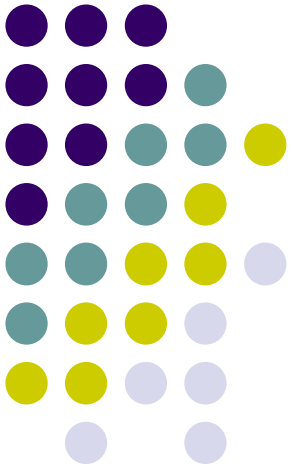
Suggested readings from NCBI

- http://www.ncbi.nlm.nih.gov/books/NBK22505/
- http://www.ncbi.nlm.nih.gov/books/NBK22541/
- http://www.ncbi.nlm.nih.gov/books/NBK22604/
- http://www.ncbi.nlm.nih.gov/books/NBK22538/
- http://www.ncbi.nlm.nih.gov/books/NBK22489/
- http://www.ncbi.nlm.nih.gov/books/NBK22572/
- http://www.ncbi.nlm.nih.gov/books/NBK22535/
- http://www.ncbi.nlm.nih.gov/books/NBK22403/
- http://www.ncbi.nlm.nih.gov/books/NBK22345/
- http://www.ncbi.nlm.nih.gov/books/NBK22503/

Moc/Bio and Nano/Micro

Lee and Stowell

Moc/Bio-Lecture 3



Functions of Biomolecules
- **Energy production**
  - **OxPhos**
  - **Photosynthesis**
- **Sensory Systems**
  - **Light**
  - **Sound**
  - **Pressure**
  - **Taste**
- **The immune system**
  - **Who is who?**
- **Molecular Motors**

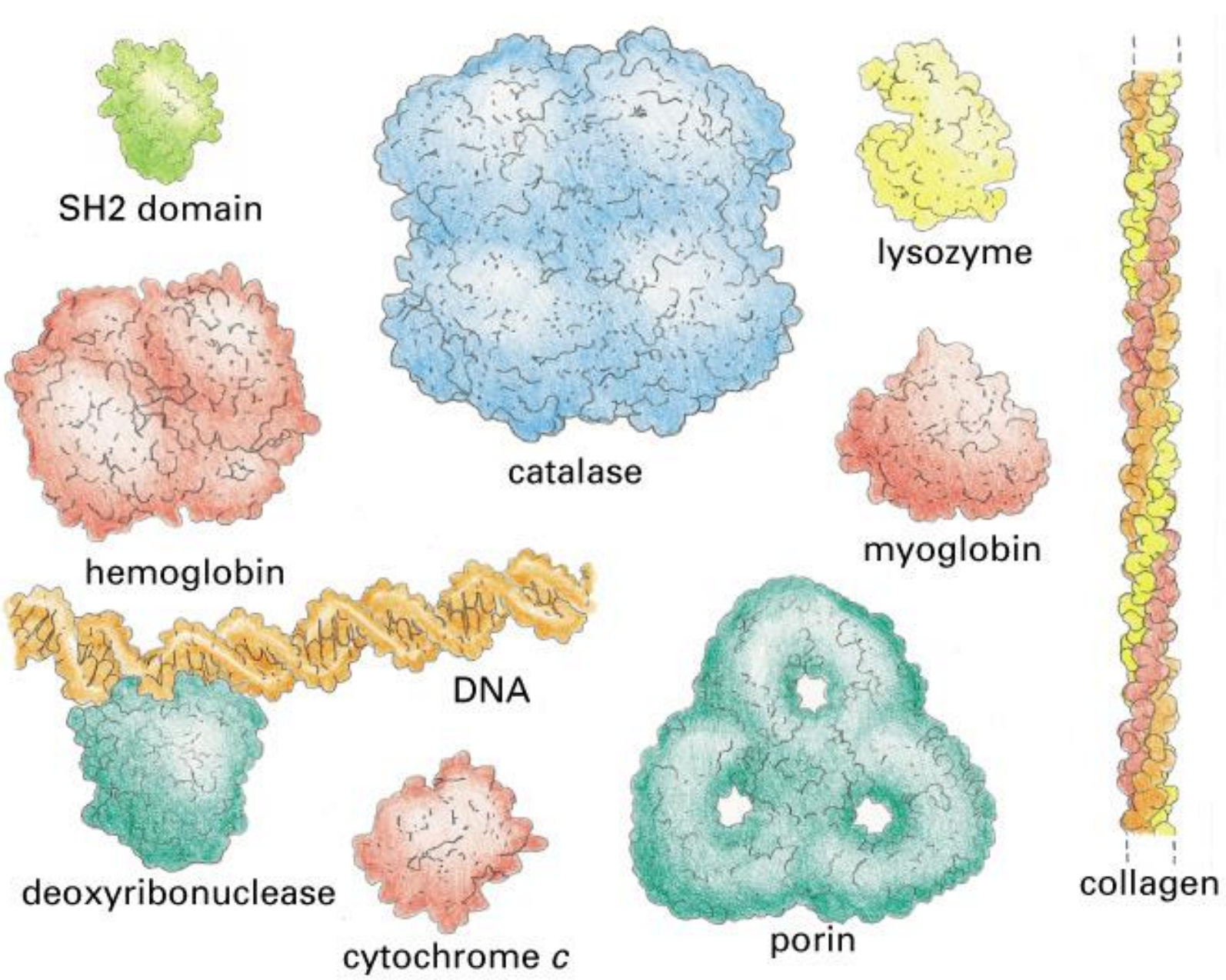
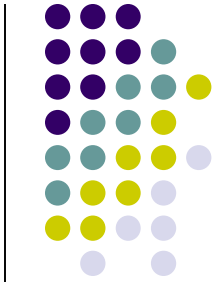


Figure 3–24 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

Energy production



- Electron transport chain and oxidative phosphorylation
- Photosynthesis
- Key concepts
  - Controlled oxidation
  - Proton gradient
  - Mechanical to chemical energy conversion
  - Charge separation

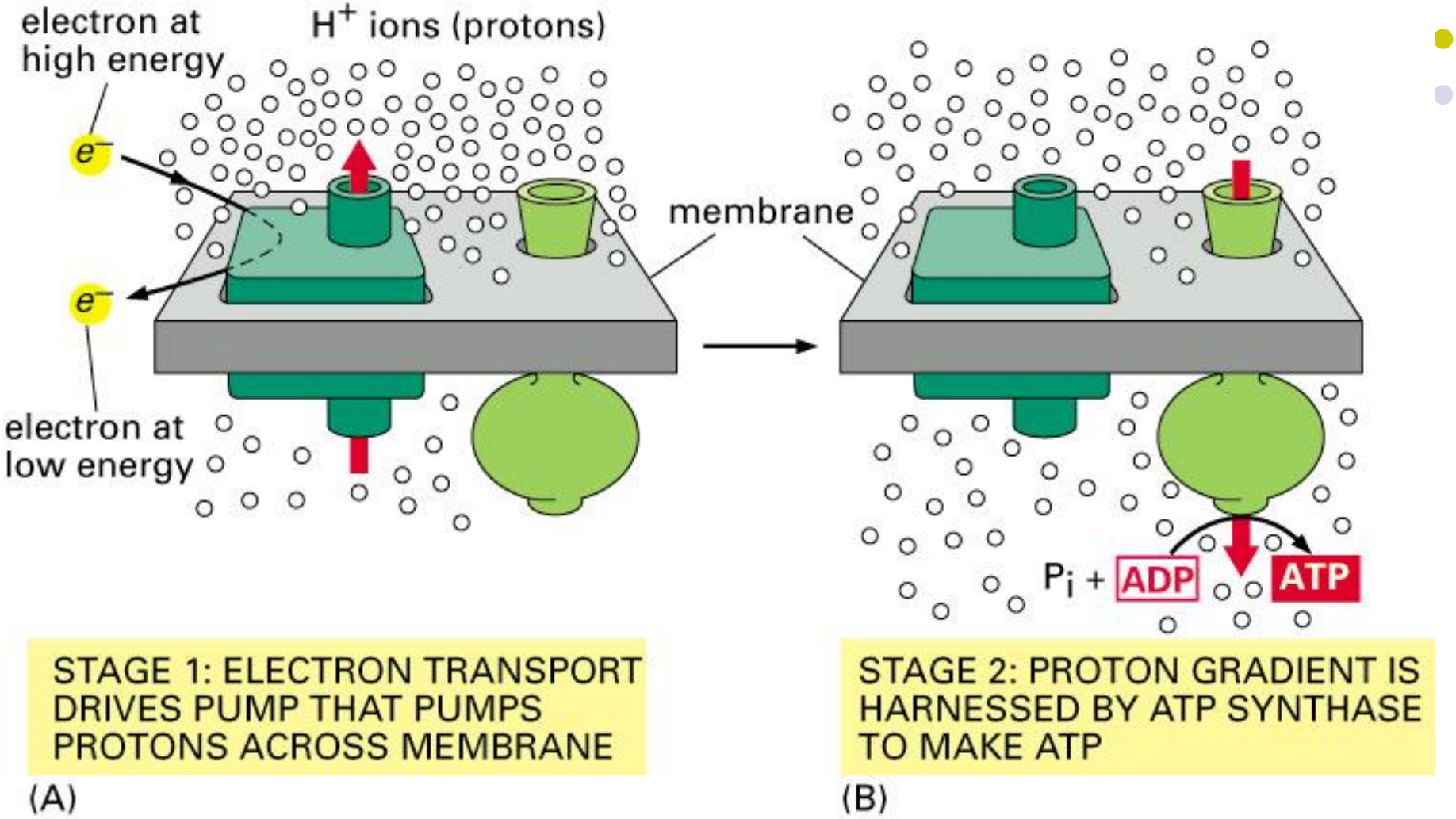
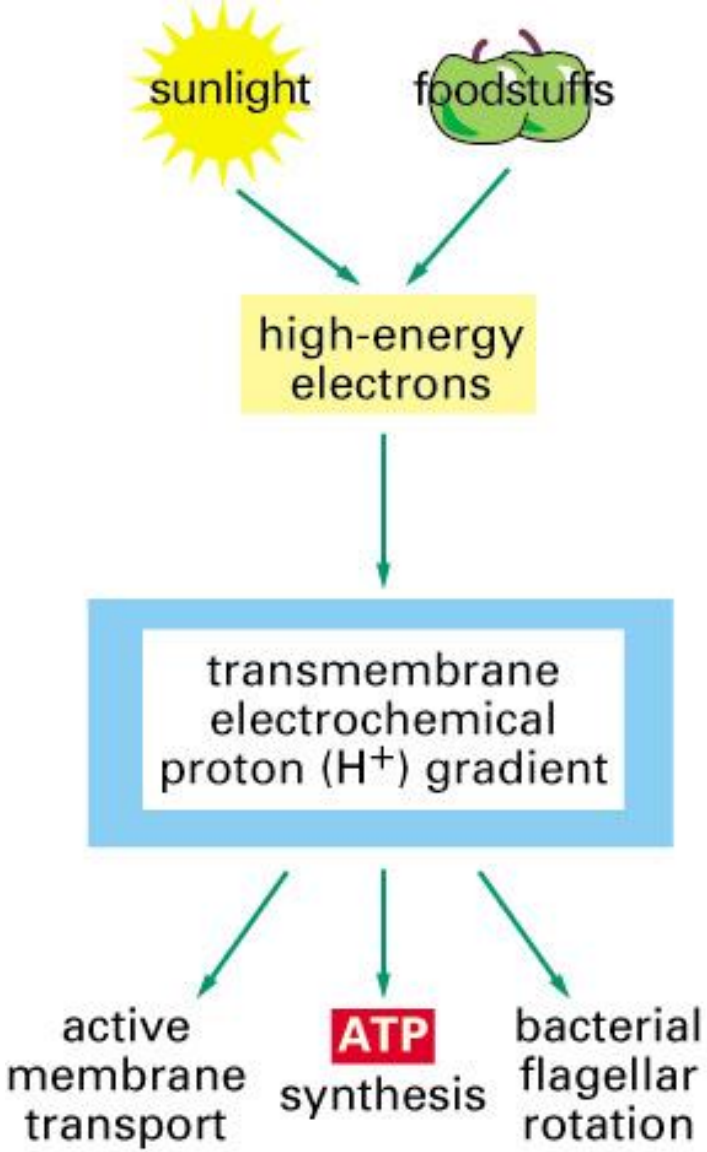


Figure 14–1. Molecular Biology of the Cell, 4th Edition.



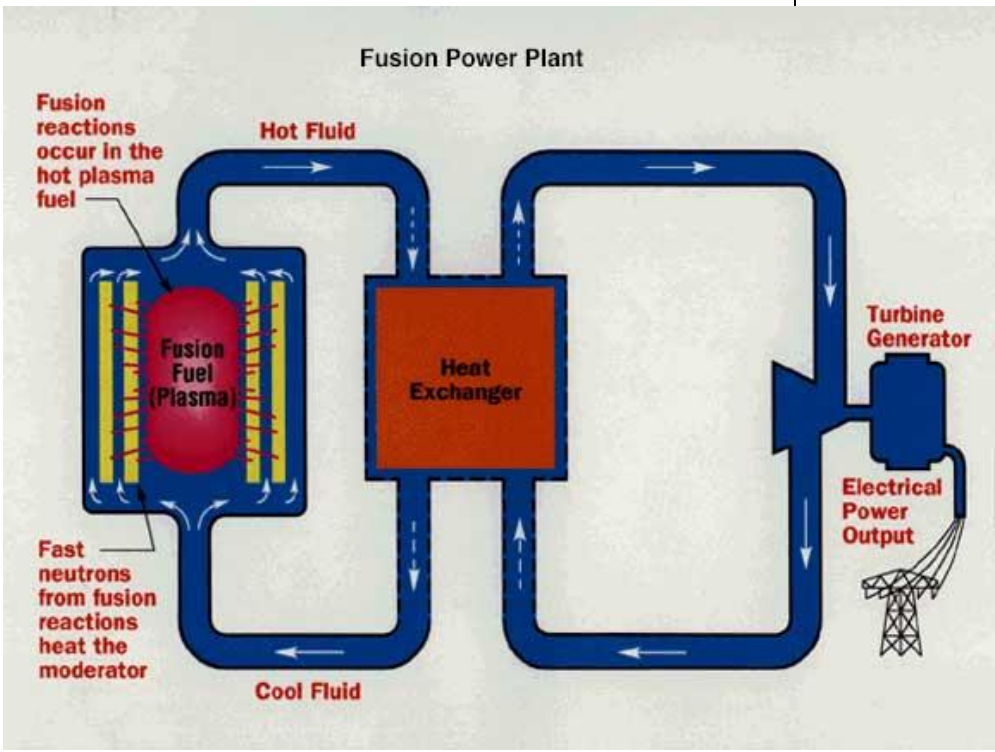


Figure 14–2. Molecular Biology of the Cell, 4th Edition.

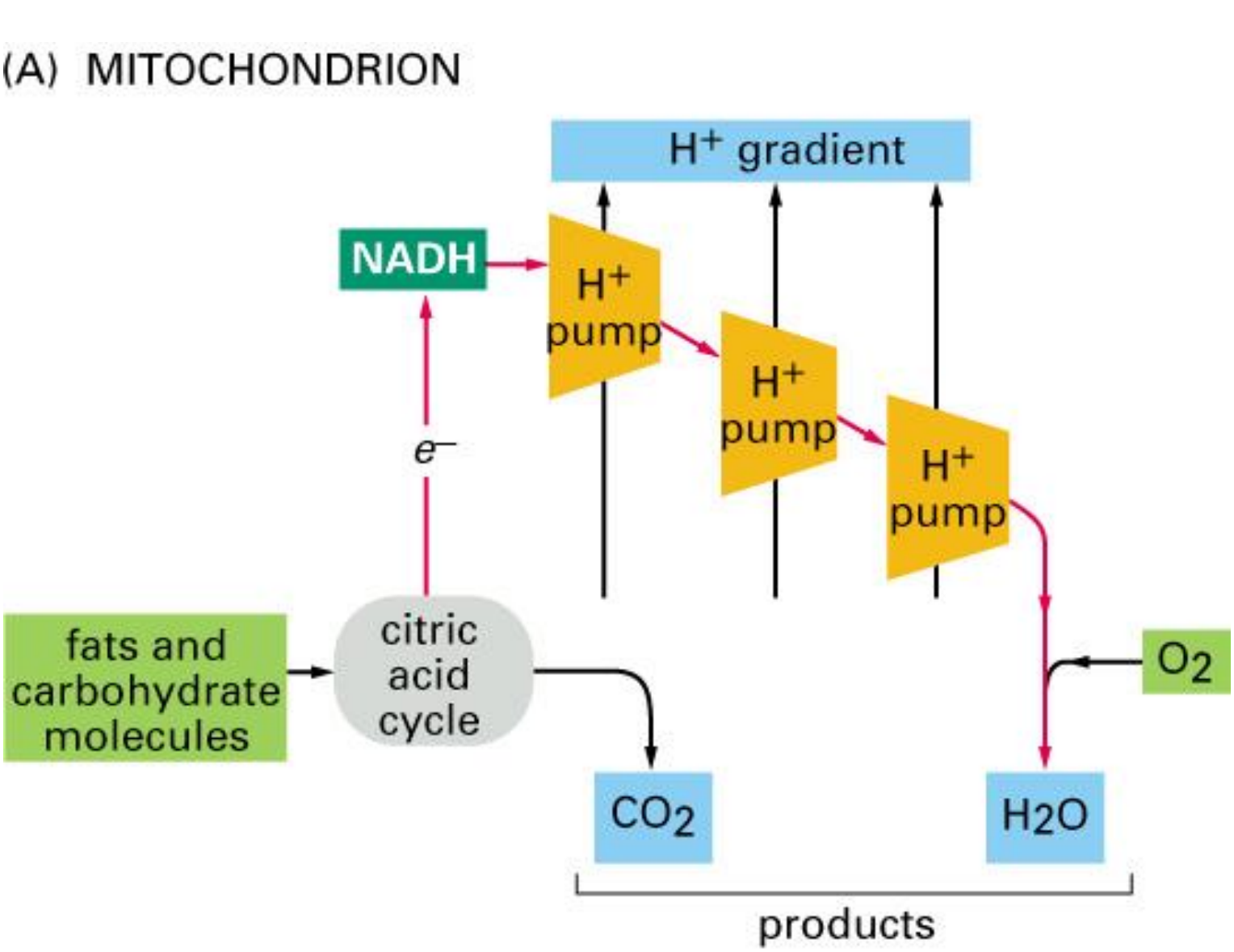


Figure 14–3 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

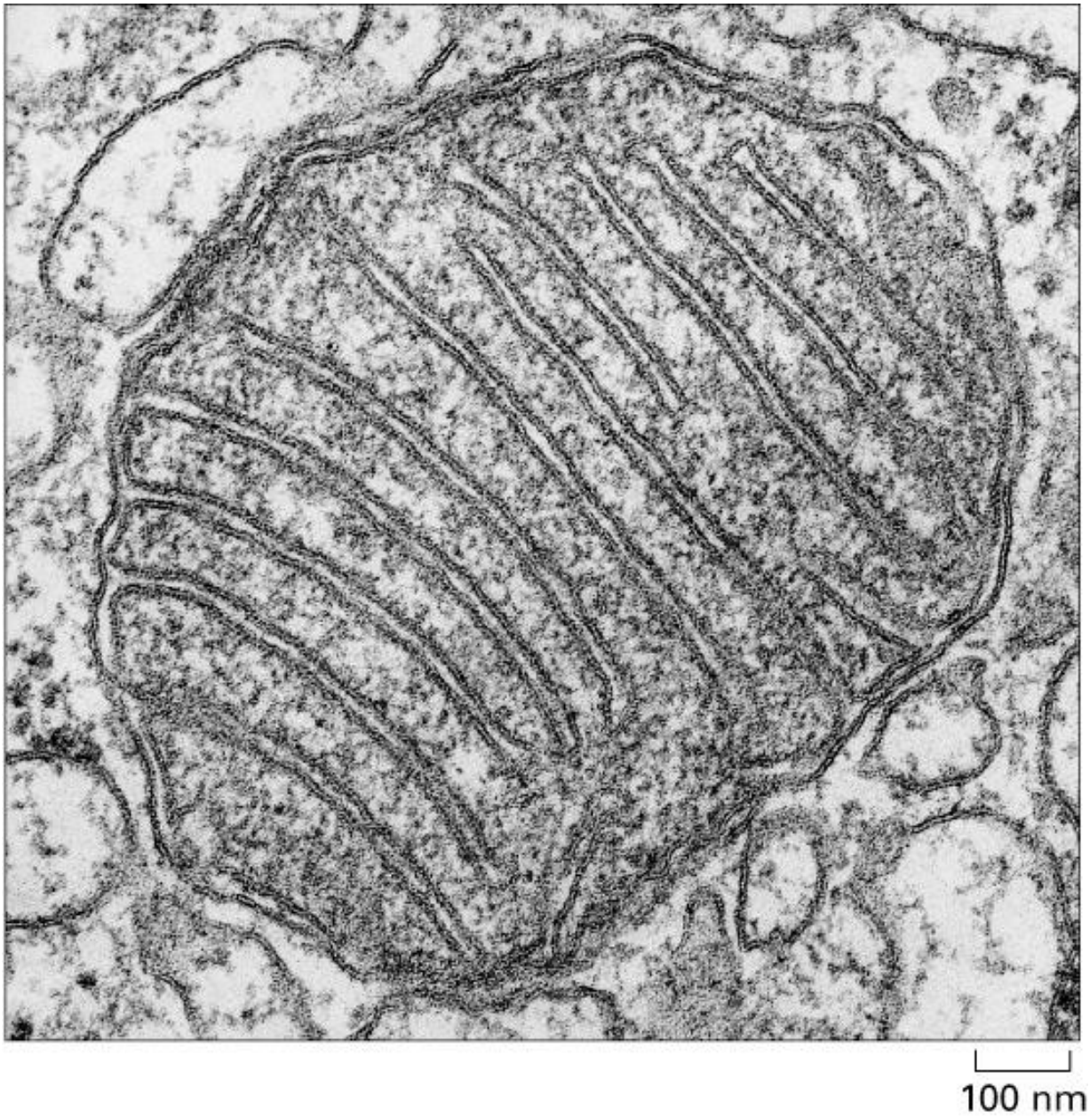


Figure 14–8 part 1 of 3. Molecular Biology of the Cell, 4th Edition.

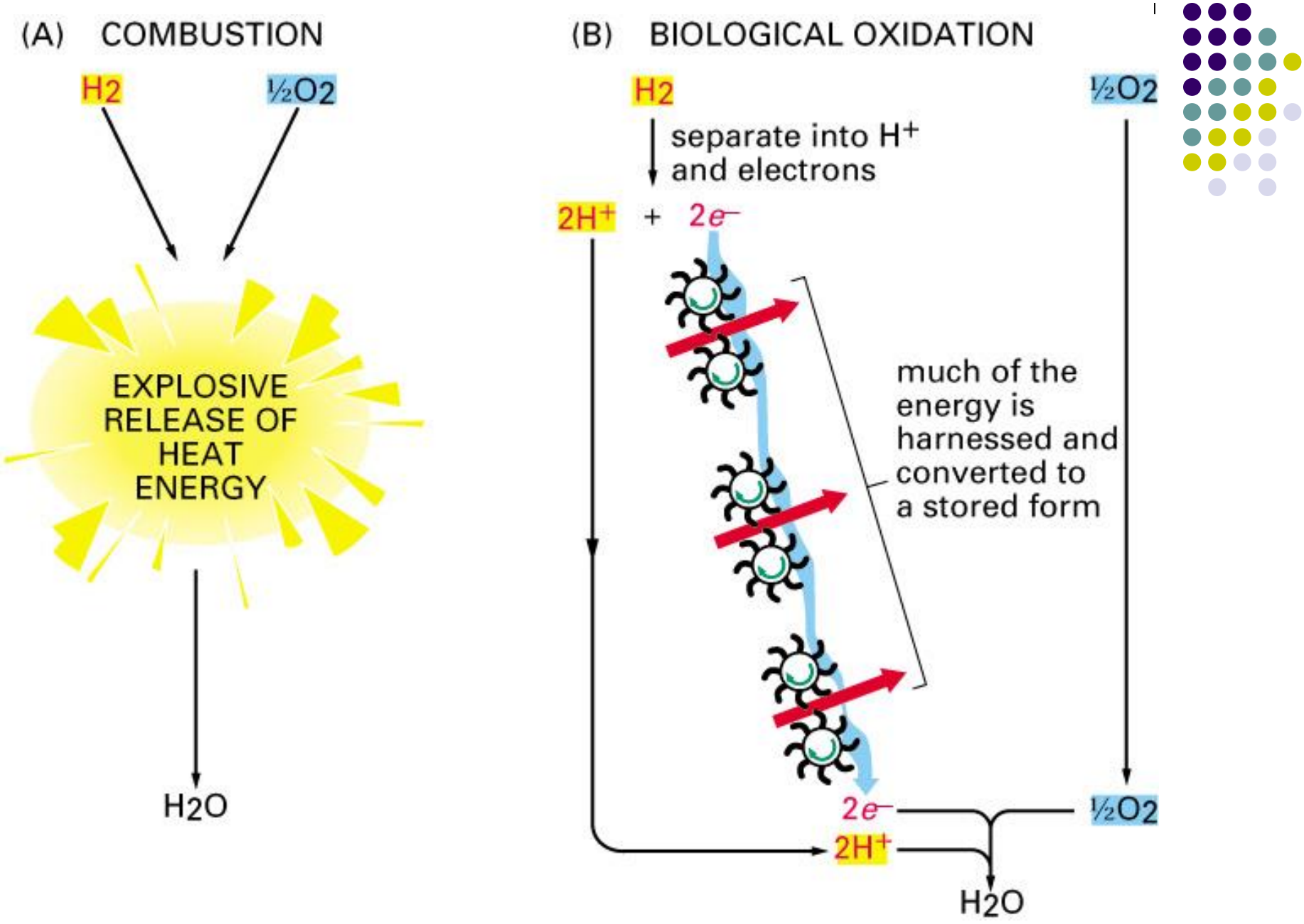


Figure 14–12. Molecular Biology of the Cell, 4th Edition.

