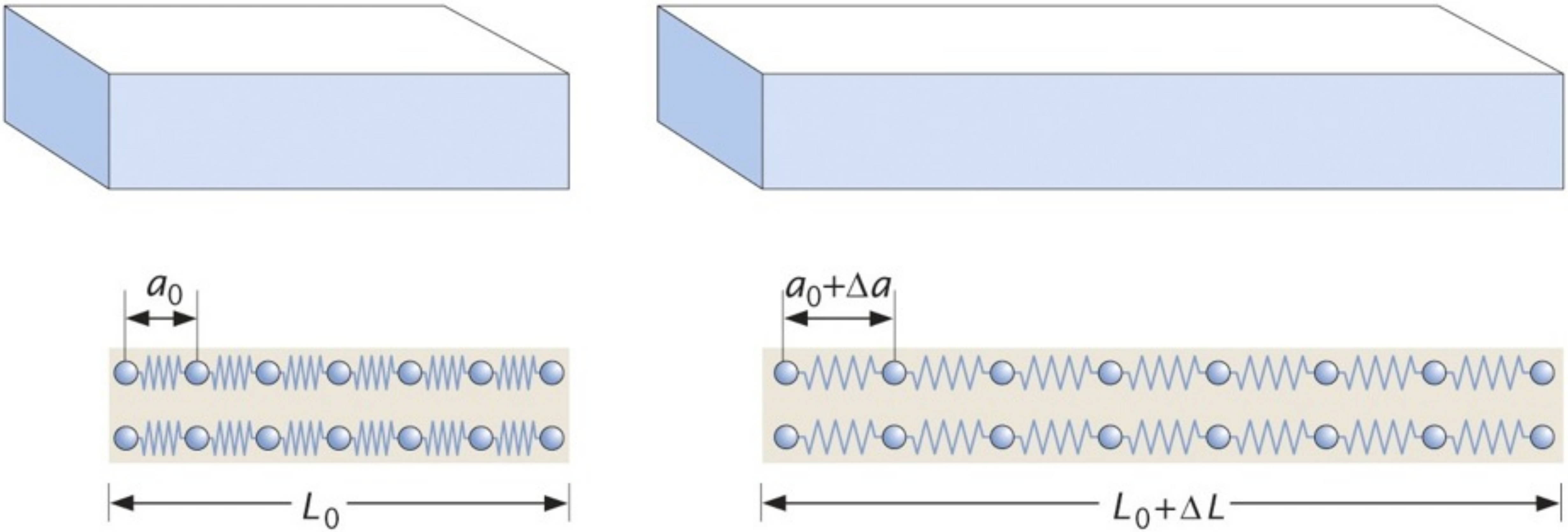