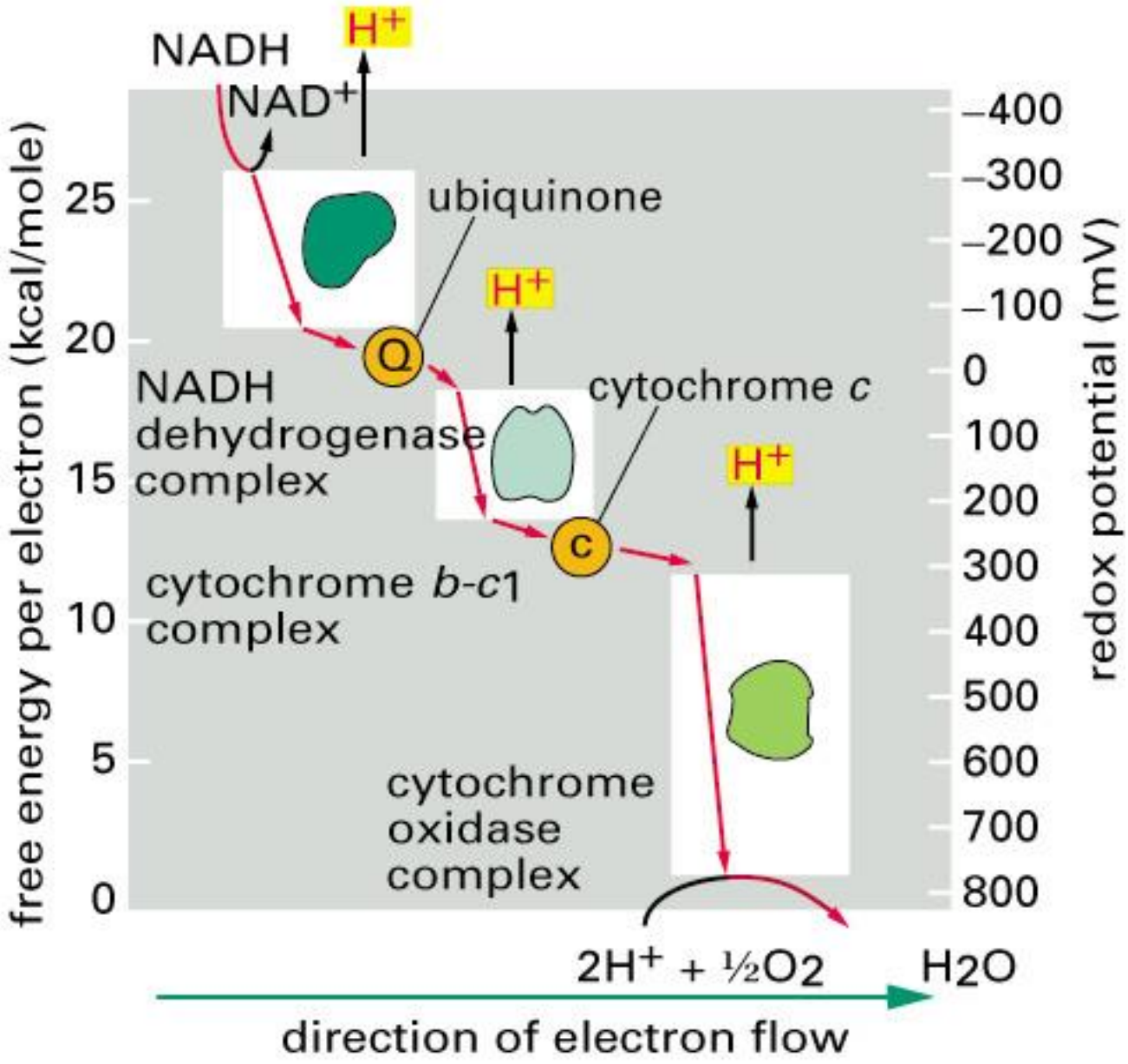
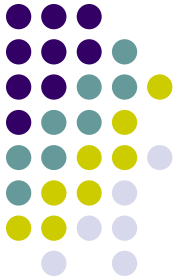


Figure 14–29. Molecular Biology of the Cell, 4th Edition.

Potential and free energy



- $\Delta G = RT \ln[K]$
- $E_{mv} = (RT/zF) \ln [K]$
  - R gas constant
  - T temp
  - Z charge
  - F Farady's constant
  - K is the equilibrium constant or concentration difference

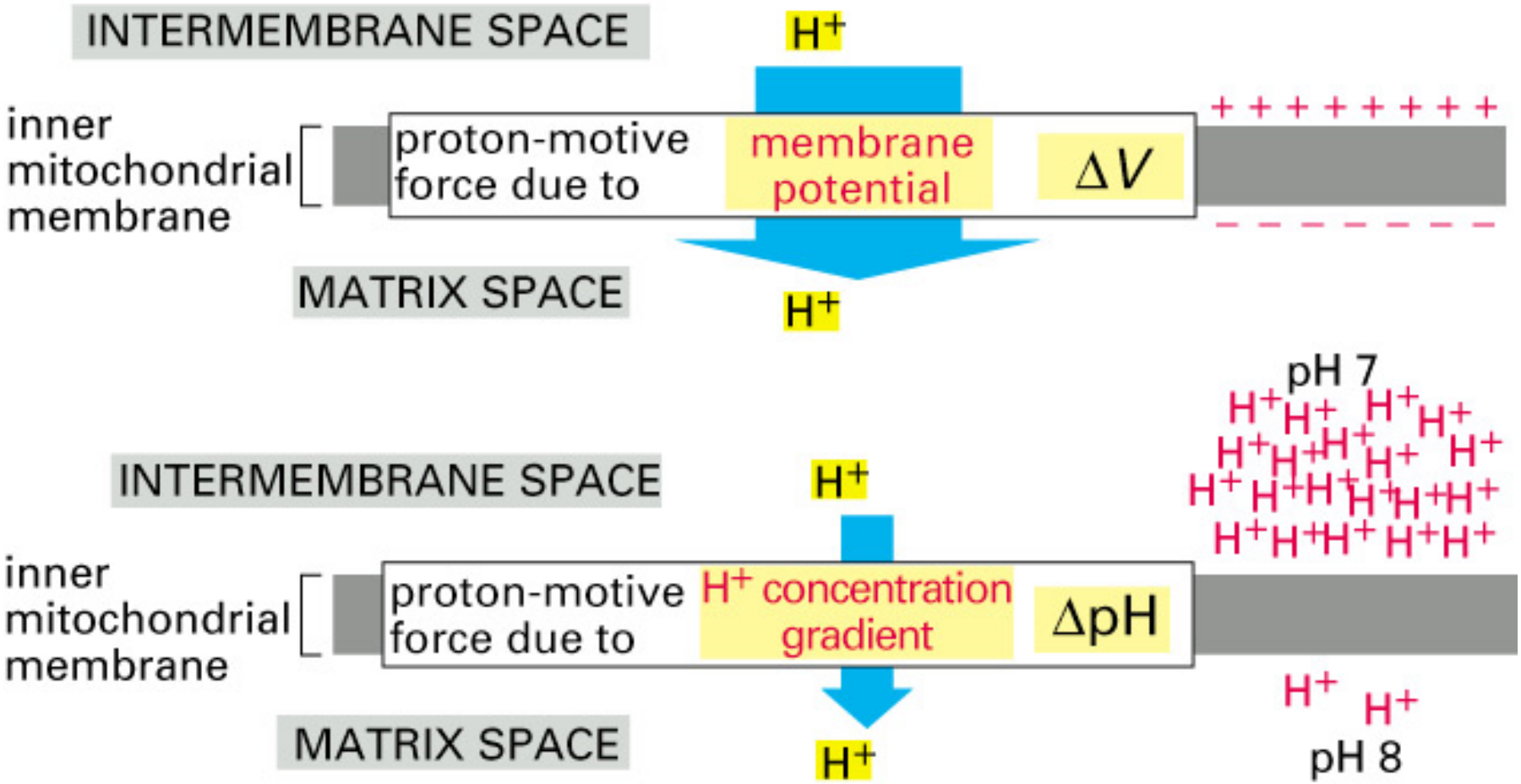


Figure 14–13. Molecular Biology of the Cell, 4th Edition.

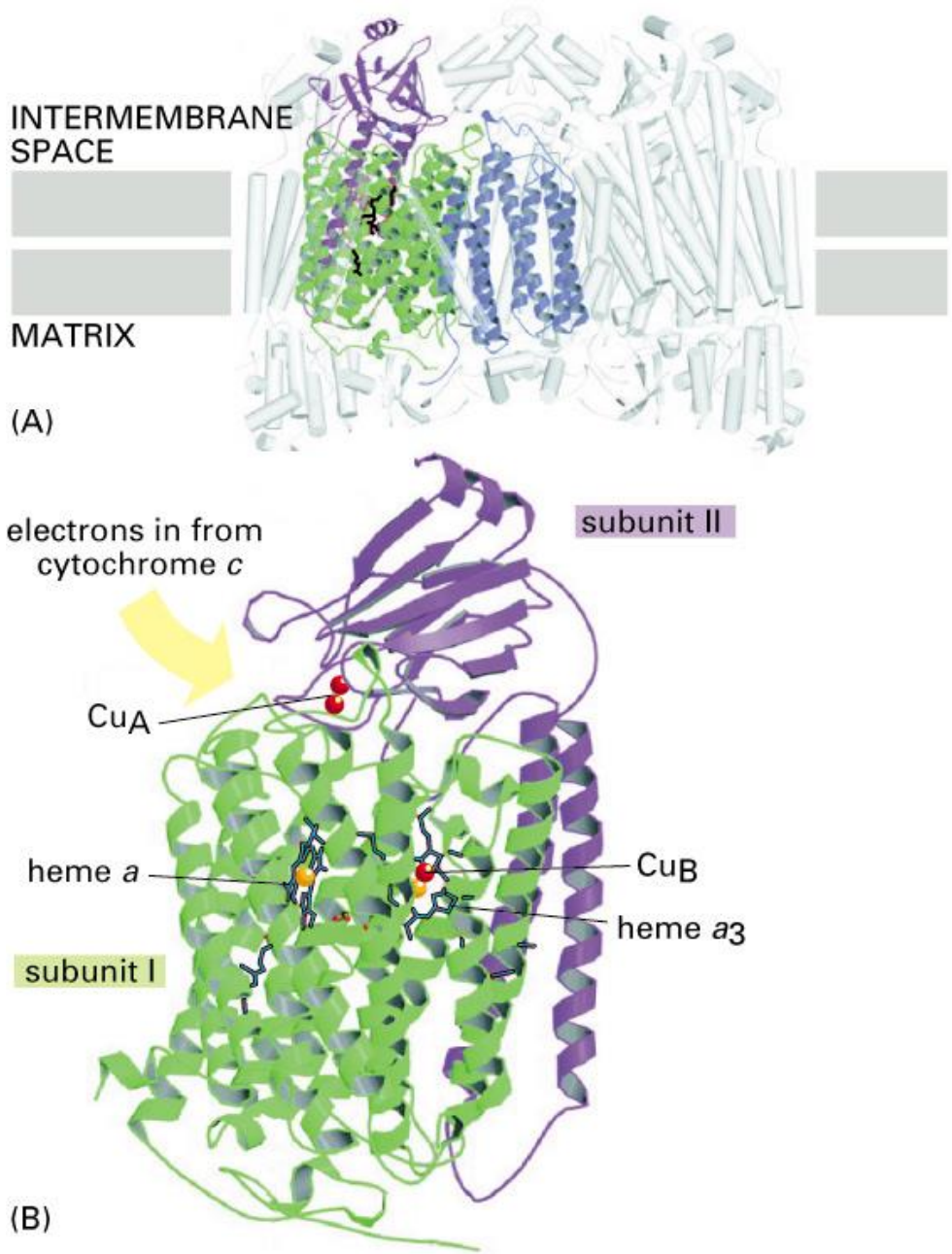


Figure 14–28. Molecular Biology of the Cell, 4th Edition.

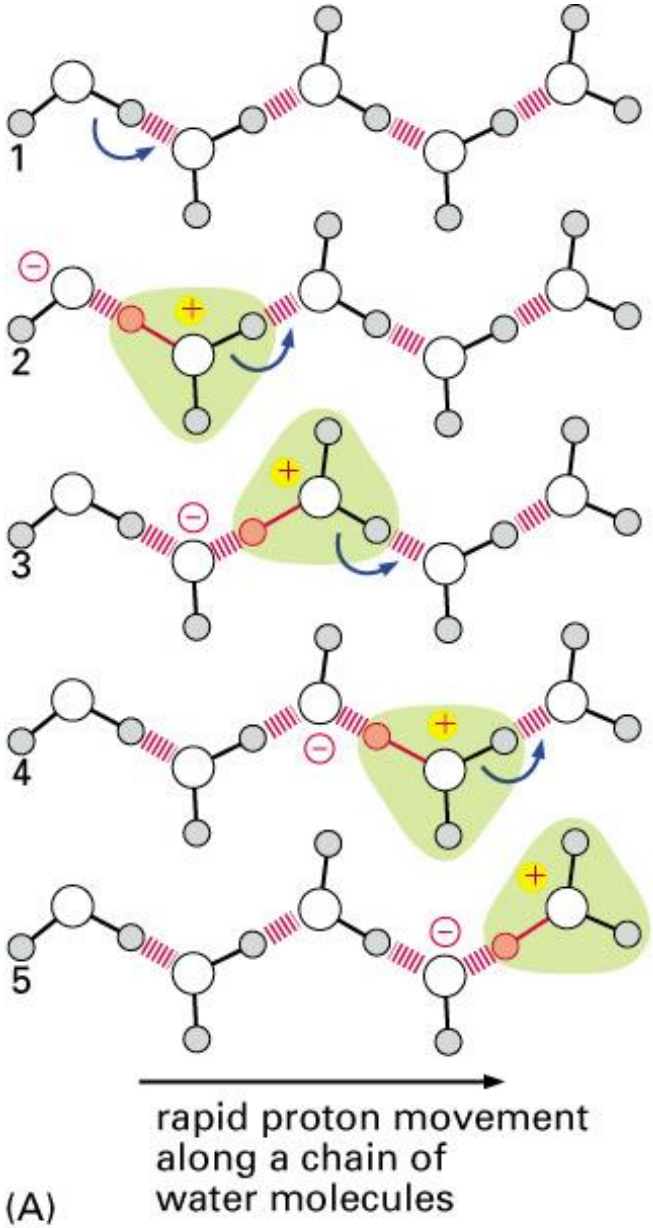
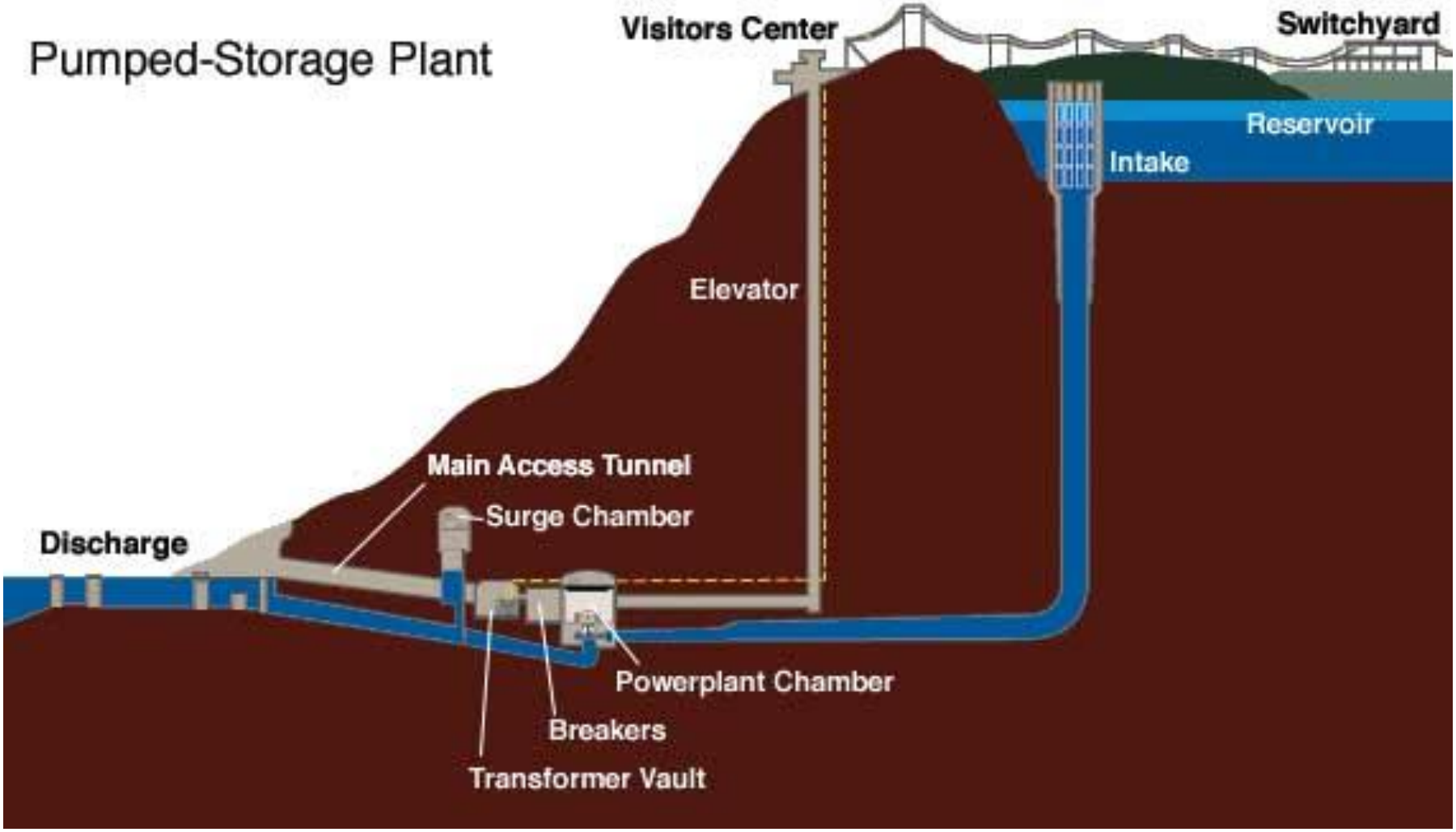


Figure 14–20 part 1 of 2. Molecular Biology of the Cell, 4th Edition.


Pumped-Storage Plant
Visitors Center
Switchyard
Reservoir
Intake
Elevator
Main Access Tunnel
Surge Chamber
Discharge
Powerplant Chamber
Breakers
Transformer Vault

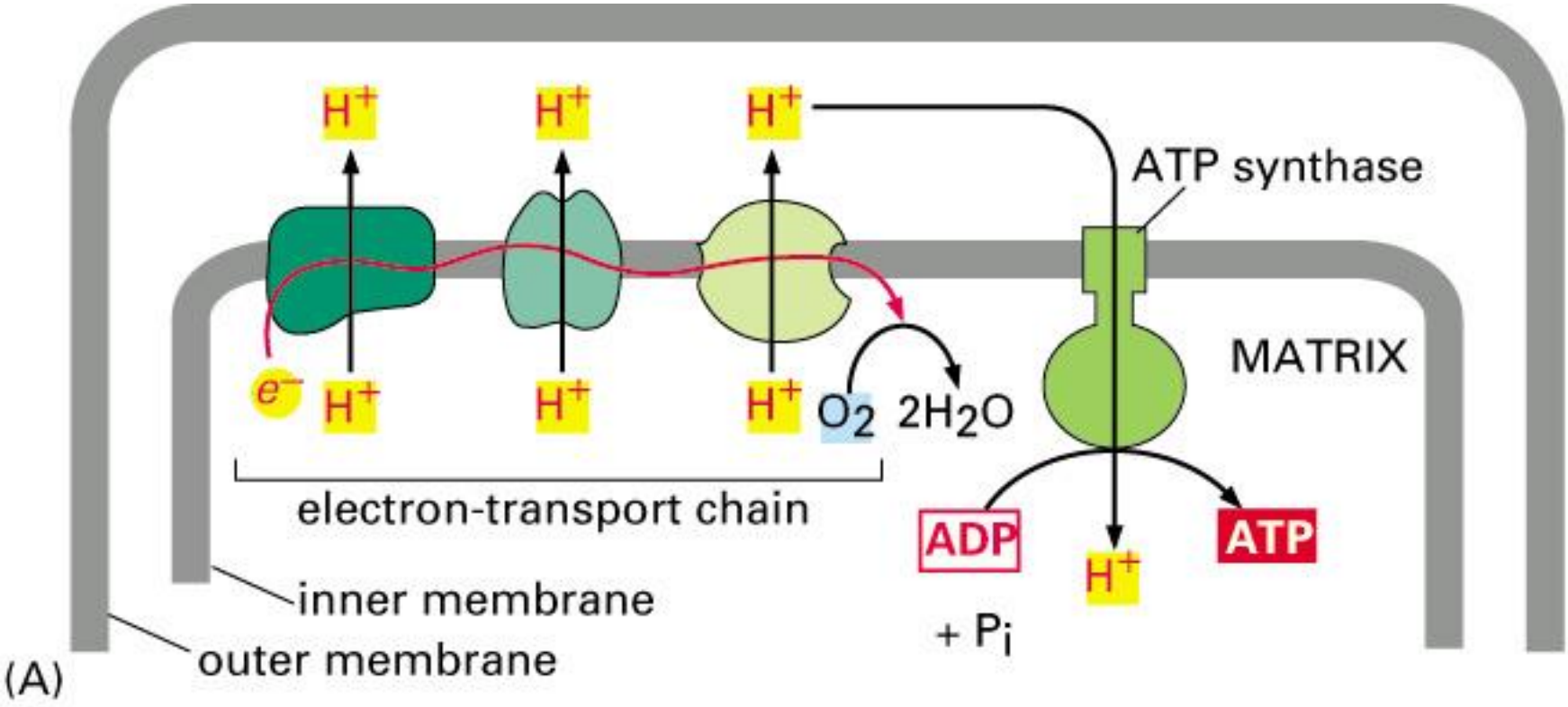


Figure 14–14 part 1 of 2. Molecular Biology of the Cell, 4th Edition.

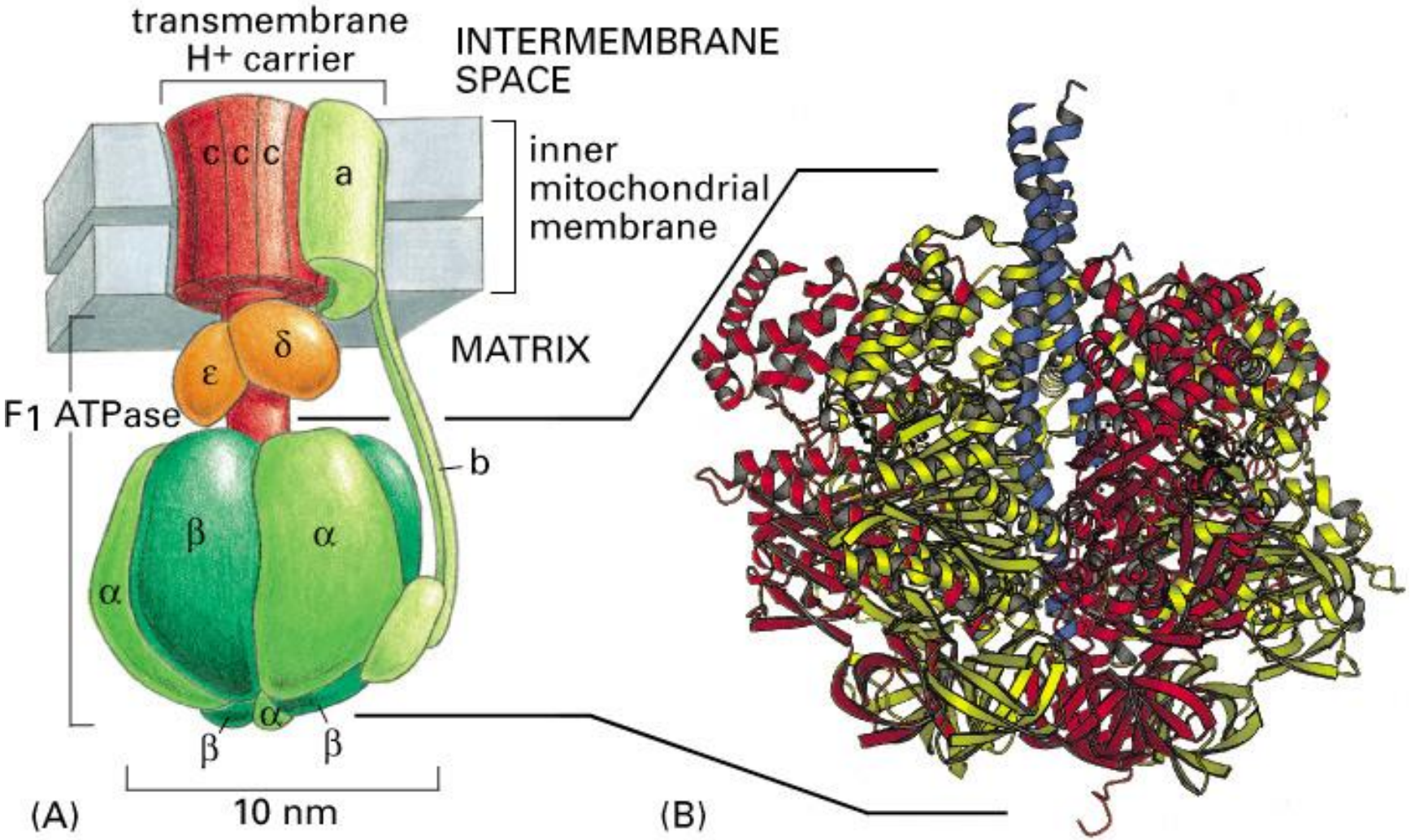


Figure 14–15. Molecular Biology of the Cell, 4th Edition.

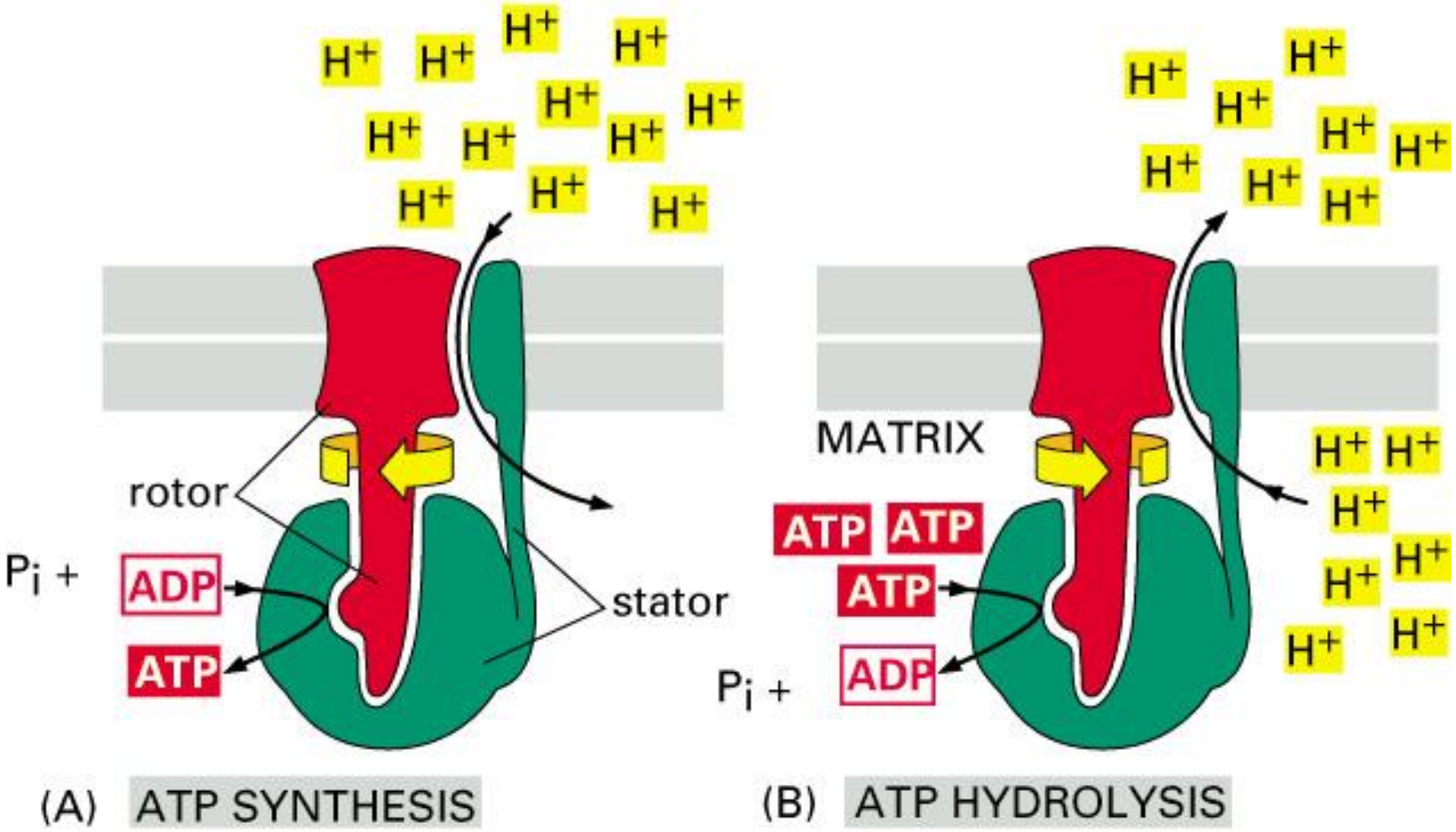
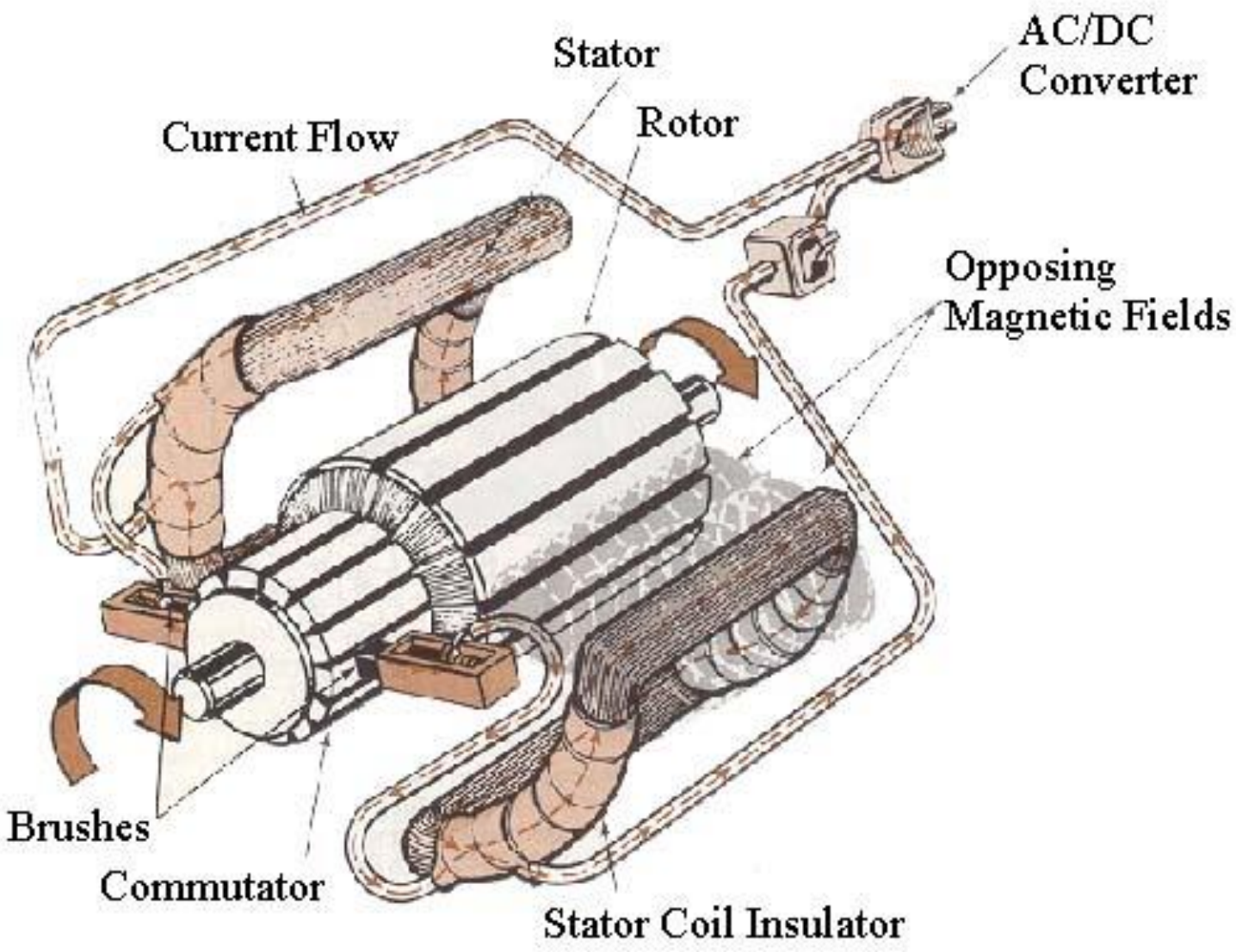


Figure 14–19. Molecular Biology of the Cell, 4th Edition.


Stator
AC/DC
Converter
Current Flow
Rotor
Opposing
Magnetic Fields
Brushes
Commutator
Stator Coil Insulator

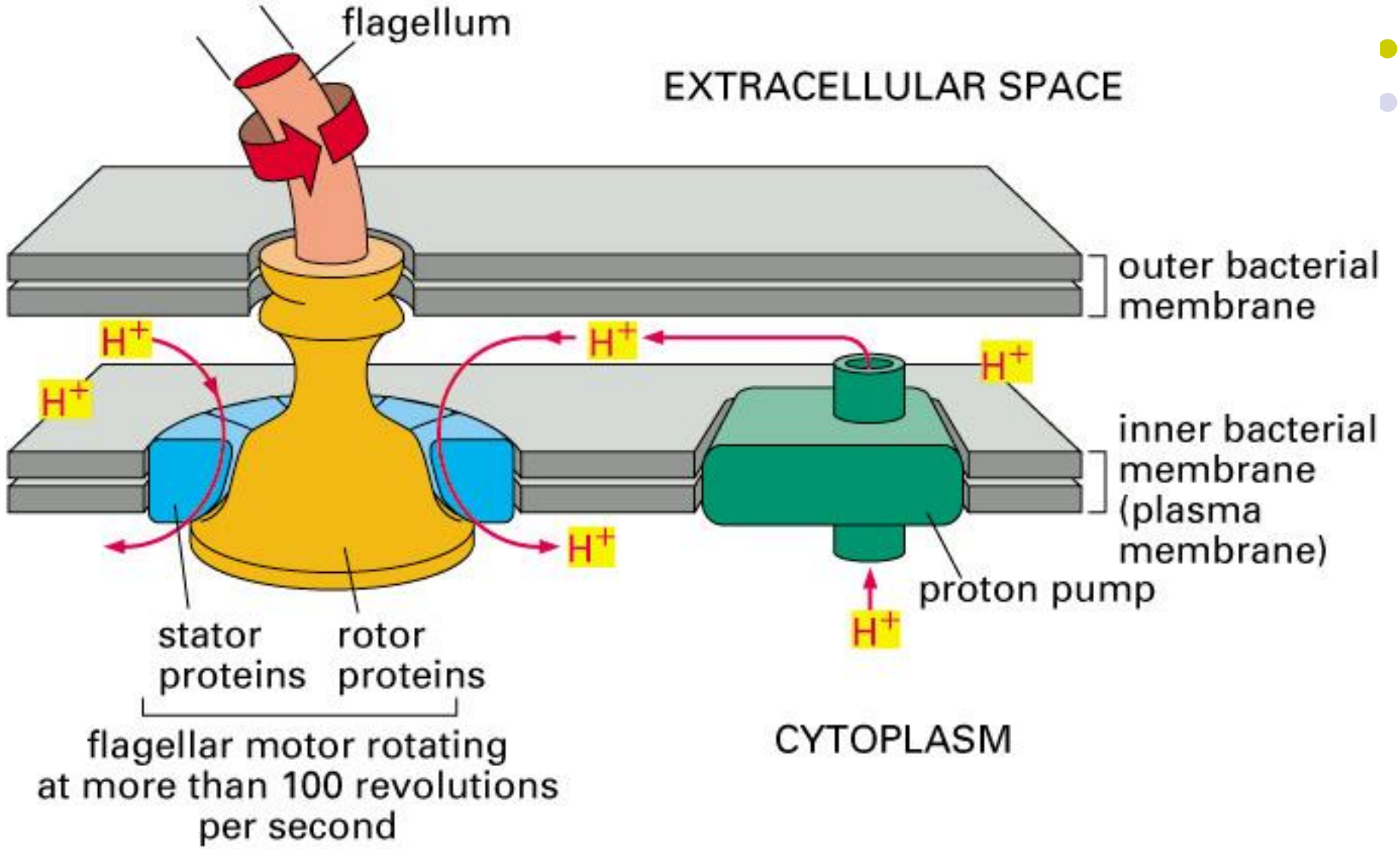


Figure 14–17. Molecular Biology of the Cell, 4th Edition.

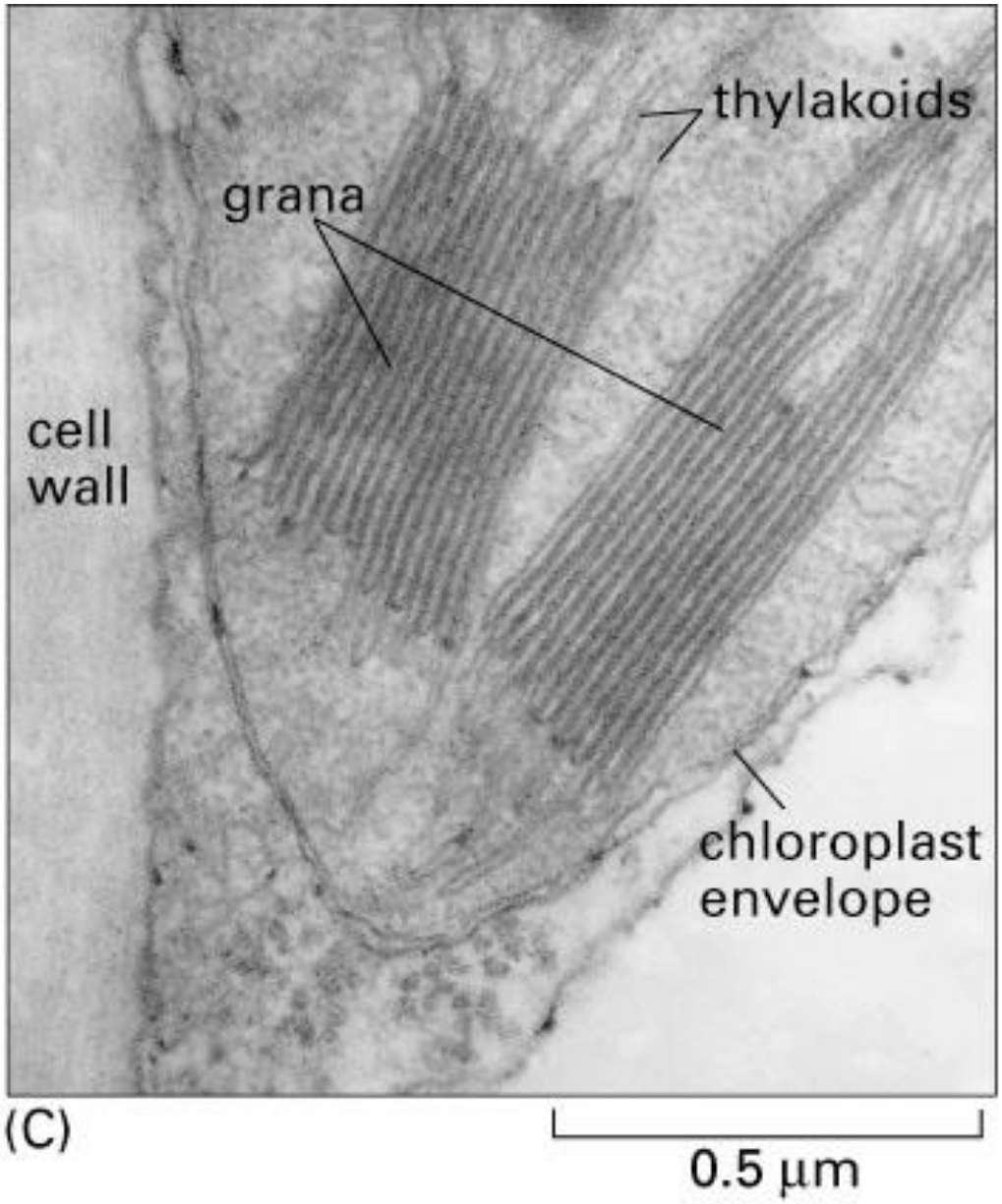


Figure 14–34 part 2 of 2. Molecular Biology of the Cell, 4th Edition.

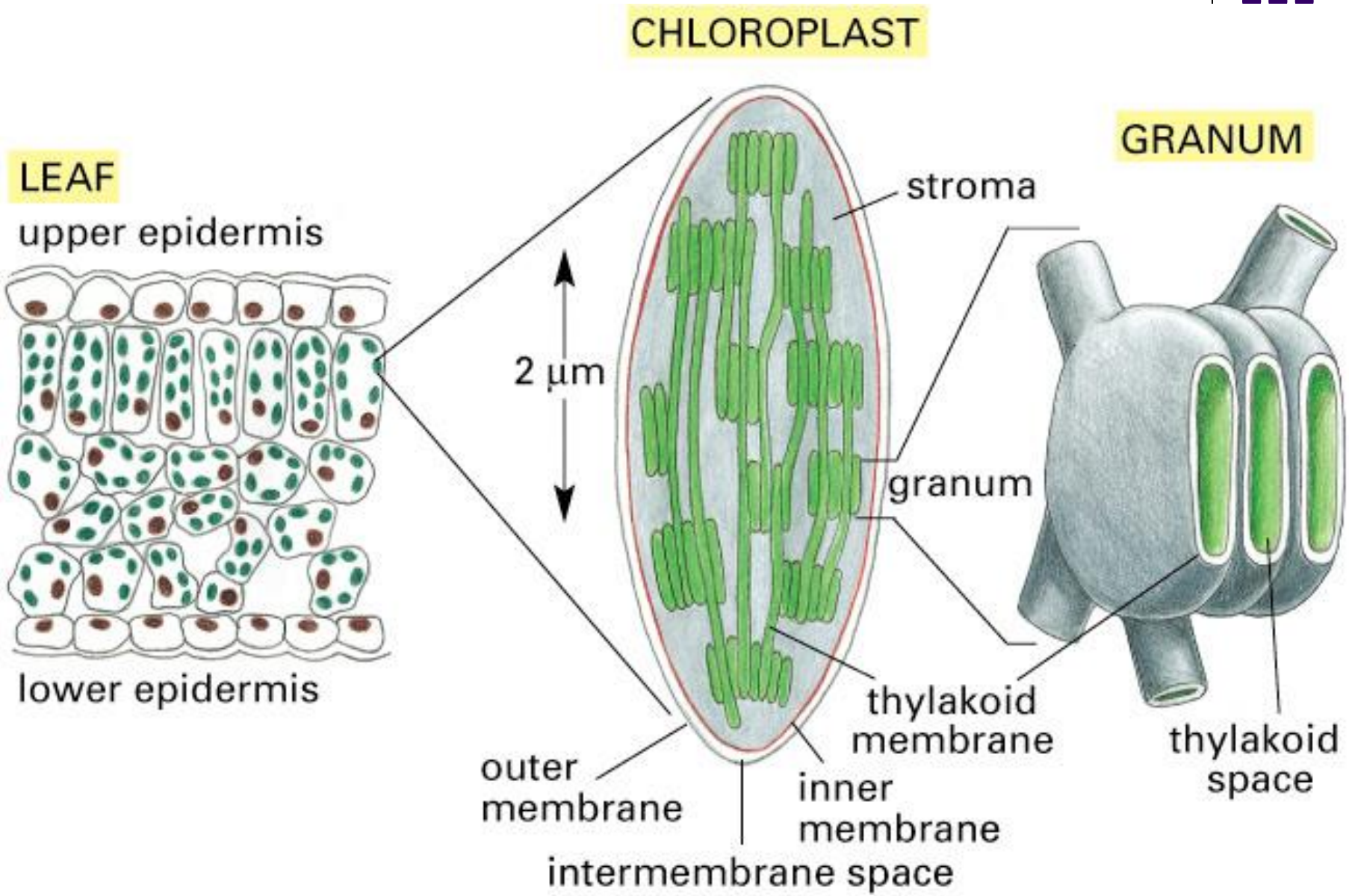


Figure 14–35. Molecular Biology of the Cell, 4th Edition.

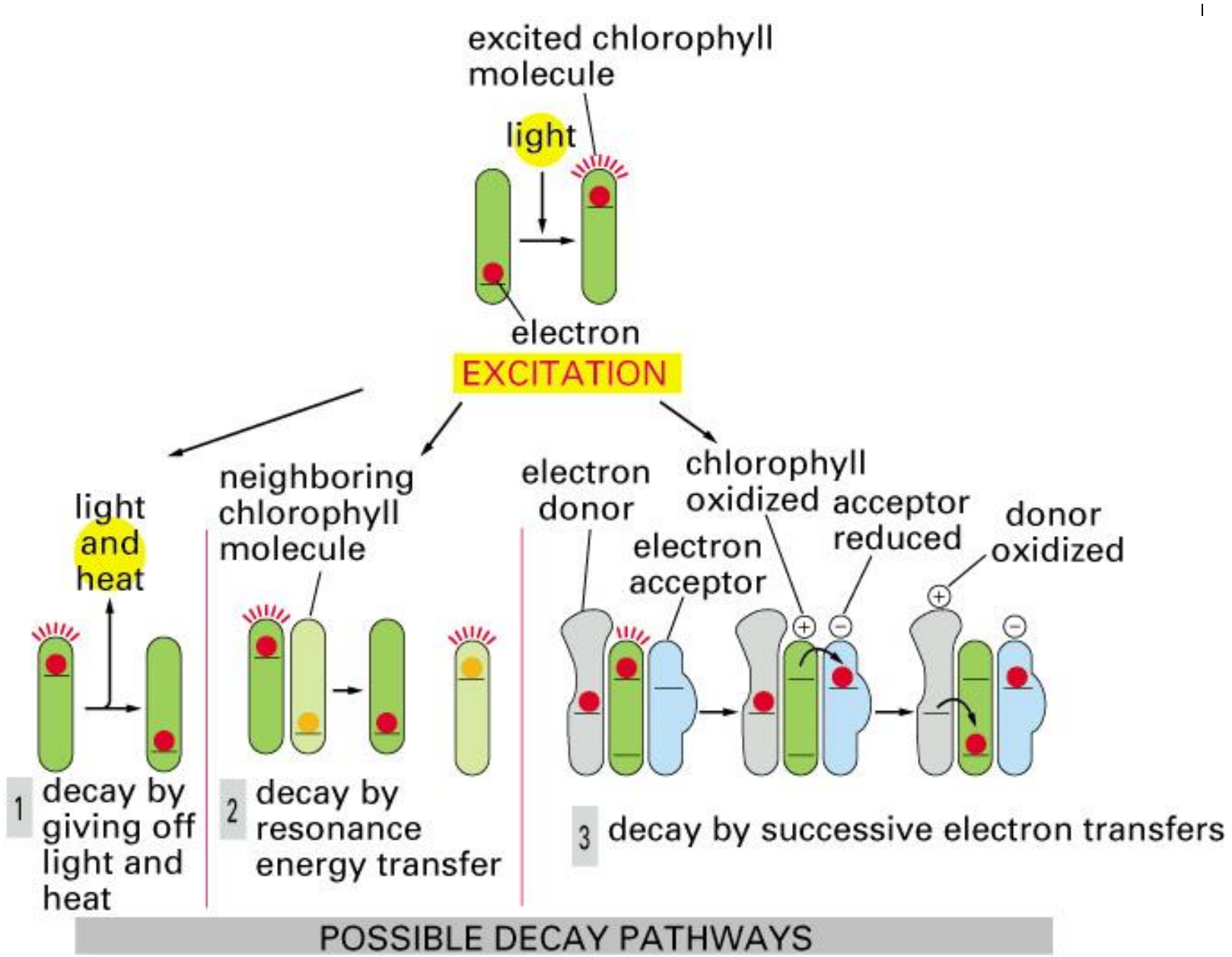
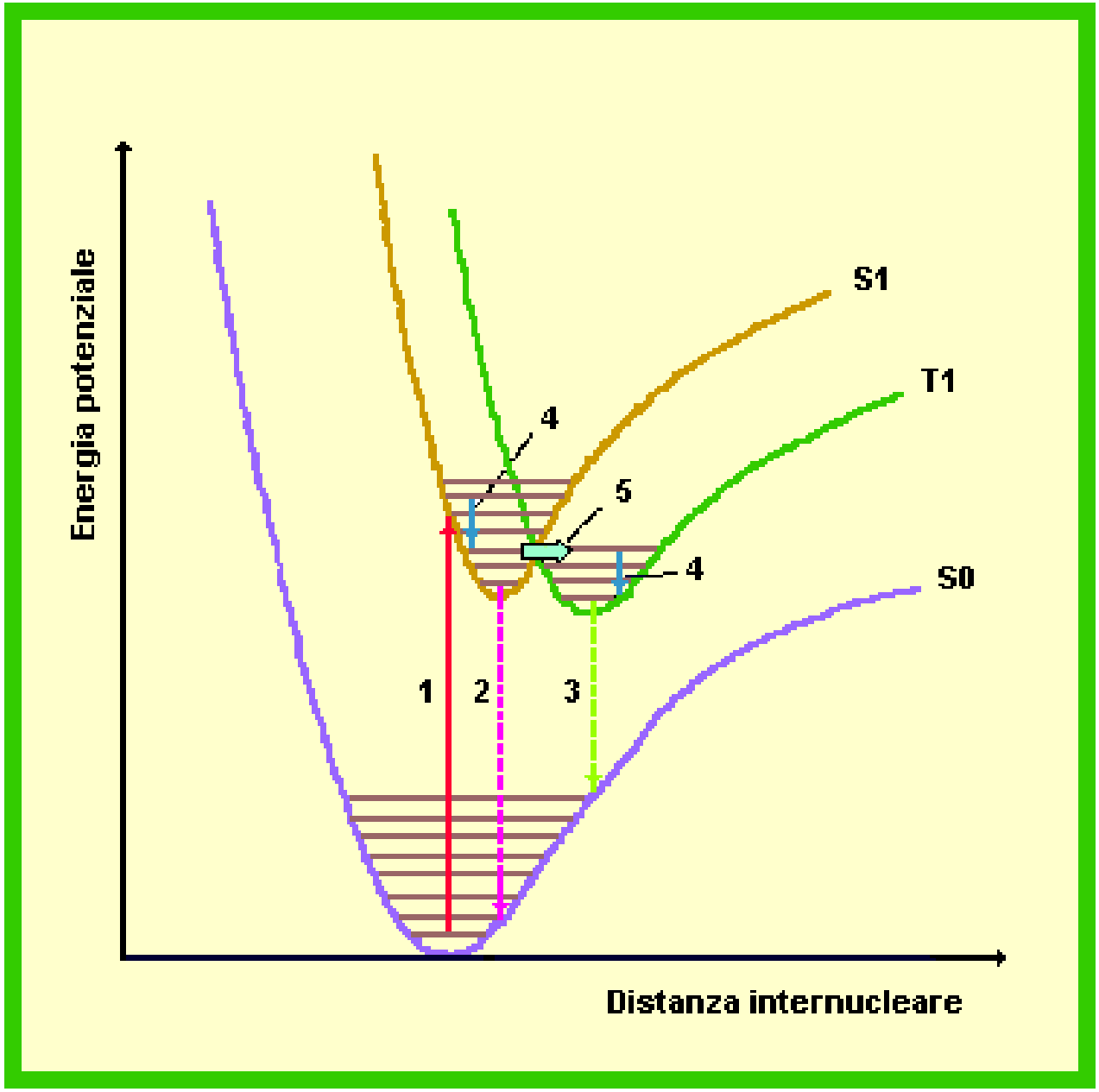


Figure 14–42. Molecular Biology of the Cell, 4th Edition.