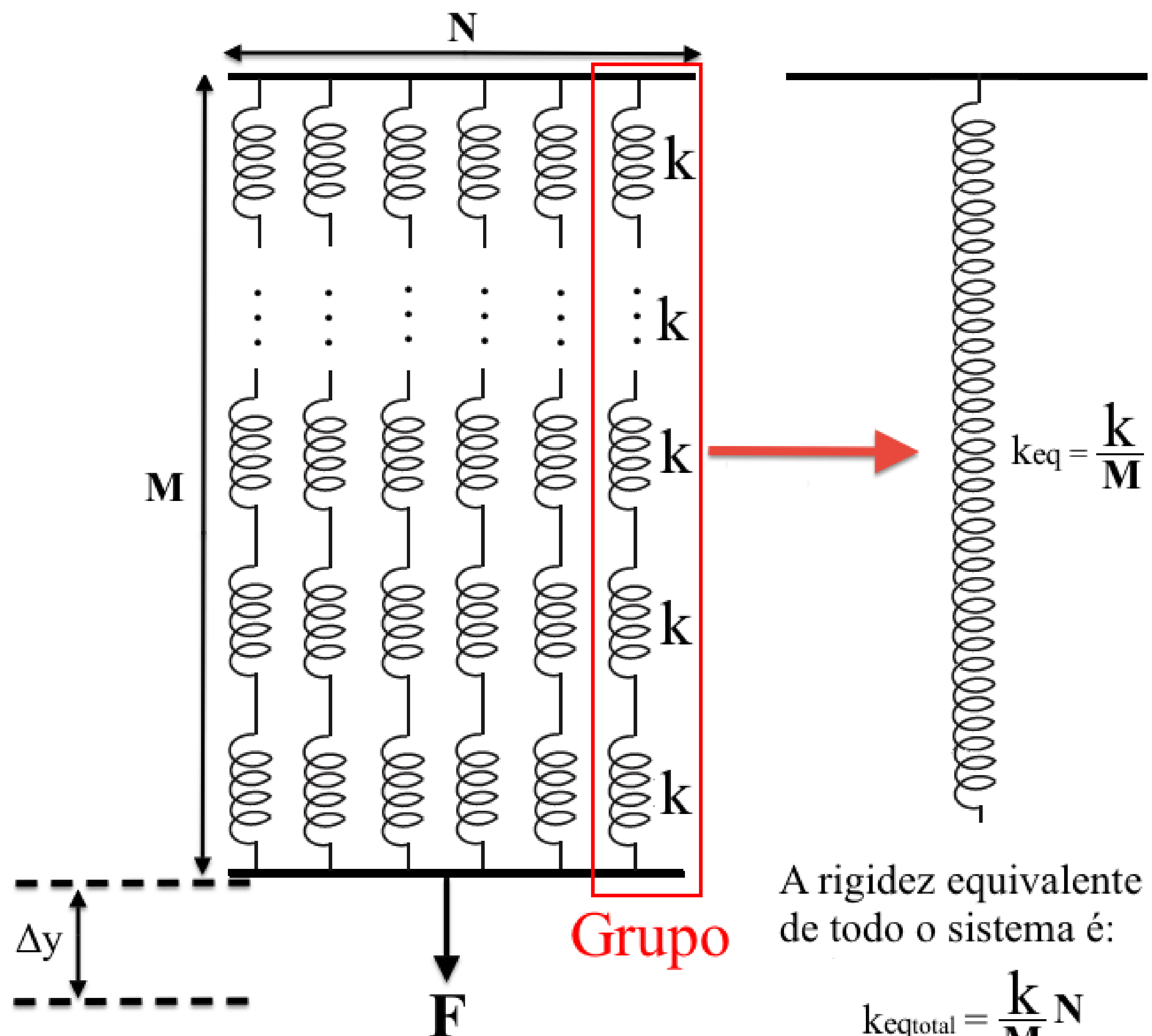