Energia potenziale
Distanza internucleare
S1
T1
S0
1
2
3
4
5
4

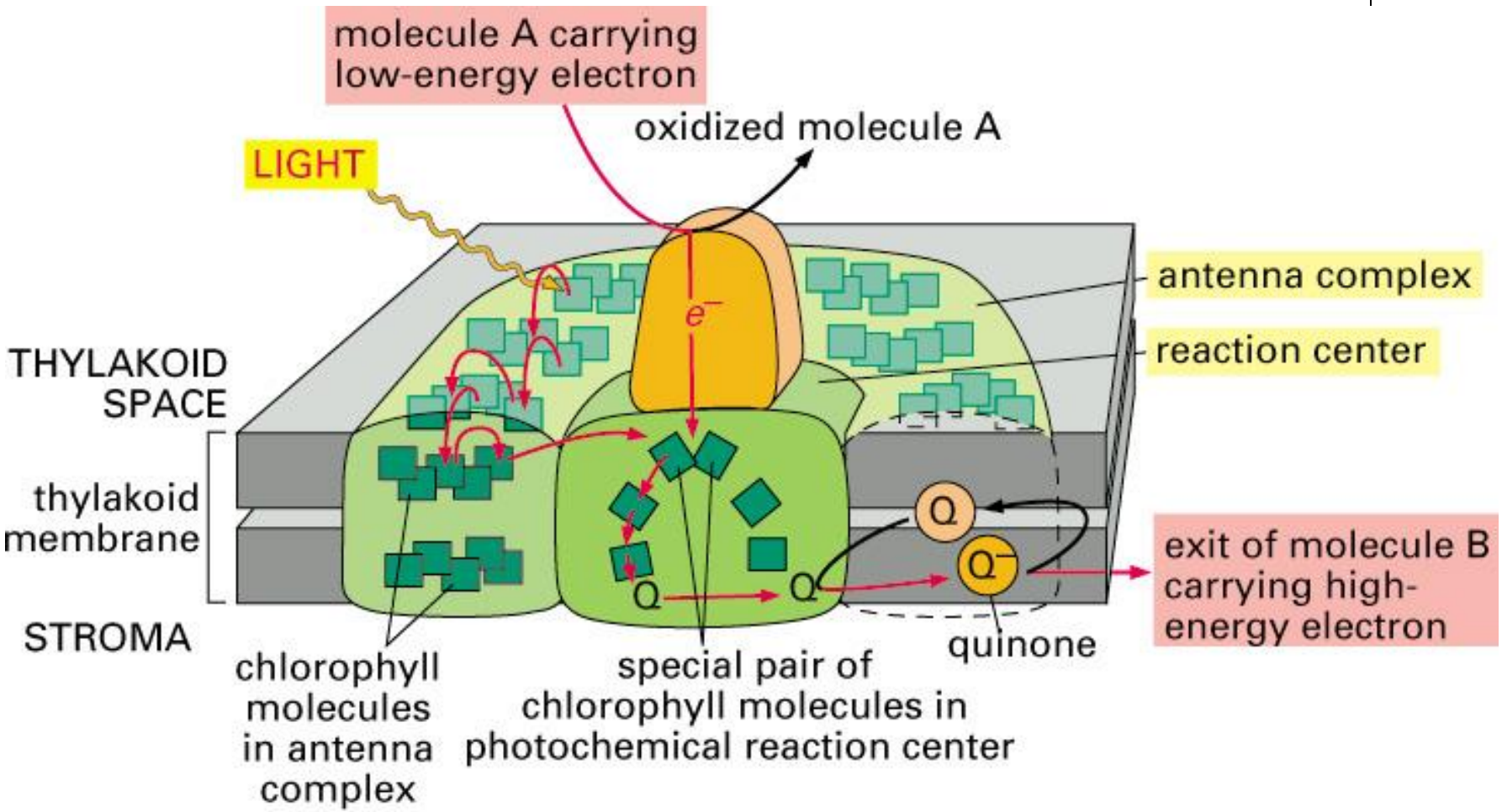


Figure 14–43. Molecular Biology of the Cell, 4th Edition.

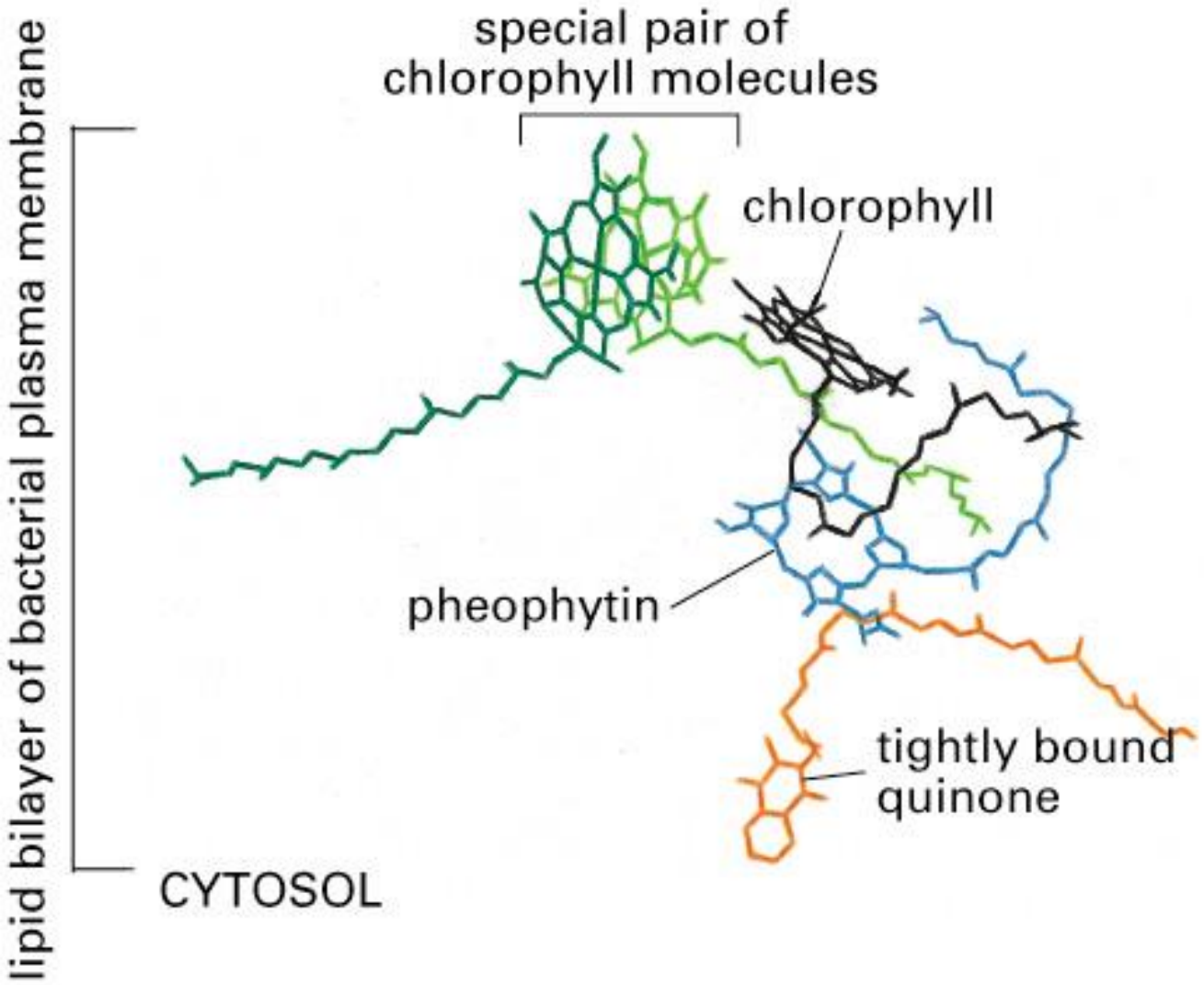


Figure 14–44. Molecular Biology of the Cell, 4th Edition.

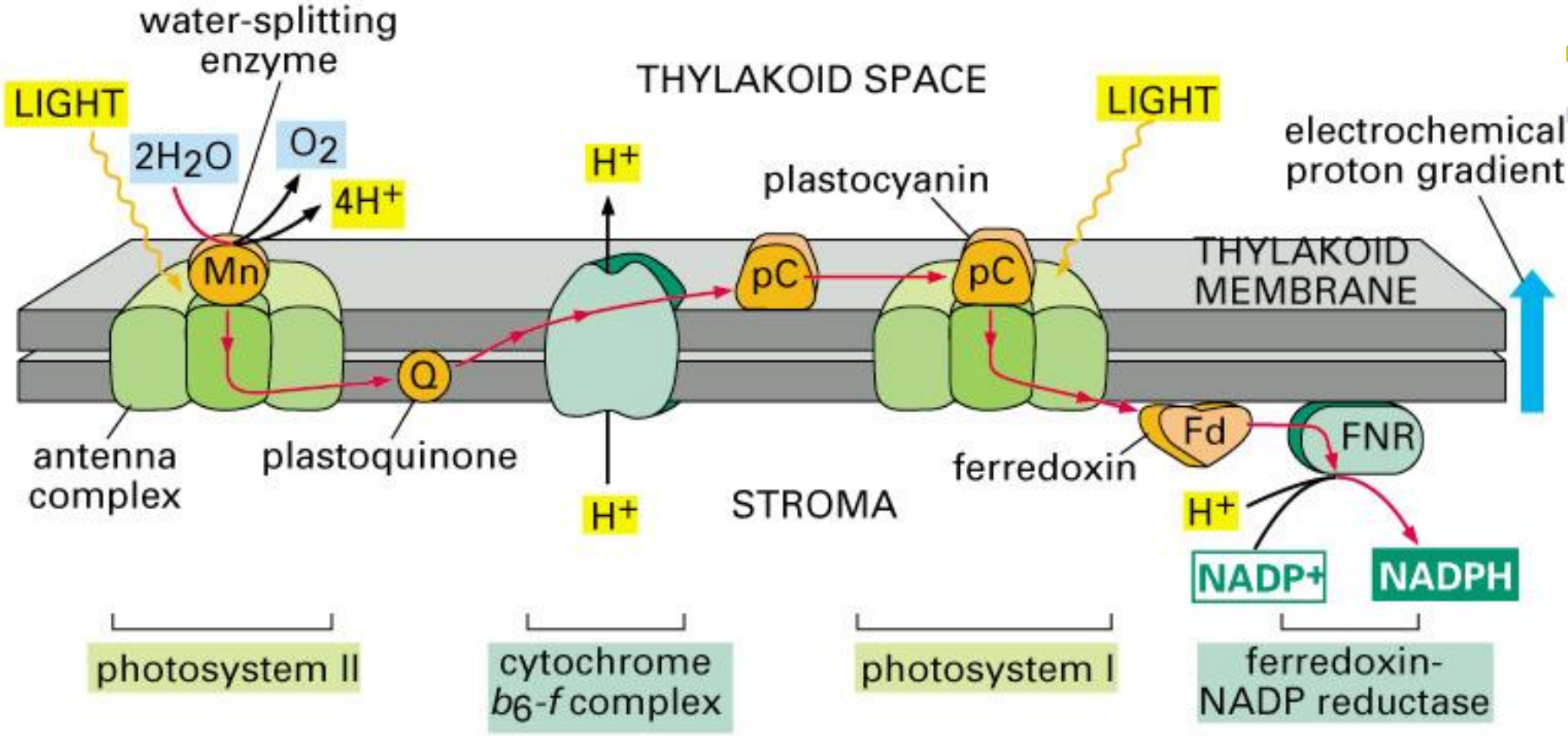


Figure 14–46. Molecular Biology of the Cell, 4th Edition.

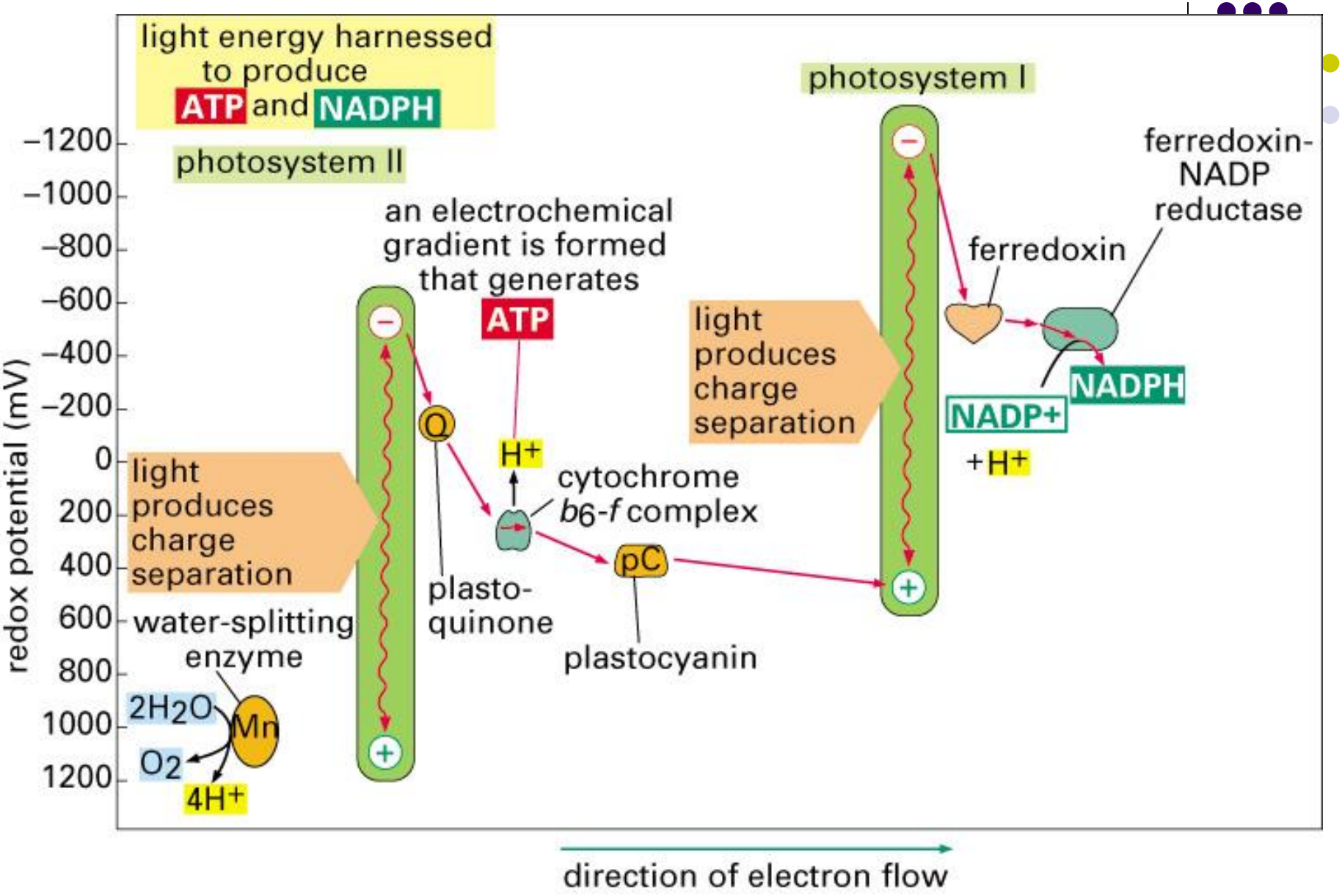


Figure 14–47. Molecular Biology of the Cell, 4th Edition.

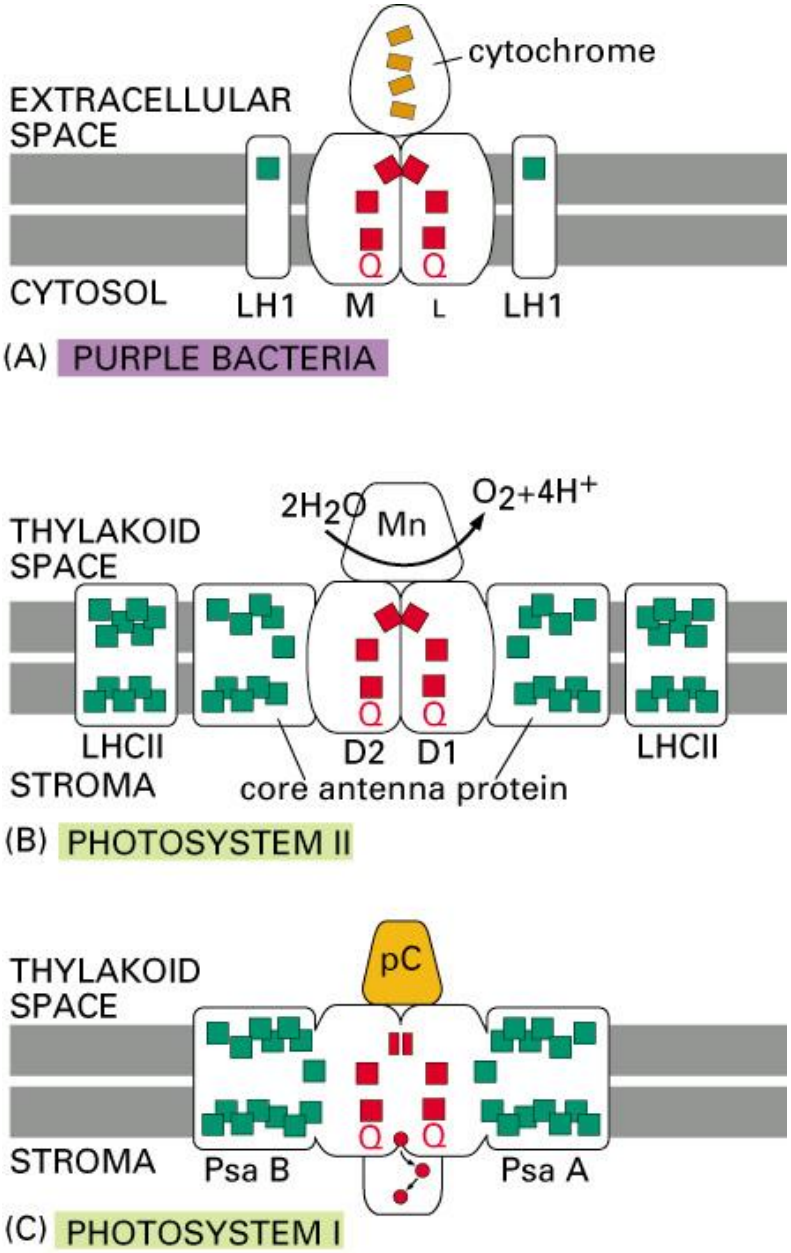


Figure 14–48. Molecular Biology of the Cell, 4th Edition.

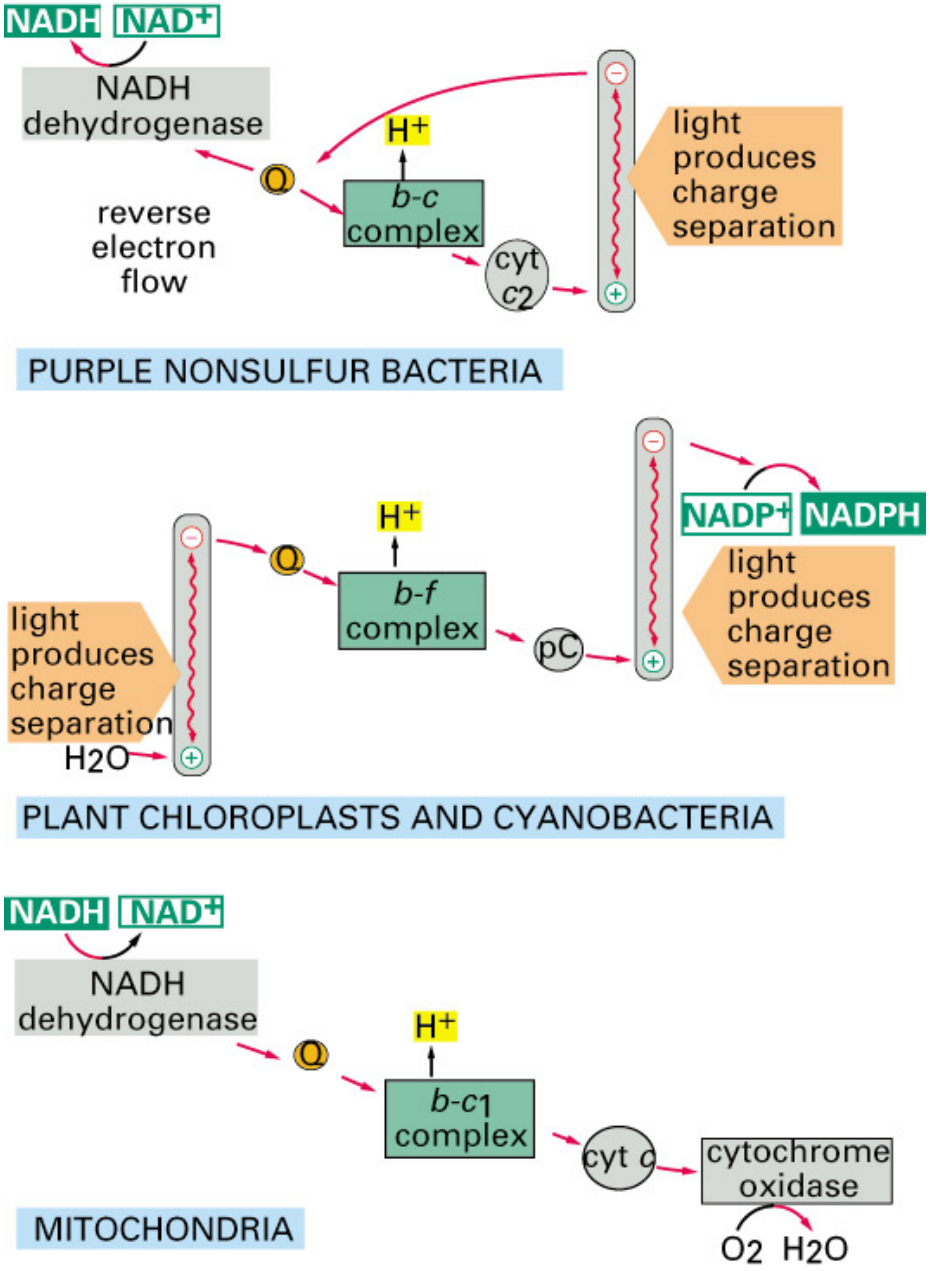
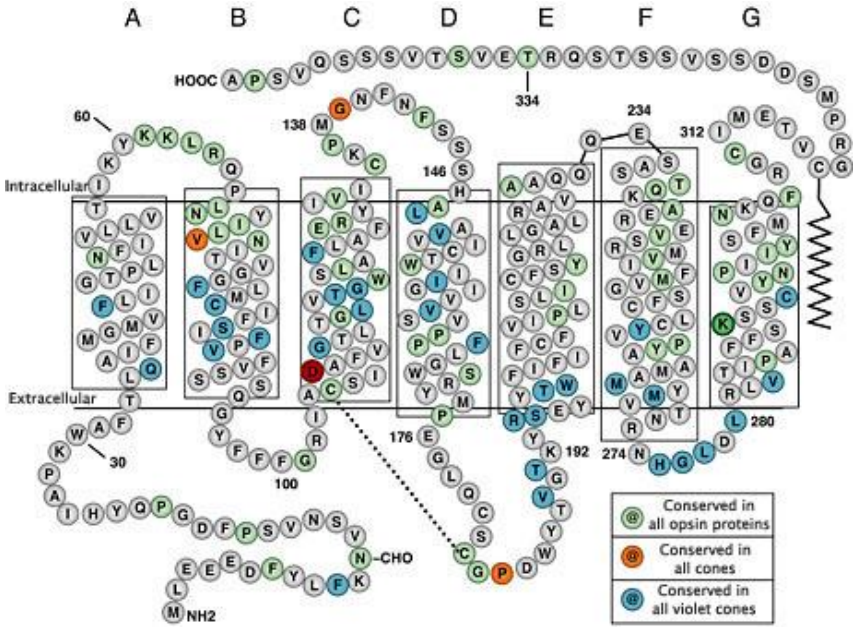
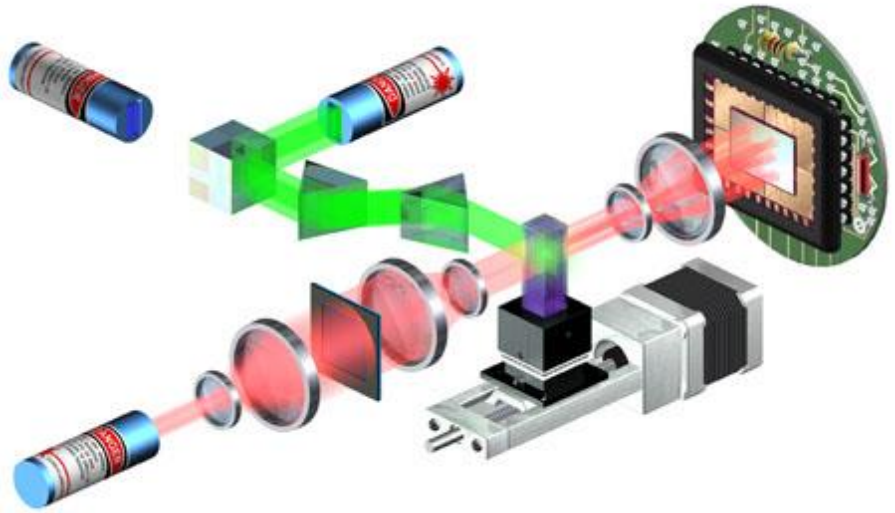


Figure 14–71. Molecular Biology of the Cell, 4th Edition.

Example: Protein Based Memory Device

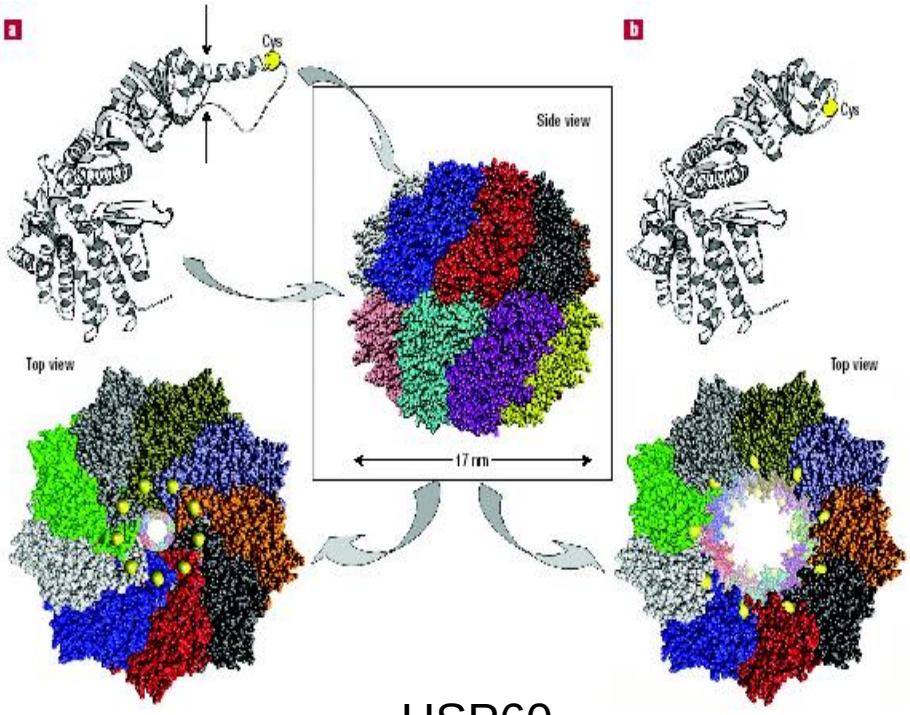




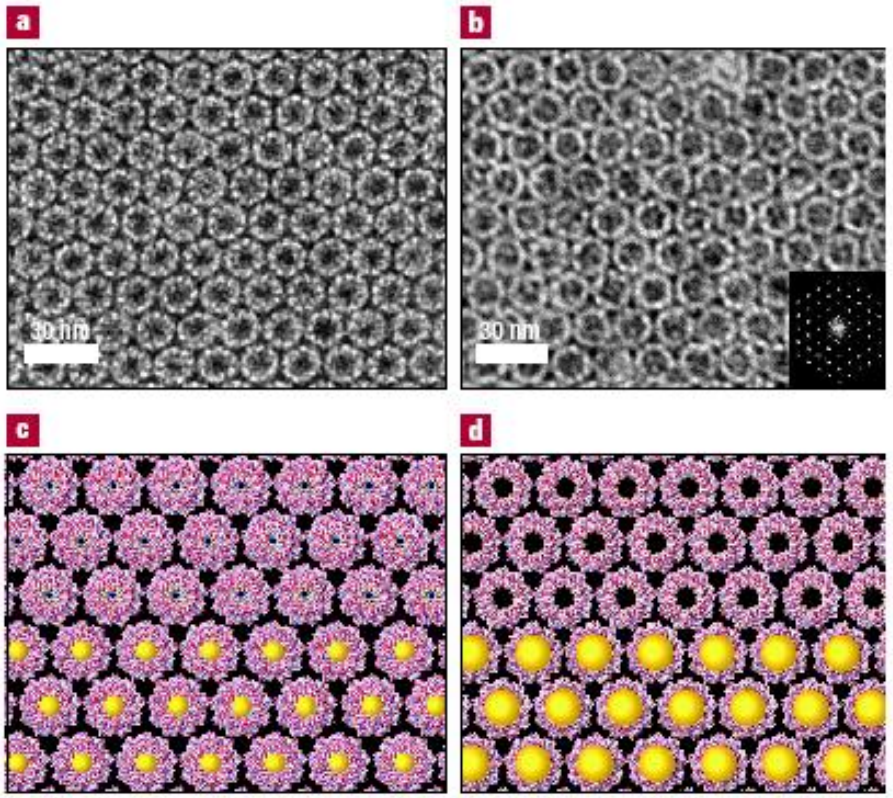
Birge 1995 issue of *Scientific American*

Chen, Z., D. Govender, et al. (1995). "." Biosystems **35**(2-3): 145-51.

Quantum dot storage array



HSP60

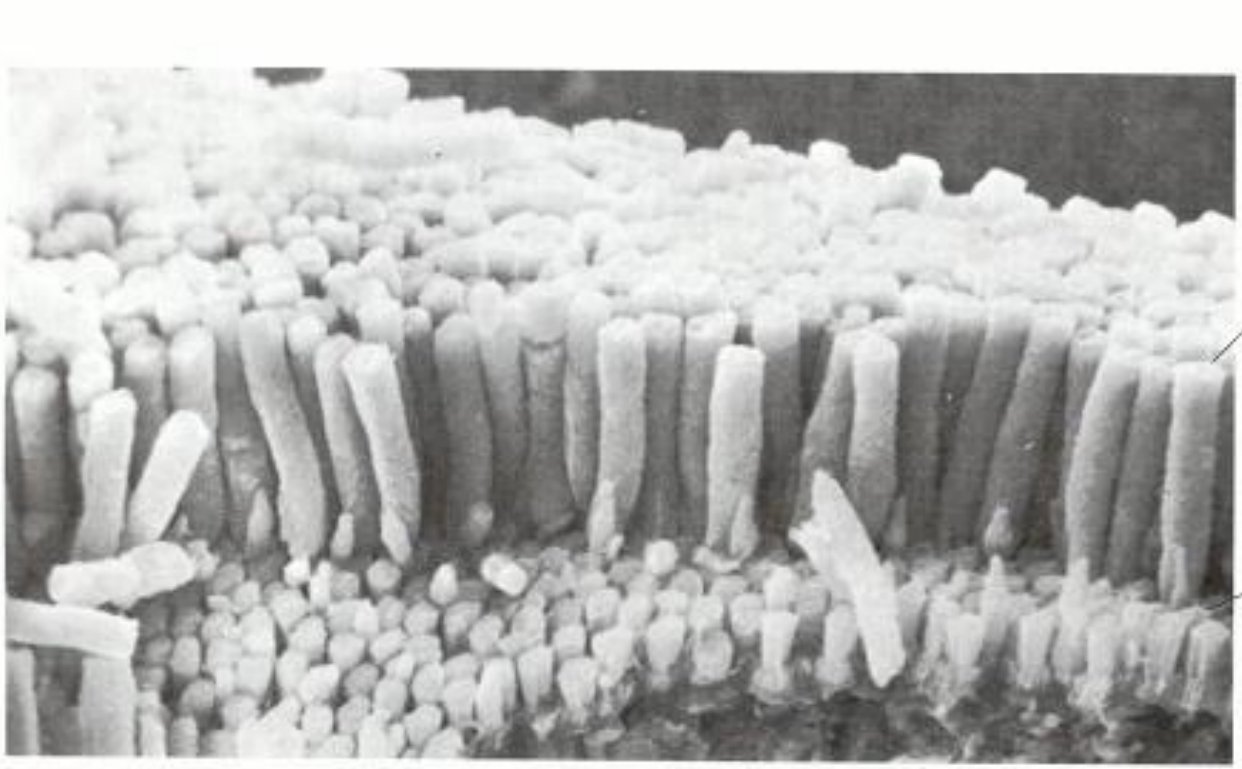


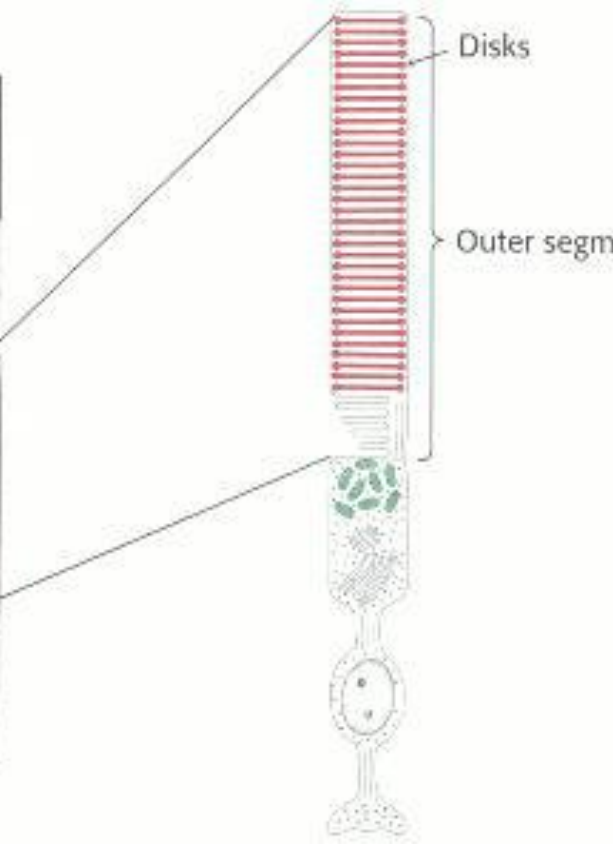
http://www.nature.com/nmat/journal/v1/n4/pdf/nmat775.pdf

Sensory systems

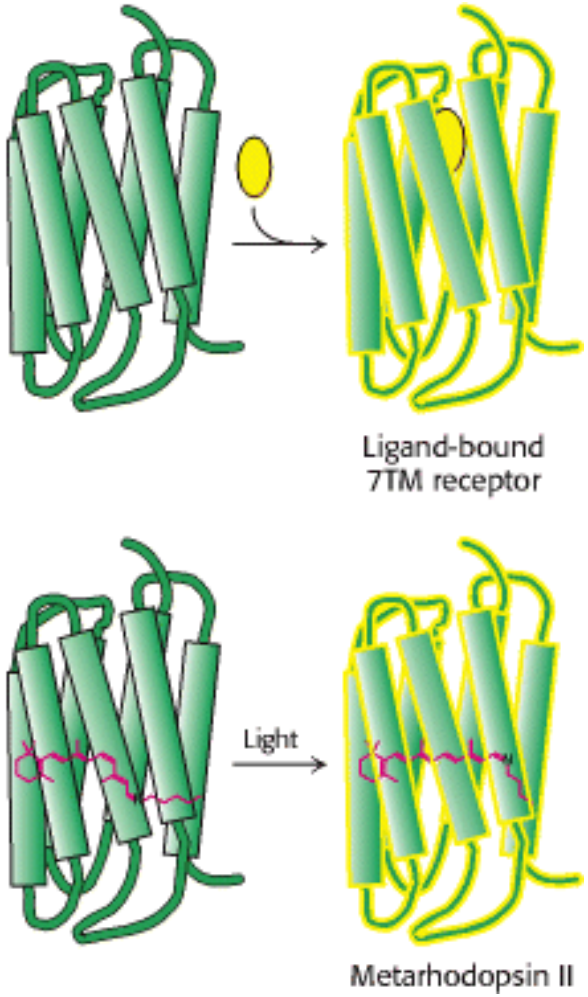
- Key concepts
  - Biomolecules are capable of remarkable sensitivity to light, sounds, pressure, and small molecules (Smell and Taste).
  - Information transfer via change in concentration gradients, conformational changes, phosphorylation etc.
  - Sensory systems usually membrane bound.

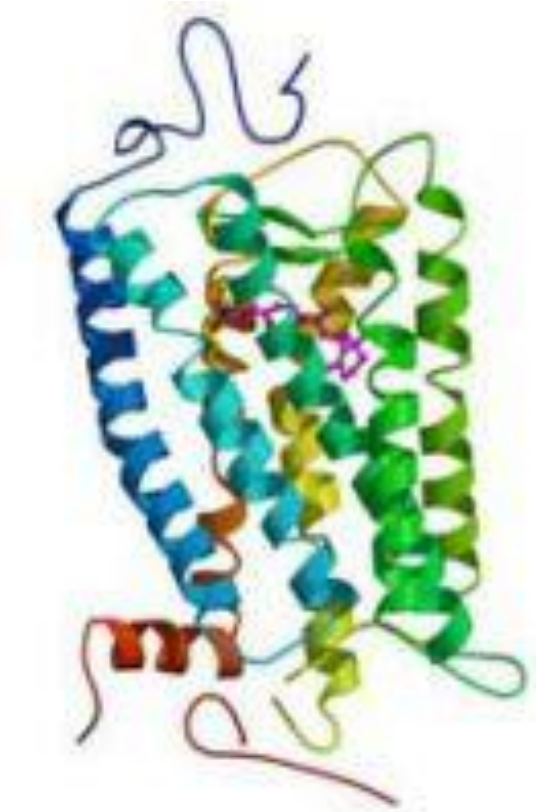
Responding to light and taste



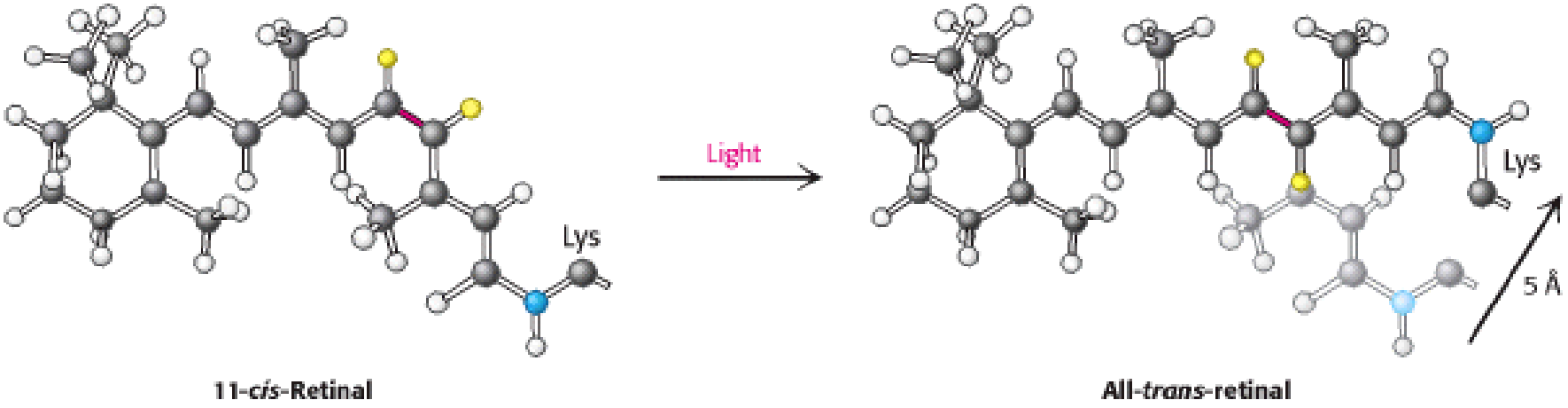


7tm(transmembrane) receptors



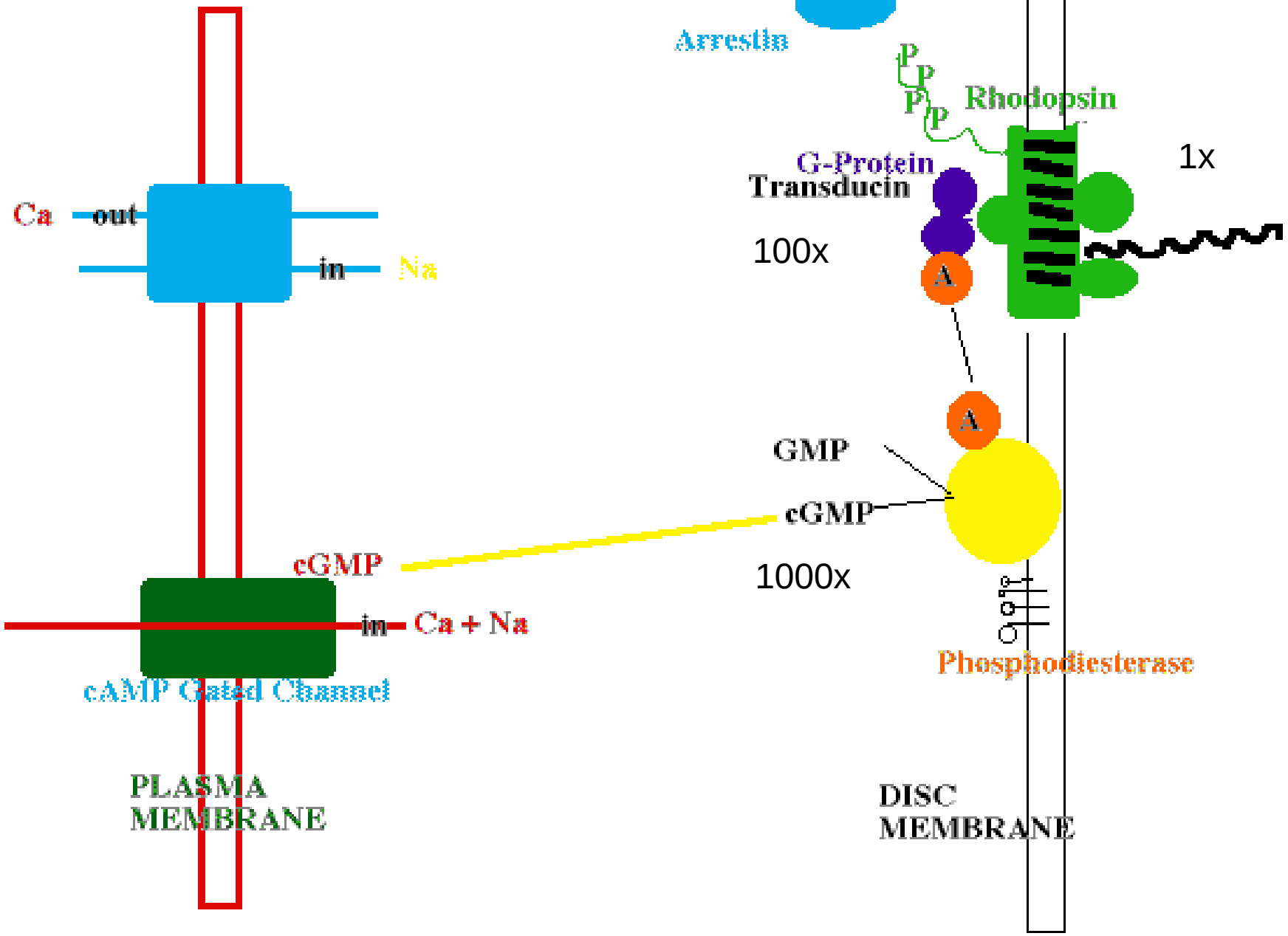


Photoisomerization

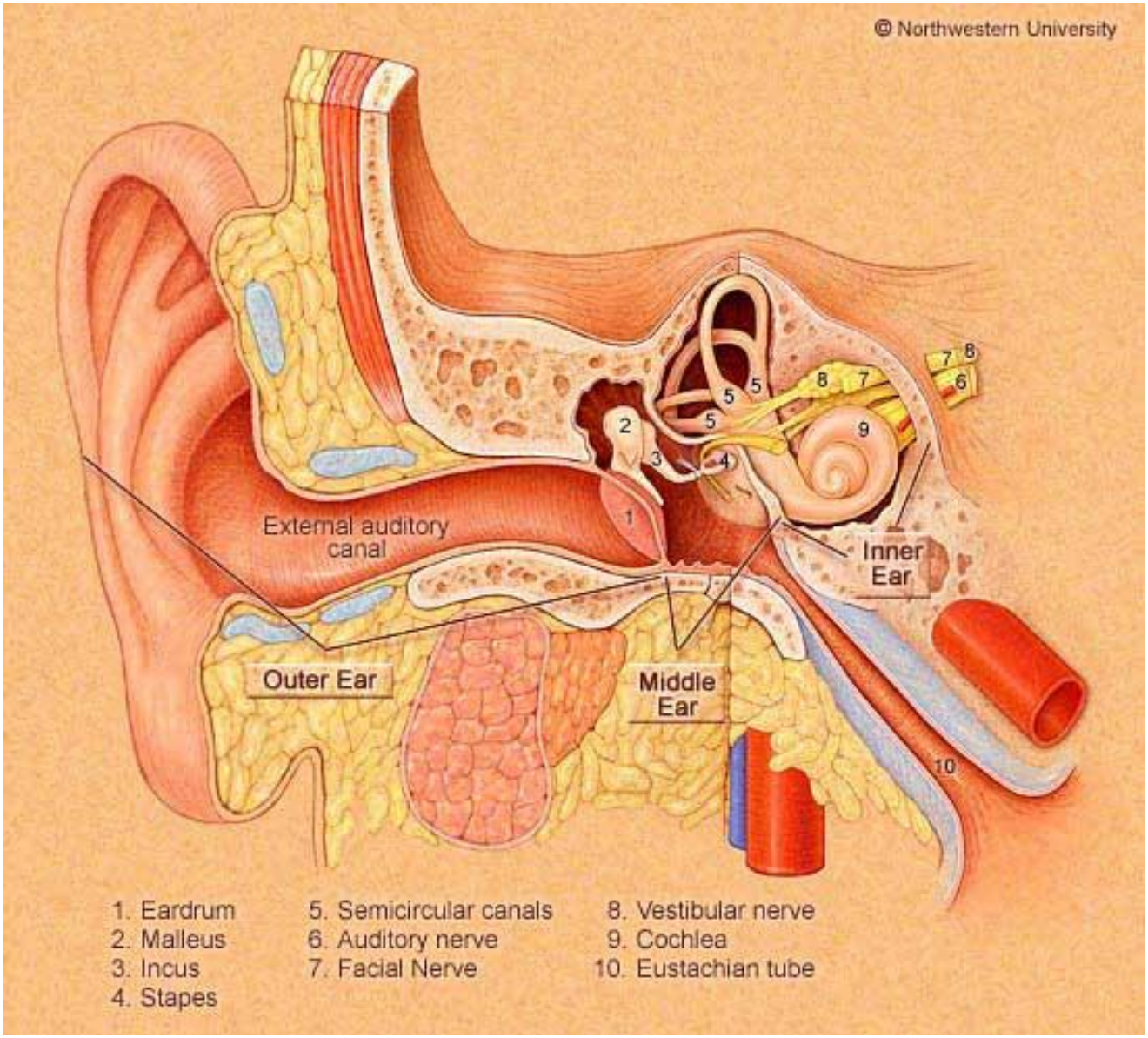


11-*cis*-Retinal

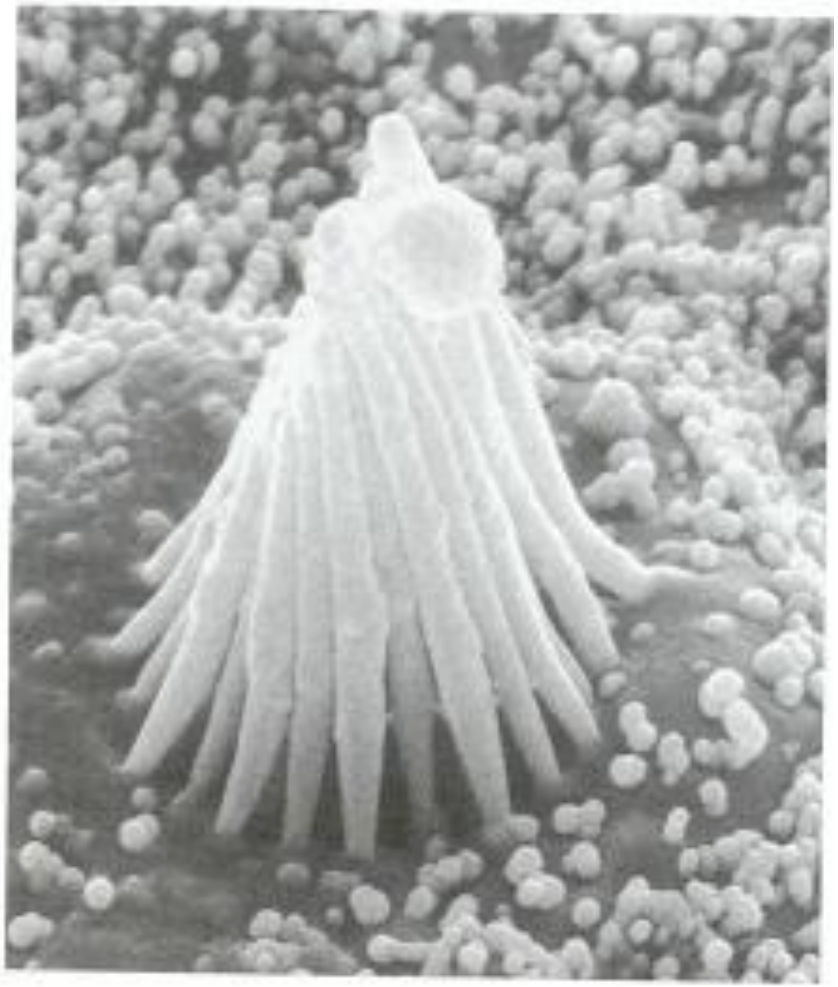
All-*trans*-retinal

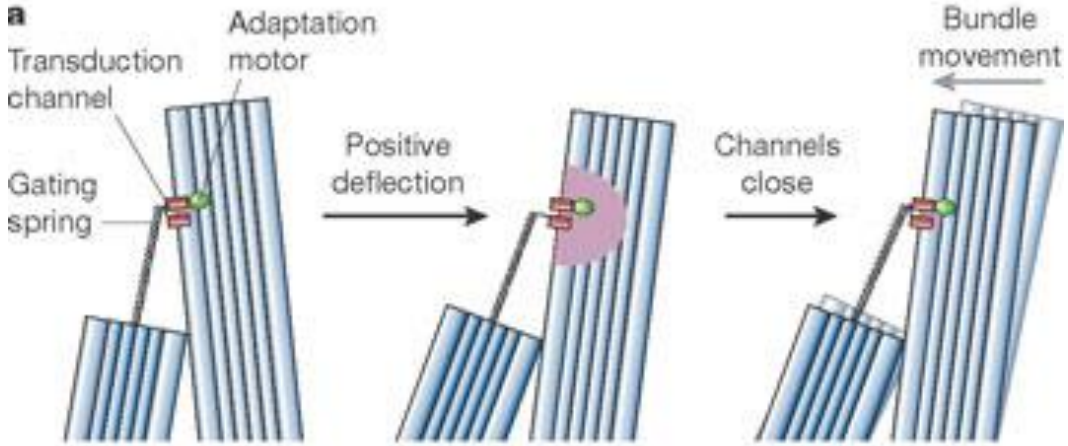

Arrestin
P
P
P
P
Rhodopsin
1x
G-Protein
Transducin
100x
A
A
GMP
cGMP
1000x
Phosphodiesterase
Ca
out
in
Na
cGMP
in
Ca + Na
cAMP Gated Channel
PLASMA
MEMBRANE
DISC
MEMBRANE

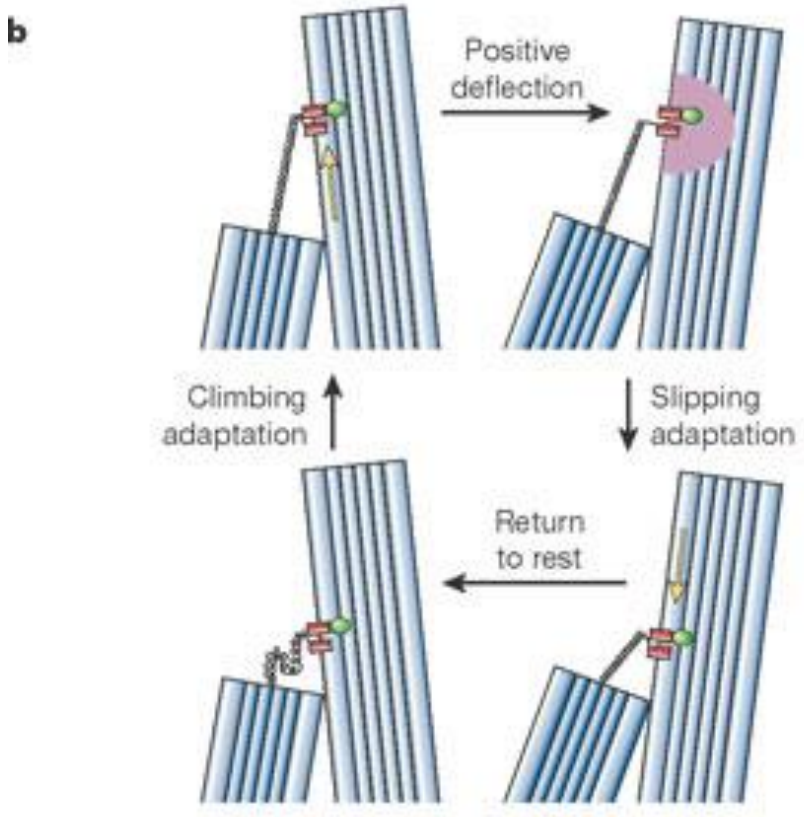
Sounds

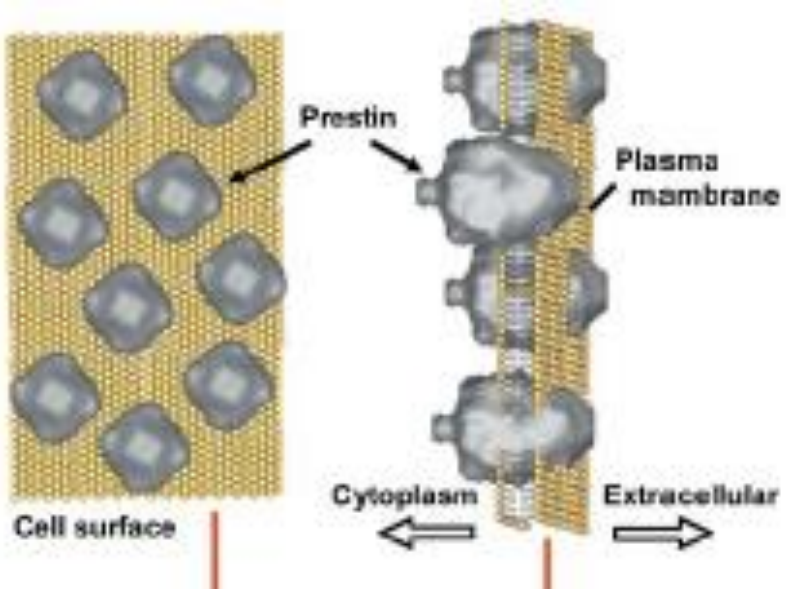

© Northwestern University
External auditory canal
Outer Ear
Middle Ear
Inner Ear
1. Eardrum
2. Malleus
3. Incus
4. Stapes
5. Semicircular canals
6. Auditory nerve
7. Facial Nerve
8. Vestibular nerve
9. Cochlea
10. Eustachian tube

Hair cells.