Figure 5.23 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

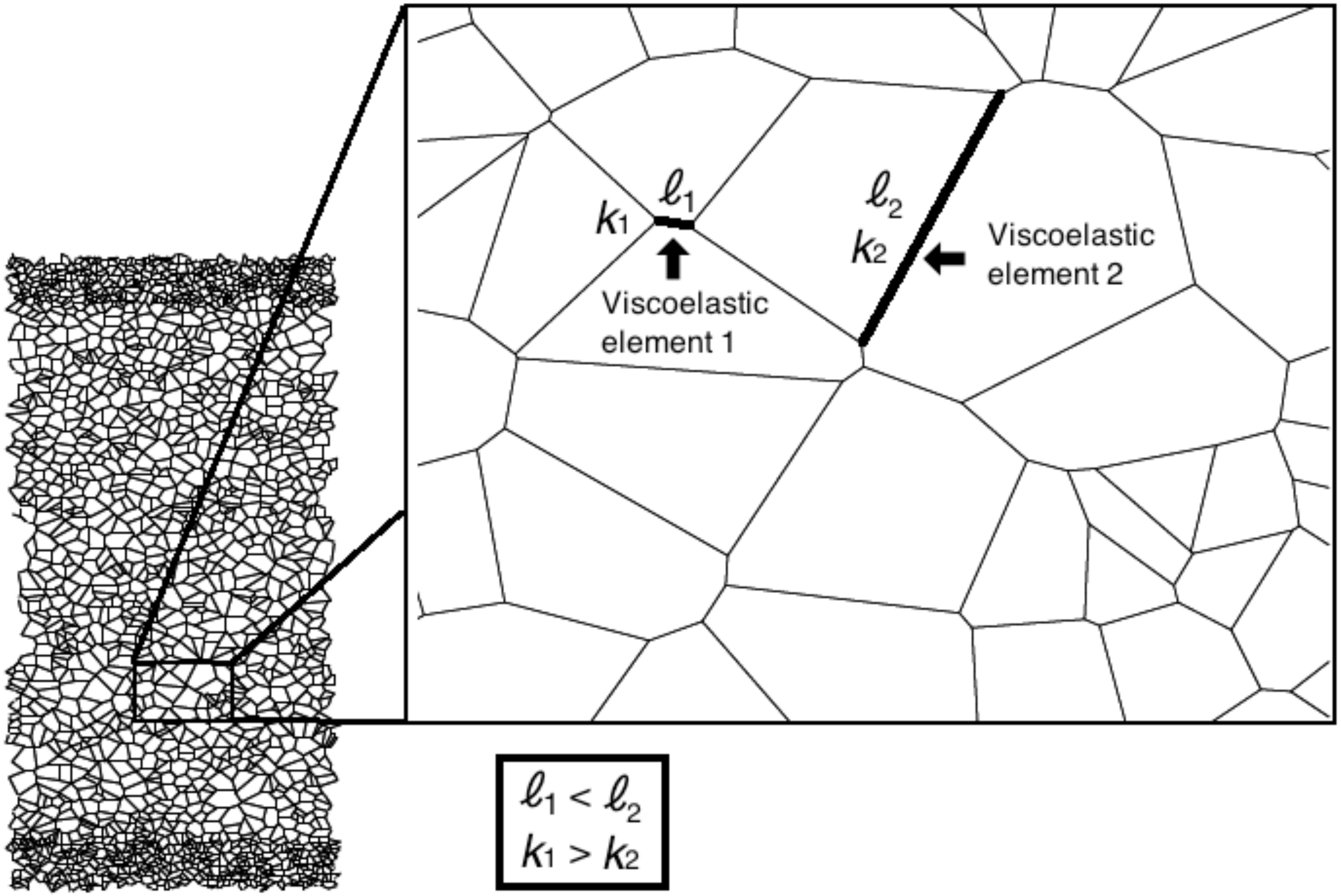
Deformação



A rigidez equivalente total de todo o sistema é:

$$k_{eqtotal} = \frac{k}{M} N$$

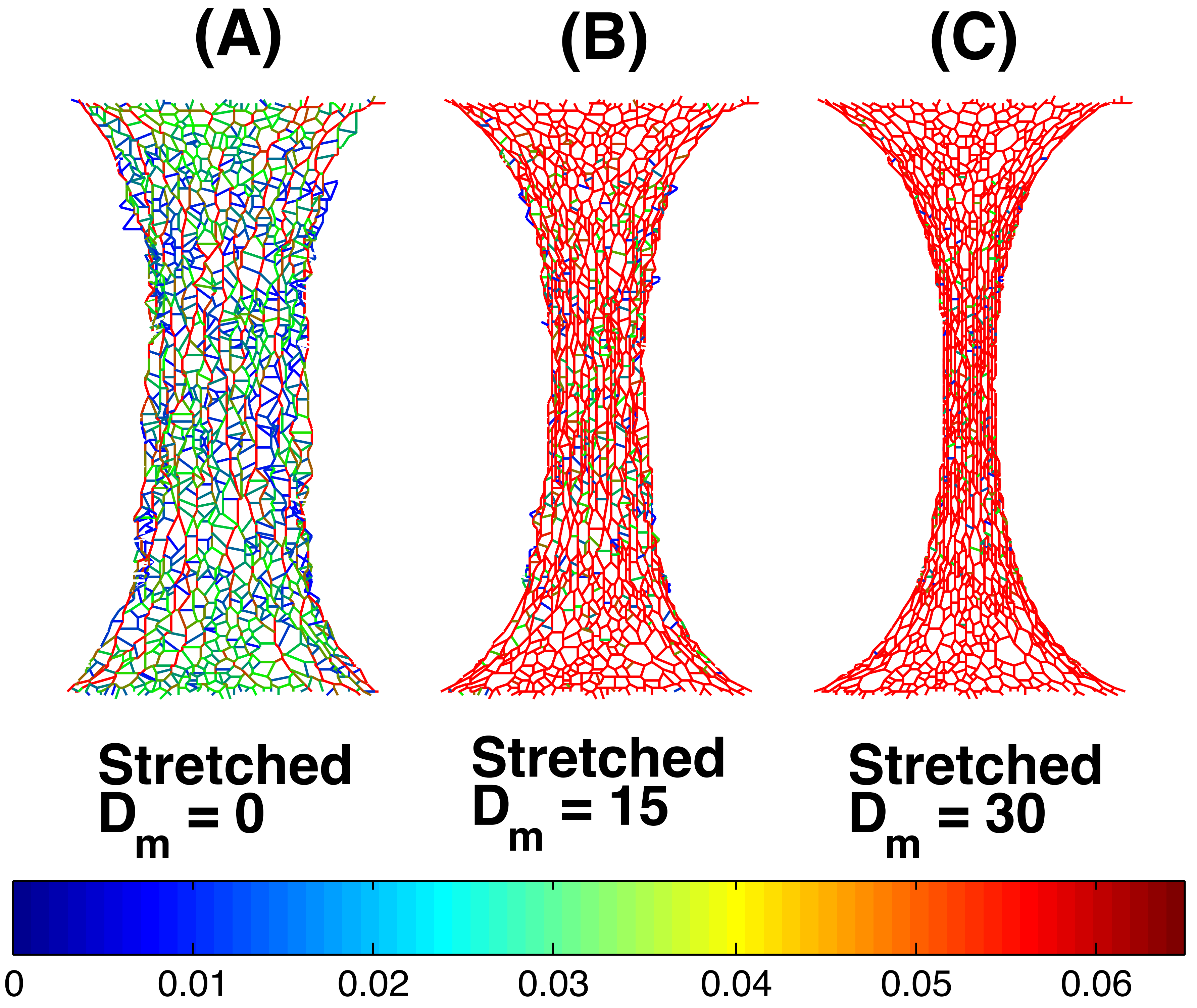
Deformação



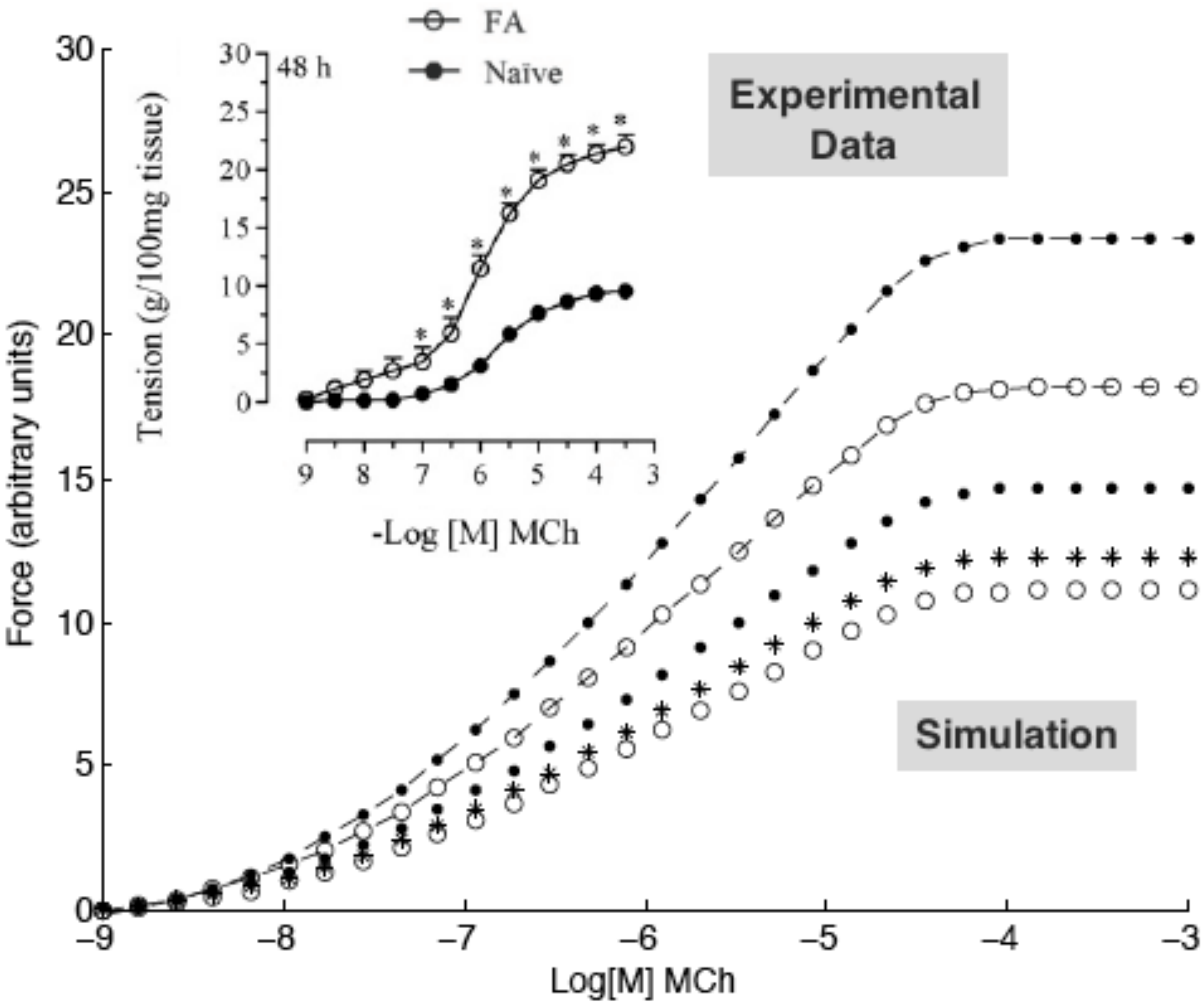
$$F_j(t) = -\frac{k_{\text{lig}} K[\epsilon_j - 1]}{\frac{K}{\ell_j^0} + k_{\text{lig}}} - c v_j$$

where $\epsilon_j = \ell_j / \ell_j^0$ is the strain, c is viscous coefficient, and v_j is the approaching velocity between the nodes connected by the jth bond. With this definition, we mimicked certain homogeneity in the system, such that the same strain would generate very similar force independent of the size of the bond of the VE.

Deformação


(A)
(B)
(C)
Stretched
$D_m = 0$
Stretched
$D_m = 15$
Stretched
$D_m = 30$
0
0.01
0.02
0.03
0.04
0.05
0.06

Deformação



A Mathematical Model of the Airway Smooth Muscle: The Effect of Methacholine and Formaldehyde

Mac Gayver S. Castro[a], Adriano M. Alencar[b,c]