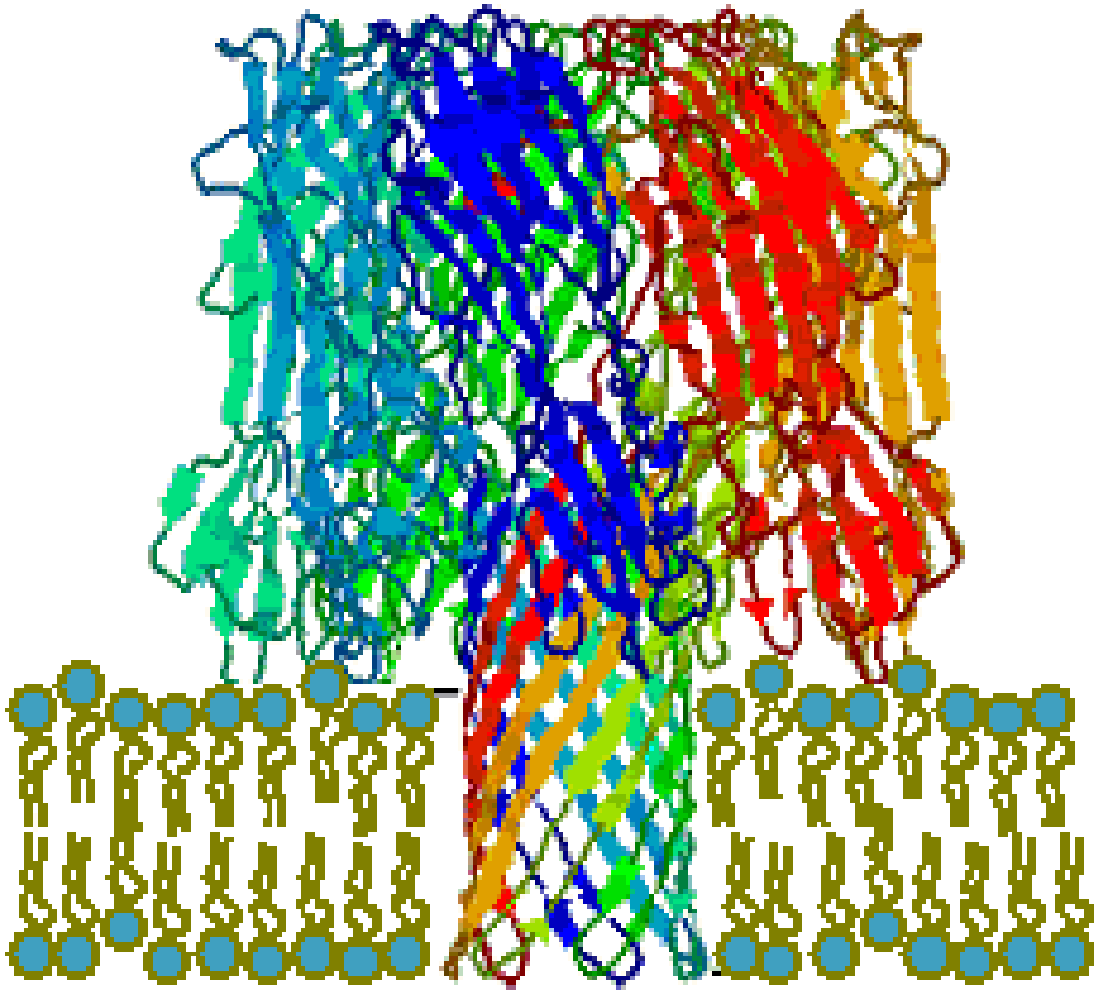



a
Transduction channel
Adaptation motor
Gating spring
Positive deflection
Channels close
Bundle movement

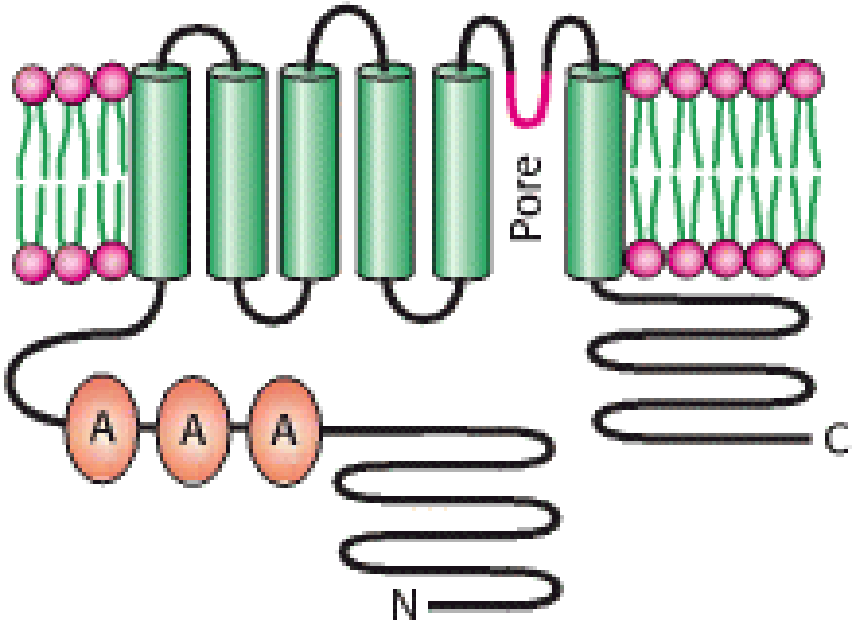

b
Positive deflection
Slipping adaptation
Return to rest
Climbing adaptation


Prestin
Plasma membrane
Cell surface
Cytoplasm
Extracellular

Holes in membranes

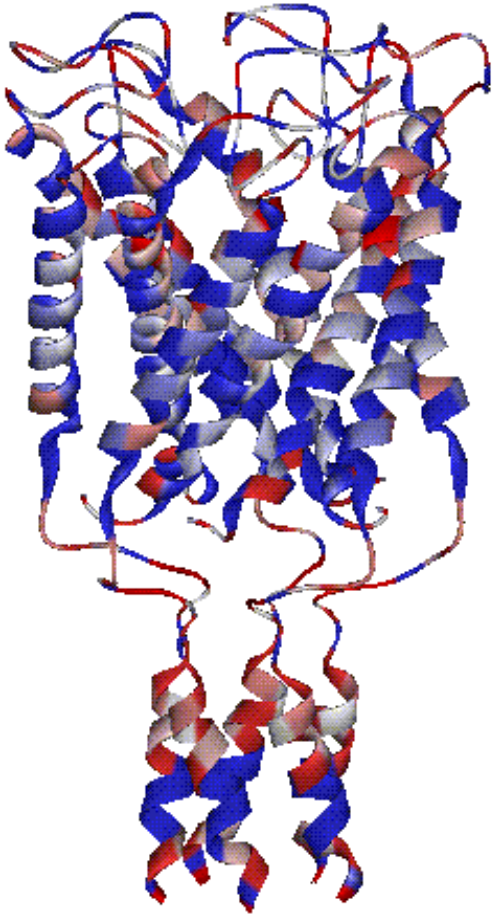


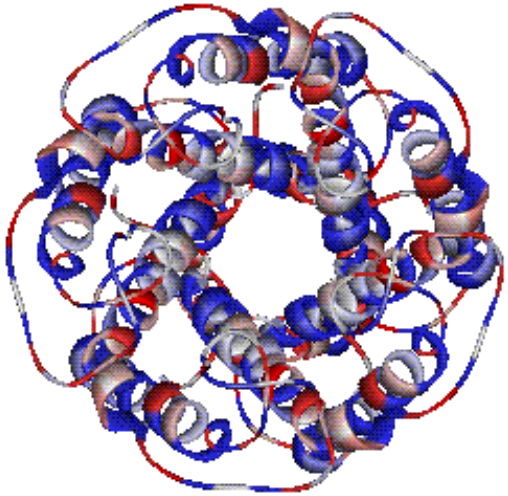
Pressure and temperature



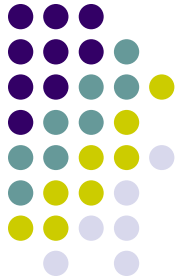
Capsaicin receptor (TRP channel)

Mechanosensitive channel



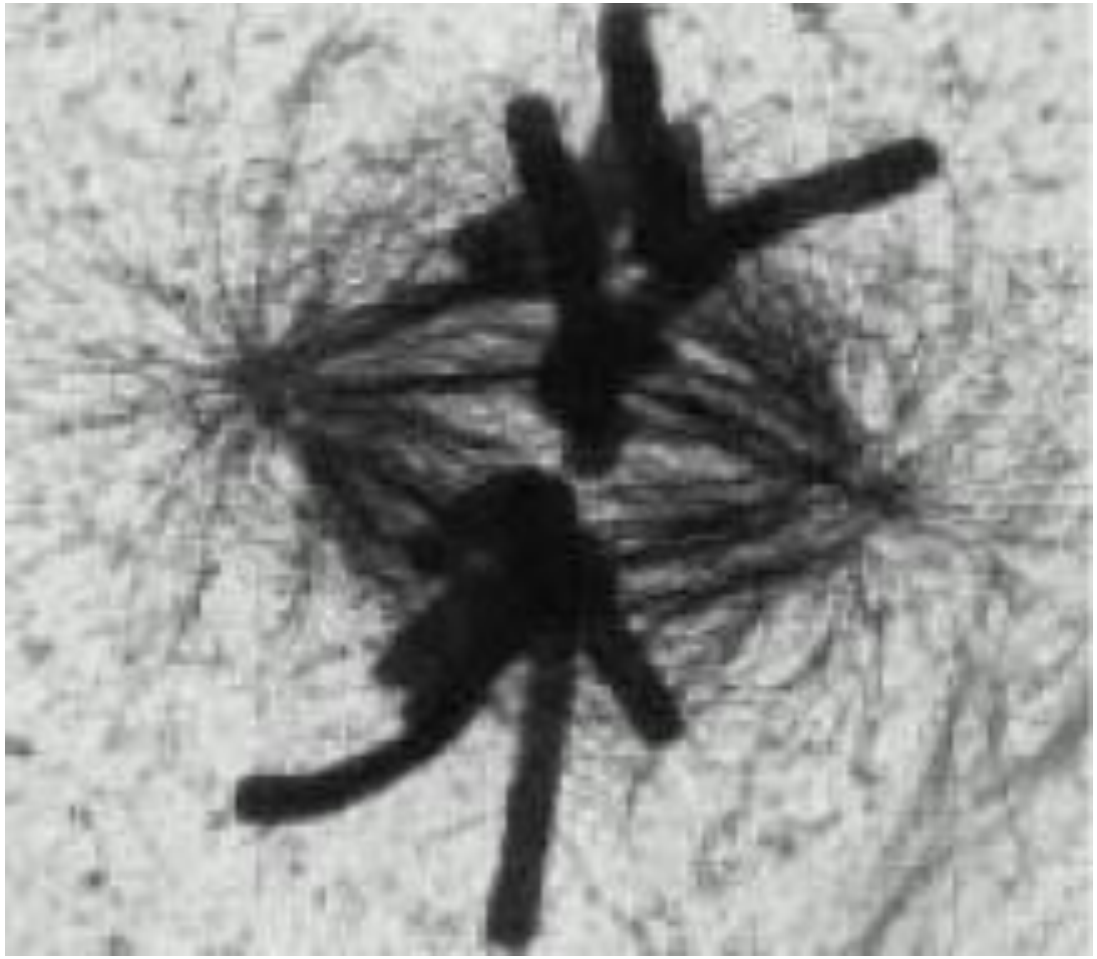


Molecular motors

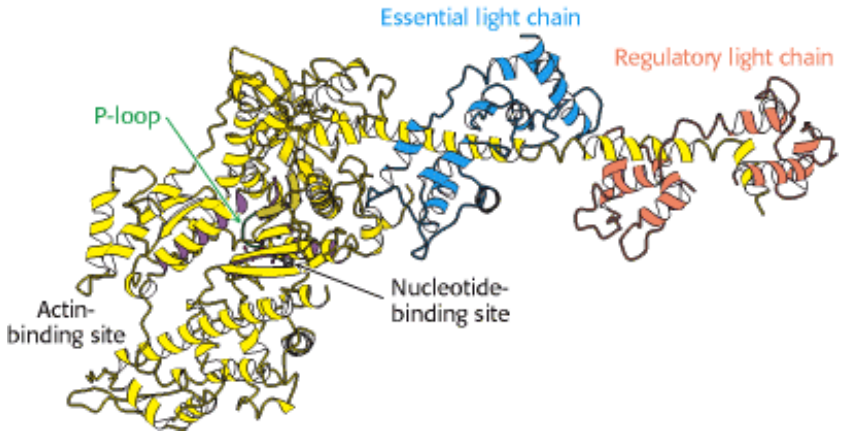


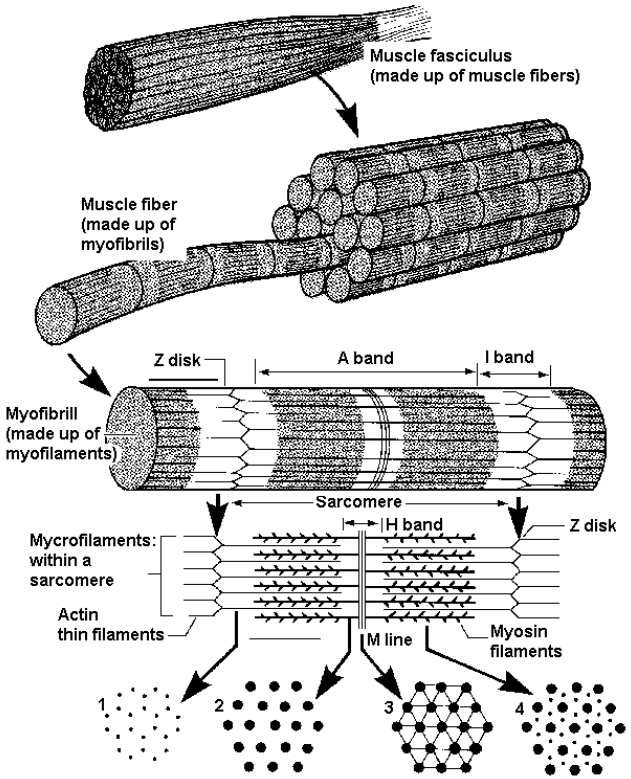
- Key concepts
  - NTP proteins (use ATP)
  - Kinesin and Dynein use Microtubule (polymer)
  - Mysosin along Actin (polymer)
  - Forces on the order of piconewtons.

Motion in the cell

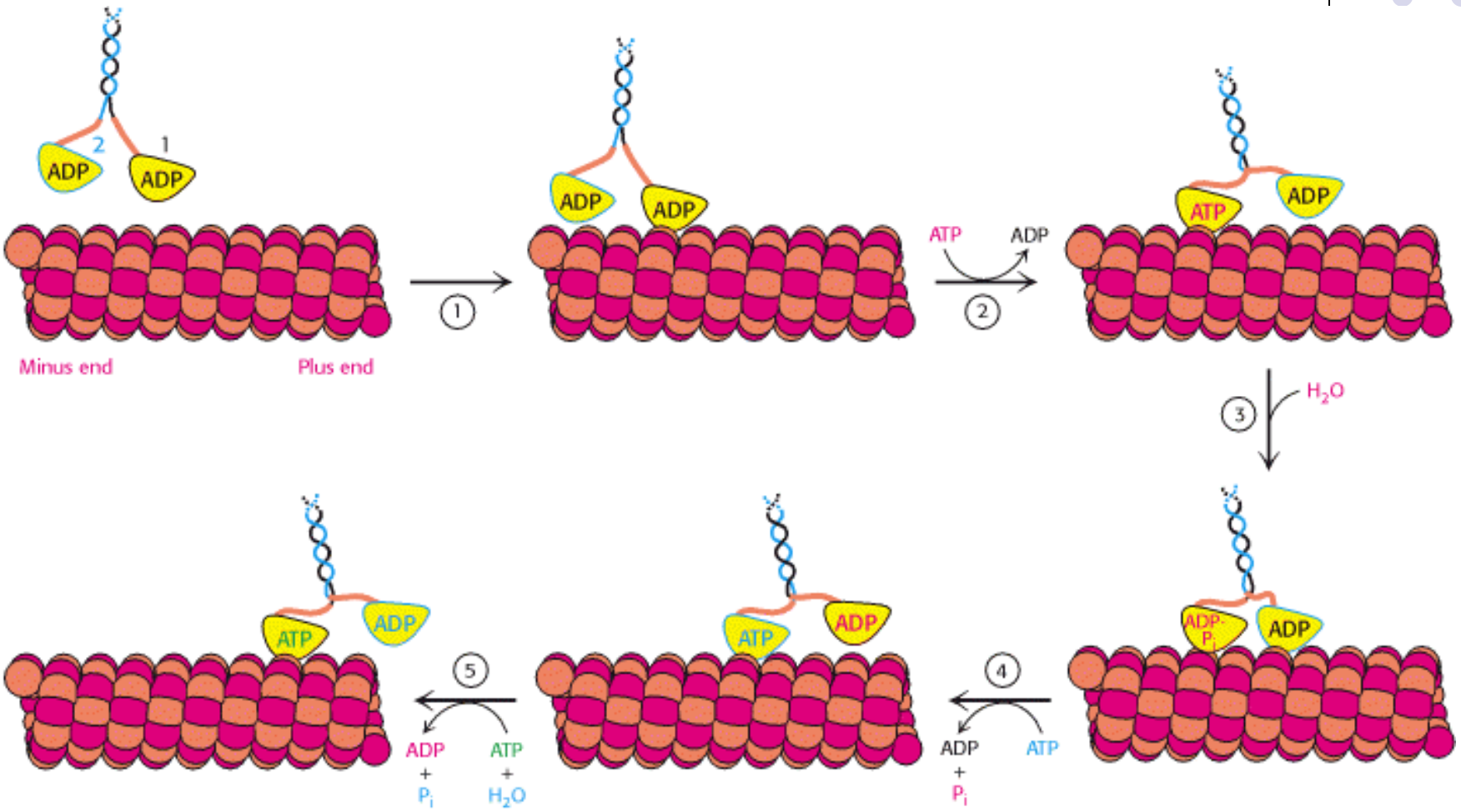


Mysosin

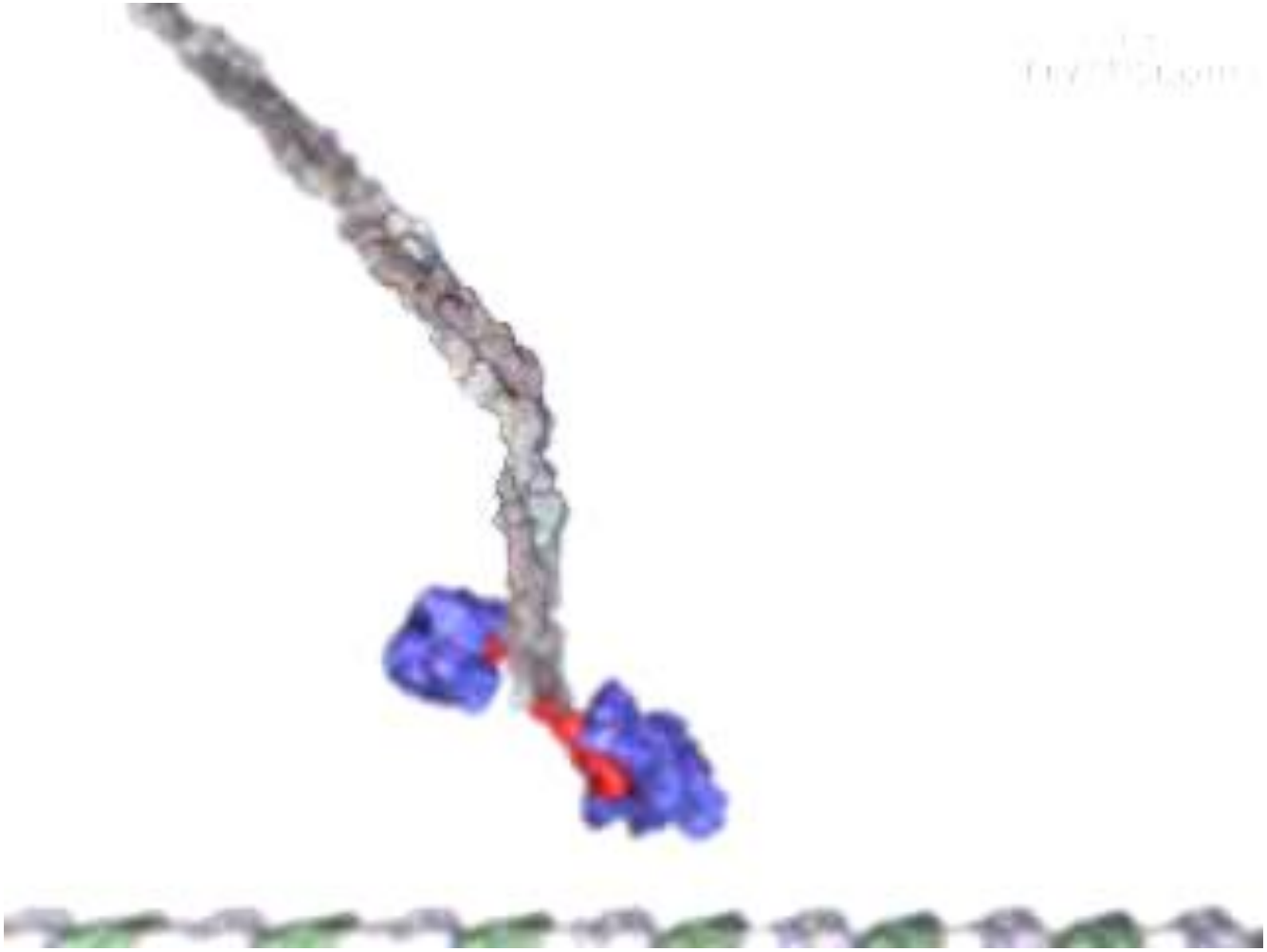

Essential light chain
Regulatory light chain
P-loop
Actin-
binding site
Nucleotide-
binding site


Muscle fasciculus
(made up of muscle fibers)
Muscle fiber
(made up of
myofibrils)
Z disk
A band
I band
Myofibrill
(made up of
myofilaments)
Sarcomere
H band
Z disk
Mycrofilaments:
within a
sarcomere
Actin
thin filaments
M line
Myosin
filaments
1
2
3
4

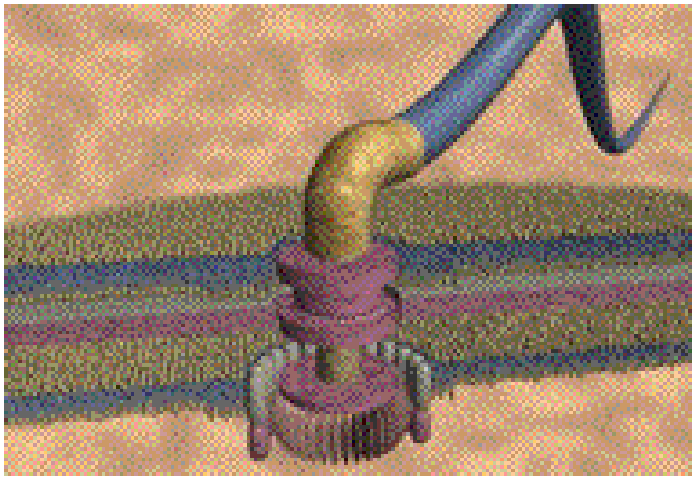
The steps of kinesin

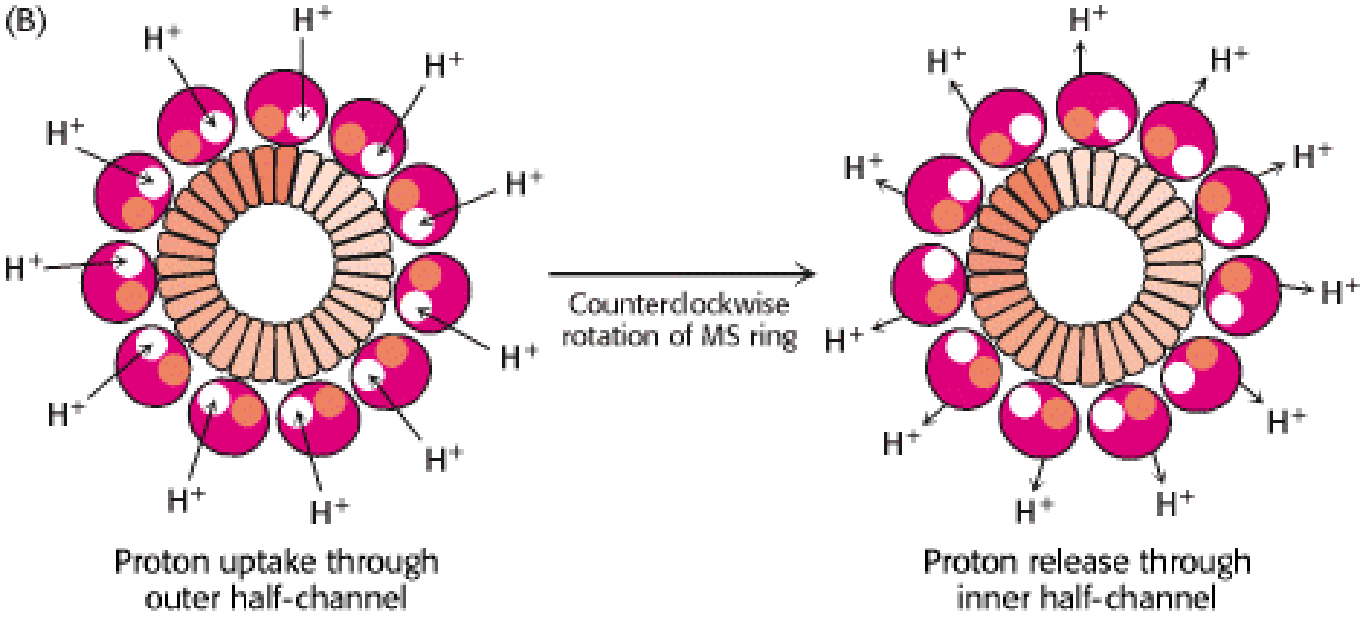


~100ATP/s and 8nm/ATP = ~800nm/s

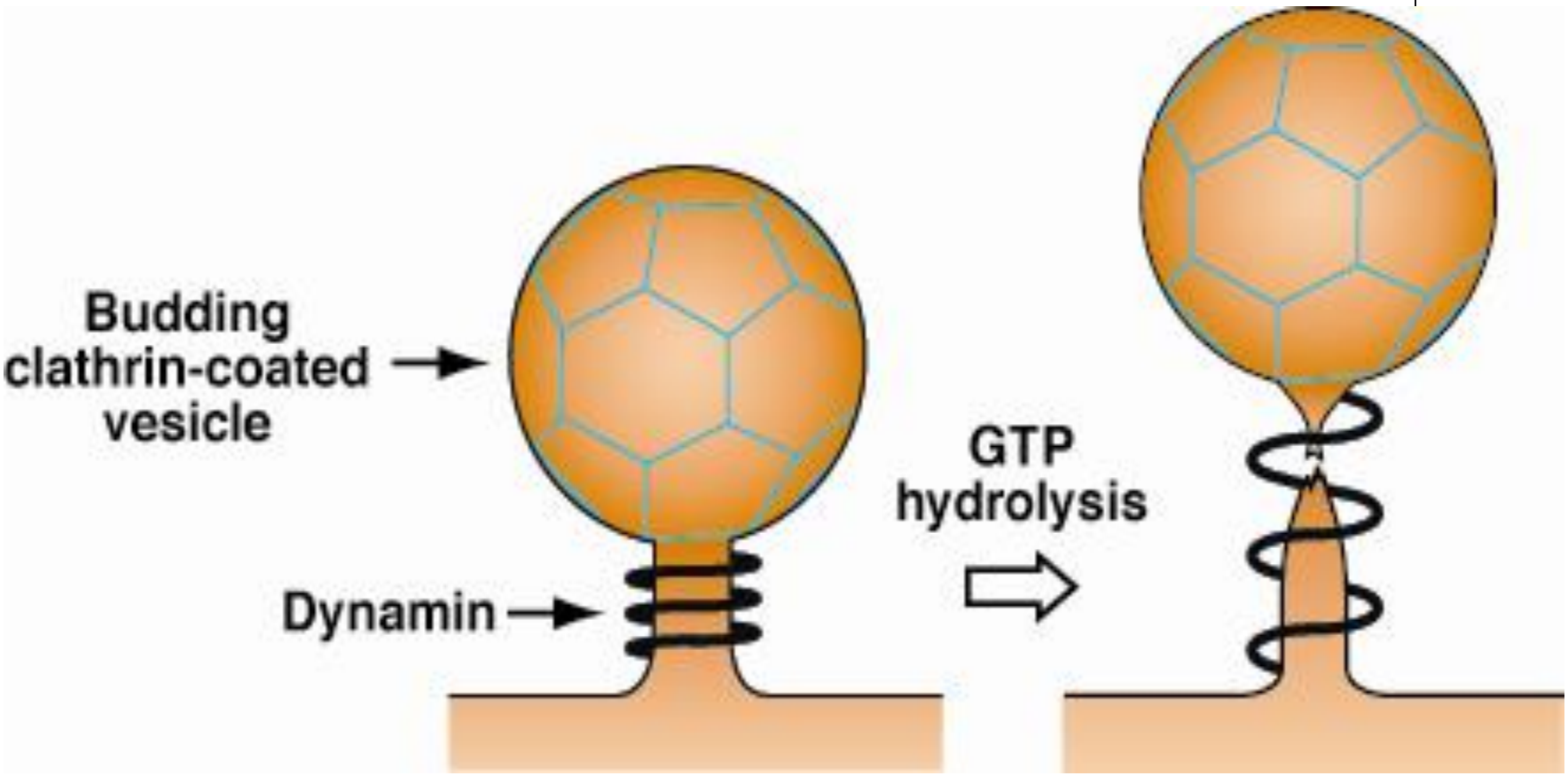


Bacterial motility

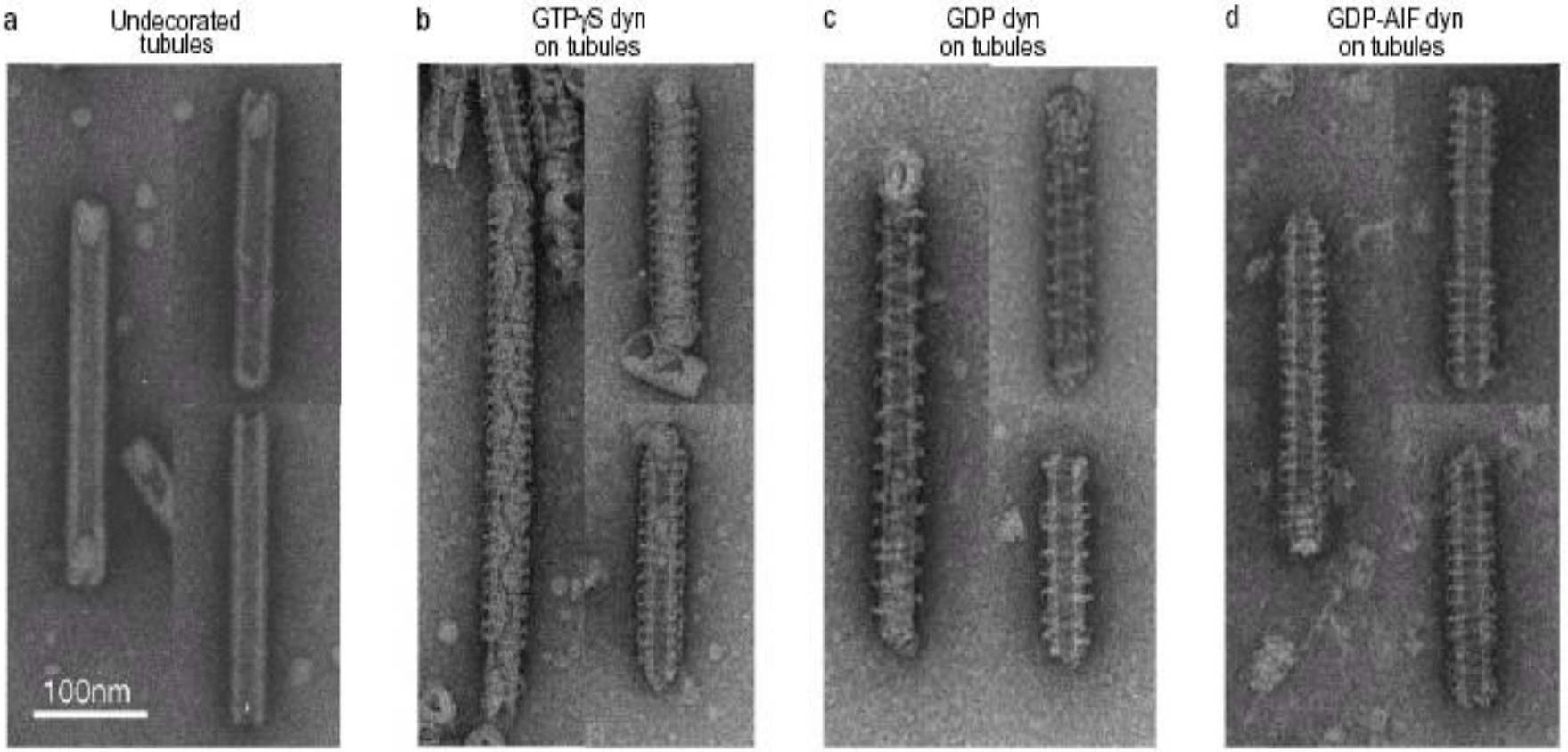




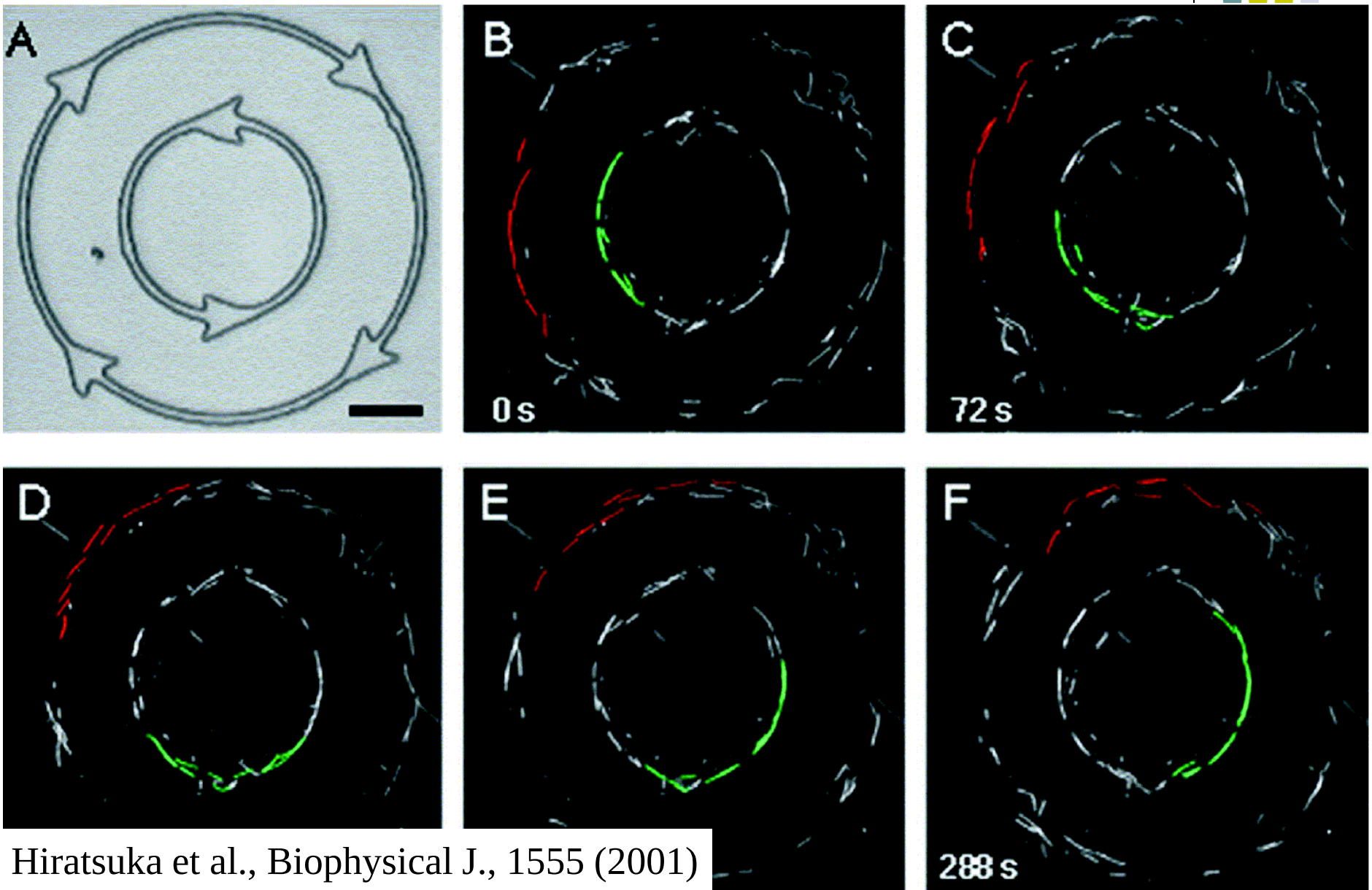
Endocytosis



Nanomolecular spring

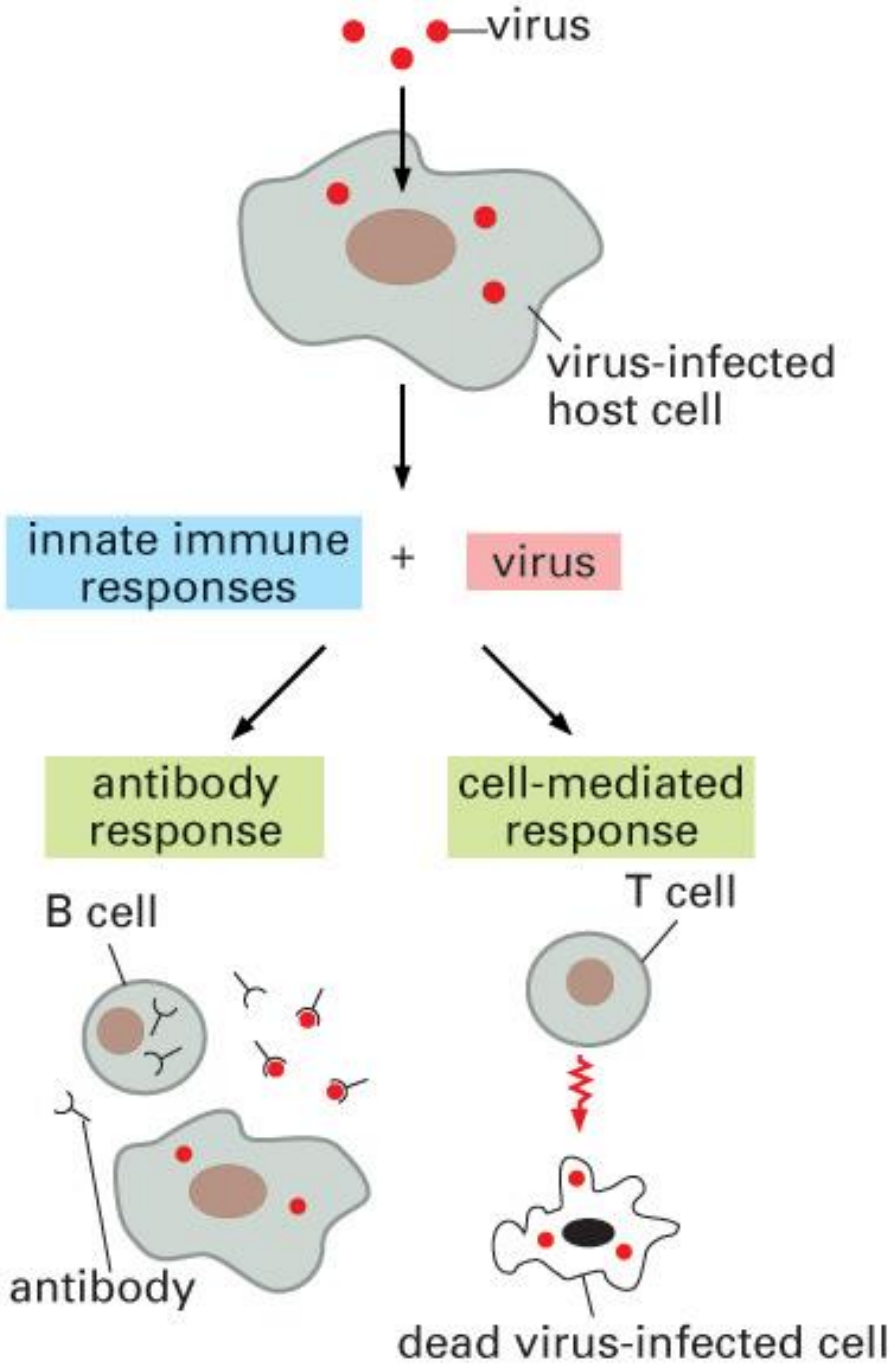


Example: Microtubules in Tracks



Hiratsuka et al., Biophysical J., 1555 (2001)

Who's who


virus
virus-infected host cell
innate immune responses
+
virus
antibody response
cell-mediated response
B cell
T cell
antibody
dead virus-infected cell

Key concepts

- Antibodies are highly diverse in specificity
- Can be raised against small molecules, biomolecules, inorganics etc.
- Relatively stable and easy to mass produce
- Multifunctional (self assembly)

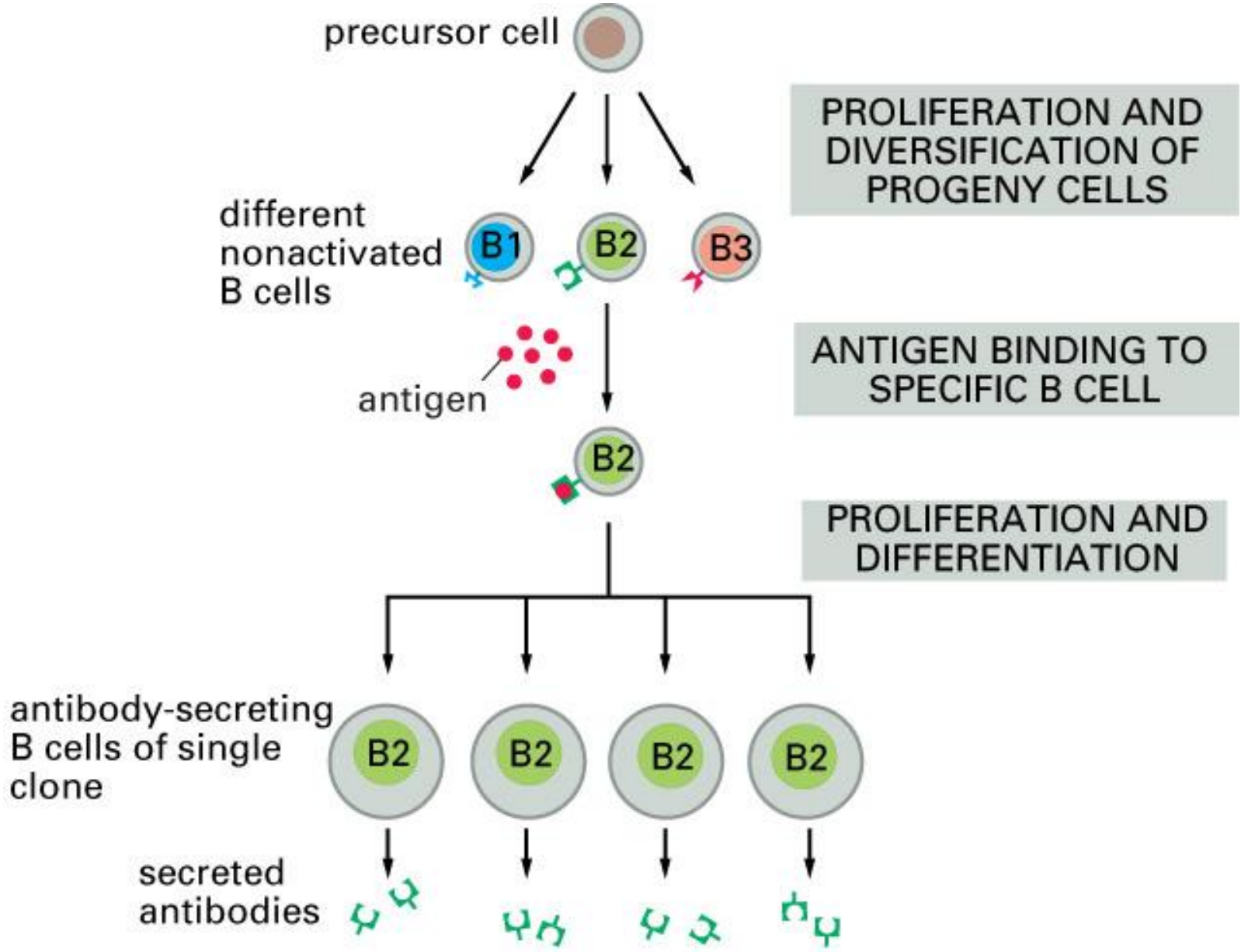


Figure 24–8. Molecular Biology of the Cell, 4th Edition.

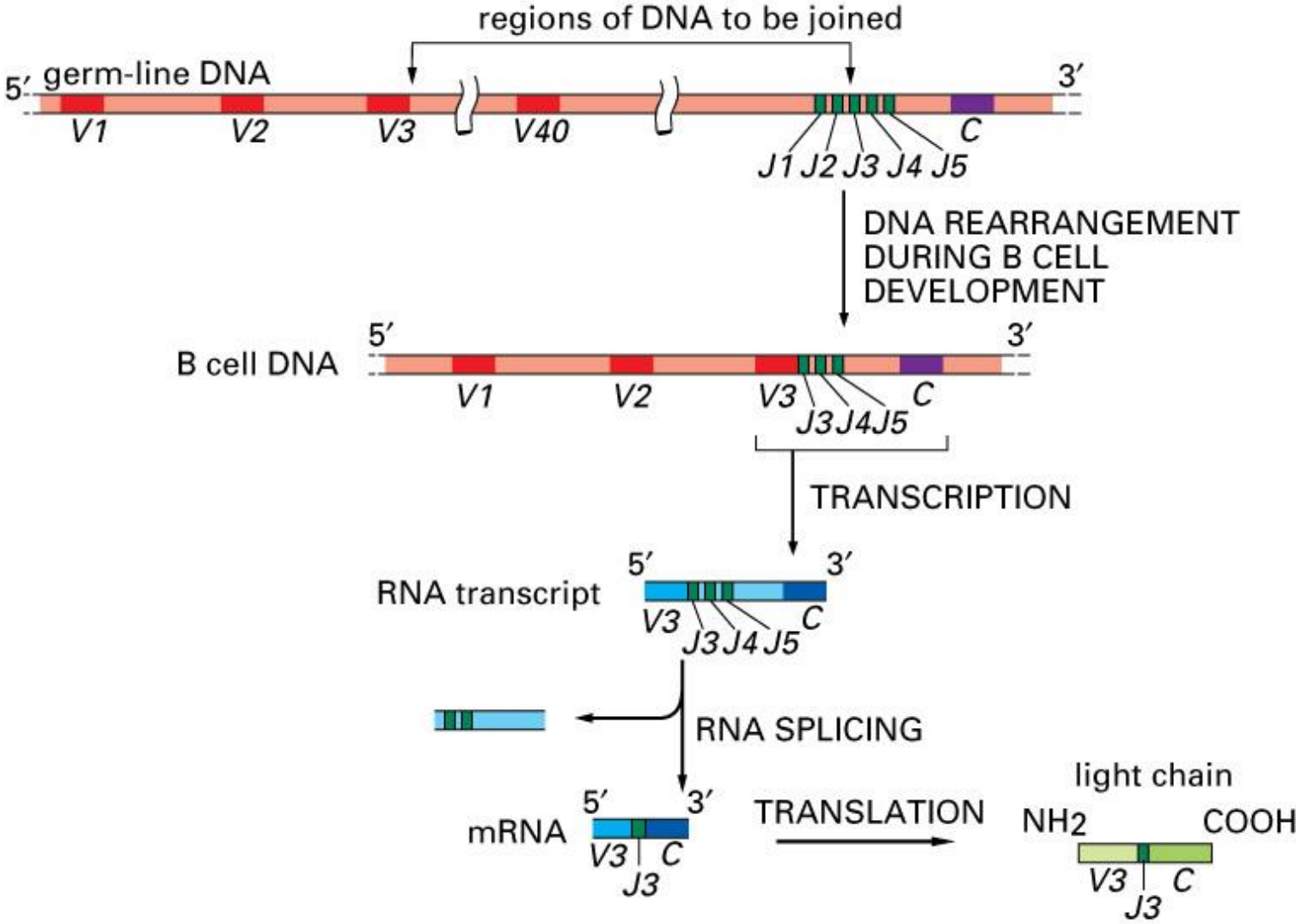
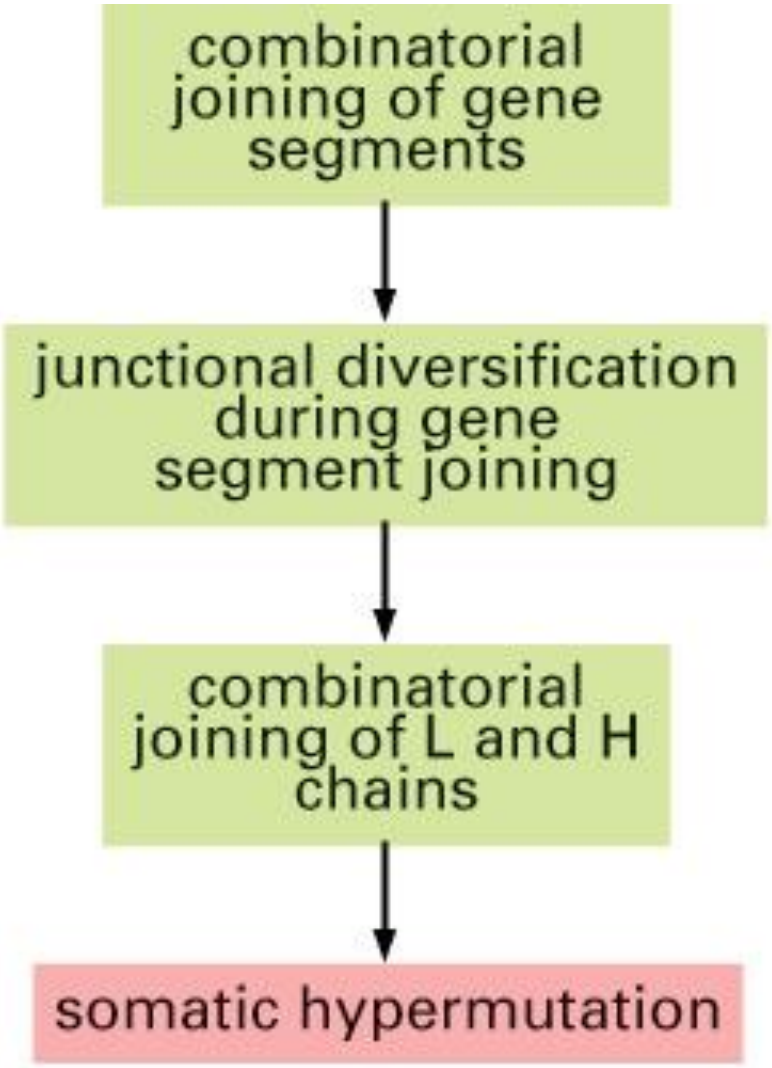


Figure 24–37. Molecular Biology of the Cell, 4th Edition.



With **150 V** genes, **5 J** genes and up to **10** possible ways of joining **VJ** genes together, the total number of (kappa) light chains possible is **7500**.

With **80 V** genes, **50 D** genes, **6 J** genes and up to **100** different ways of productively joining **V**-**D** and **D**-**J**, there are **2.4 million** possible heavy chains.

So **7500** x **2.4 million** or **18 billion** different antibodies possible

Directed Mutagenesis

Figure 24–39. Molecular Biology of the Cell, 4th Edition.

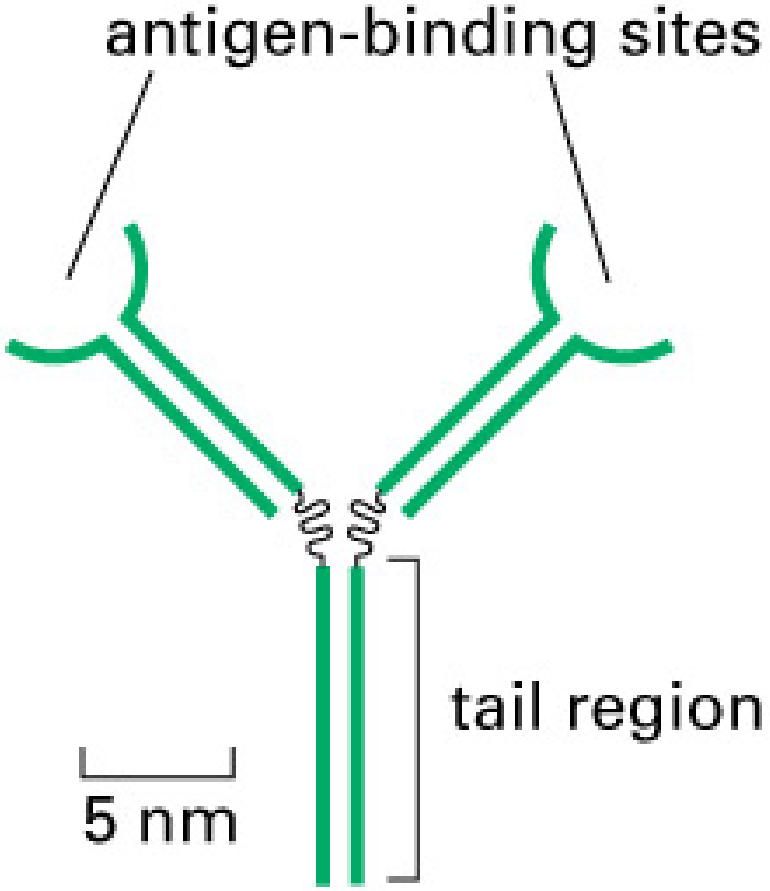


Figure 24–18. Molecular Biology of the Cell, 4th Edition.

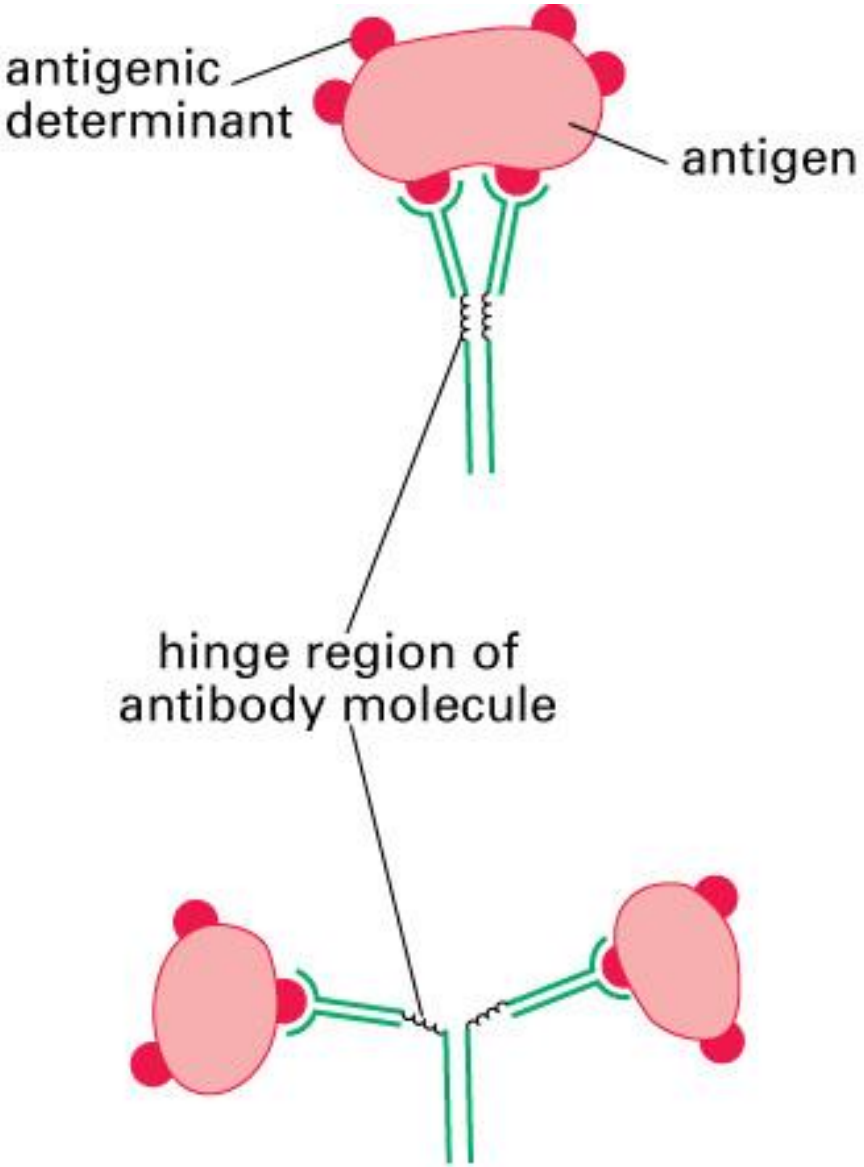


Figure 24–20. Molecular Biology of the Cell, 4th Edition.

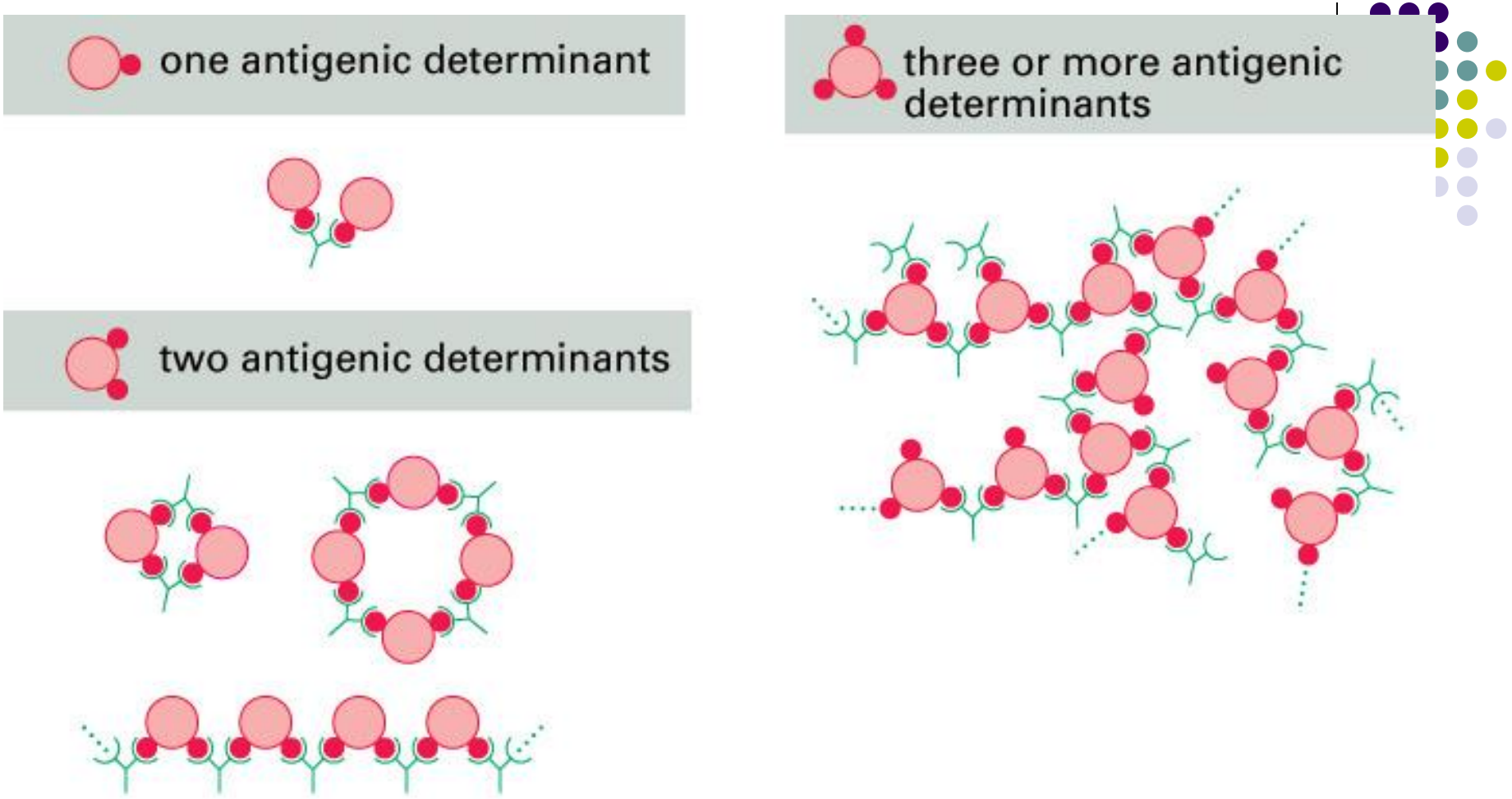


Figure 24–19. Molecular Biology of the Cell, 4th Edition.

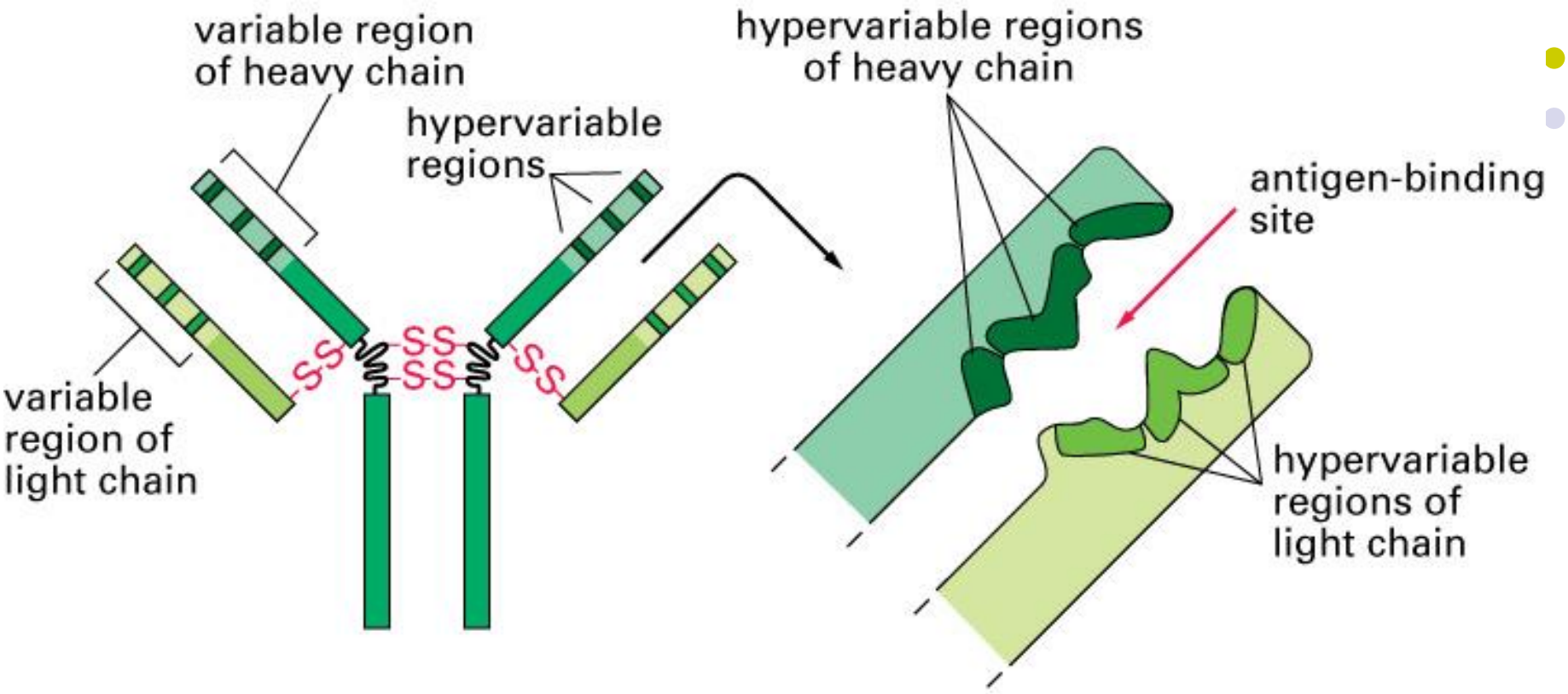


Figure 24–31. Molecular Biology of the Cell, 4th Edition.

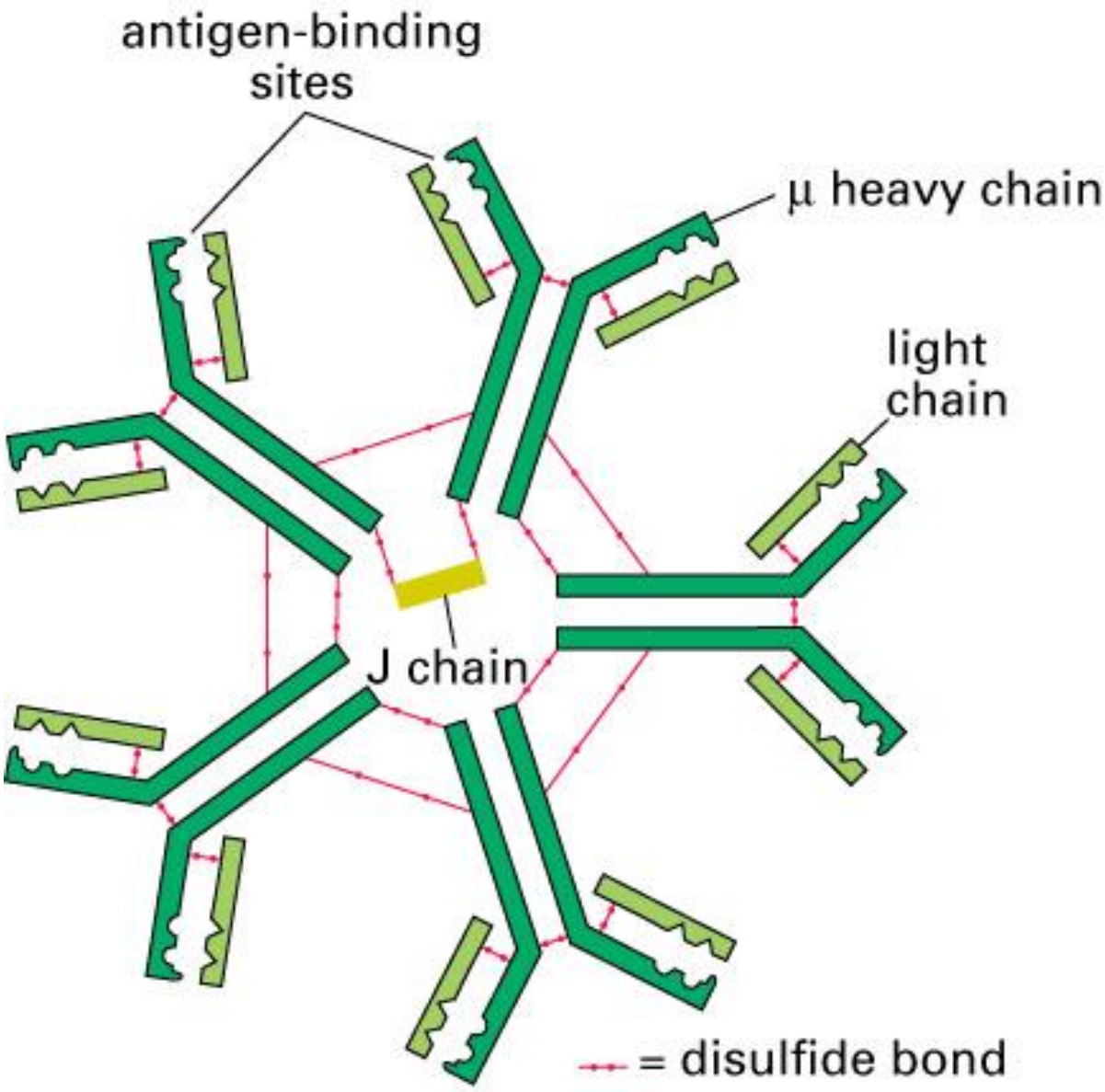


Figure 24–23. Molecular Biology of the Cell, 4th Edition.

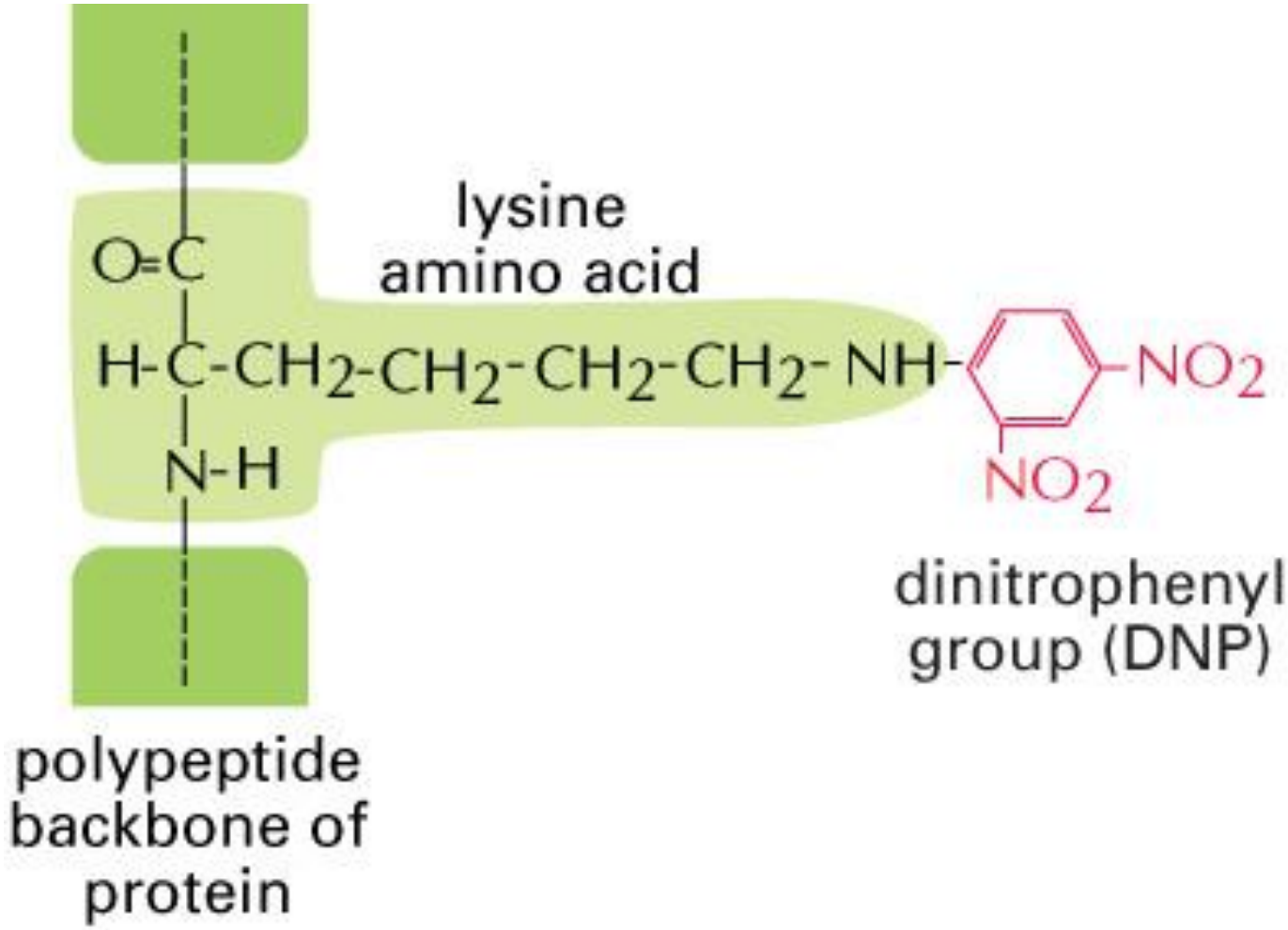


Figure 24–9. Molecular Biology of the Cell, 4th Edition.

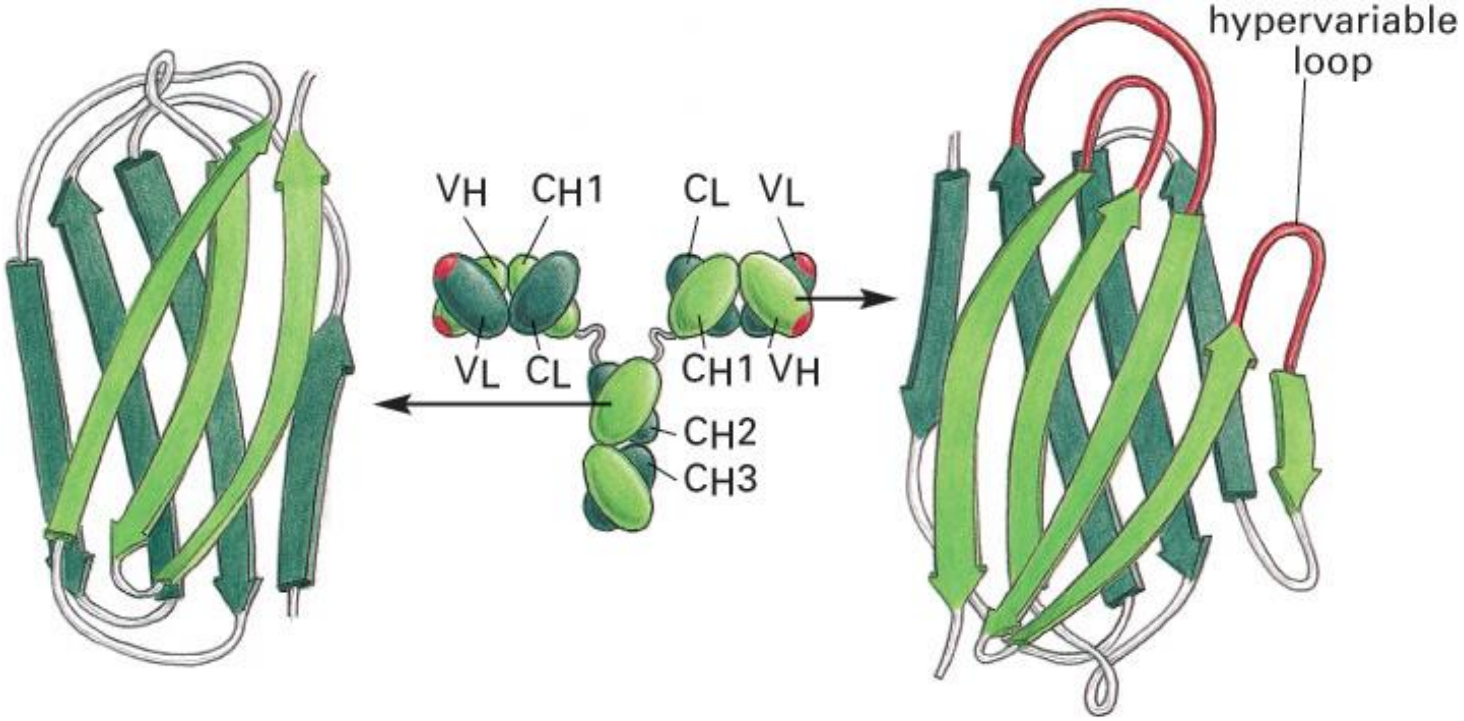
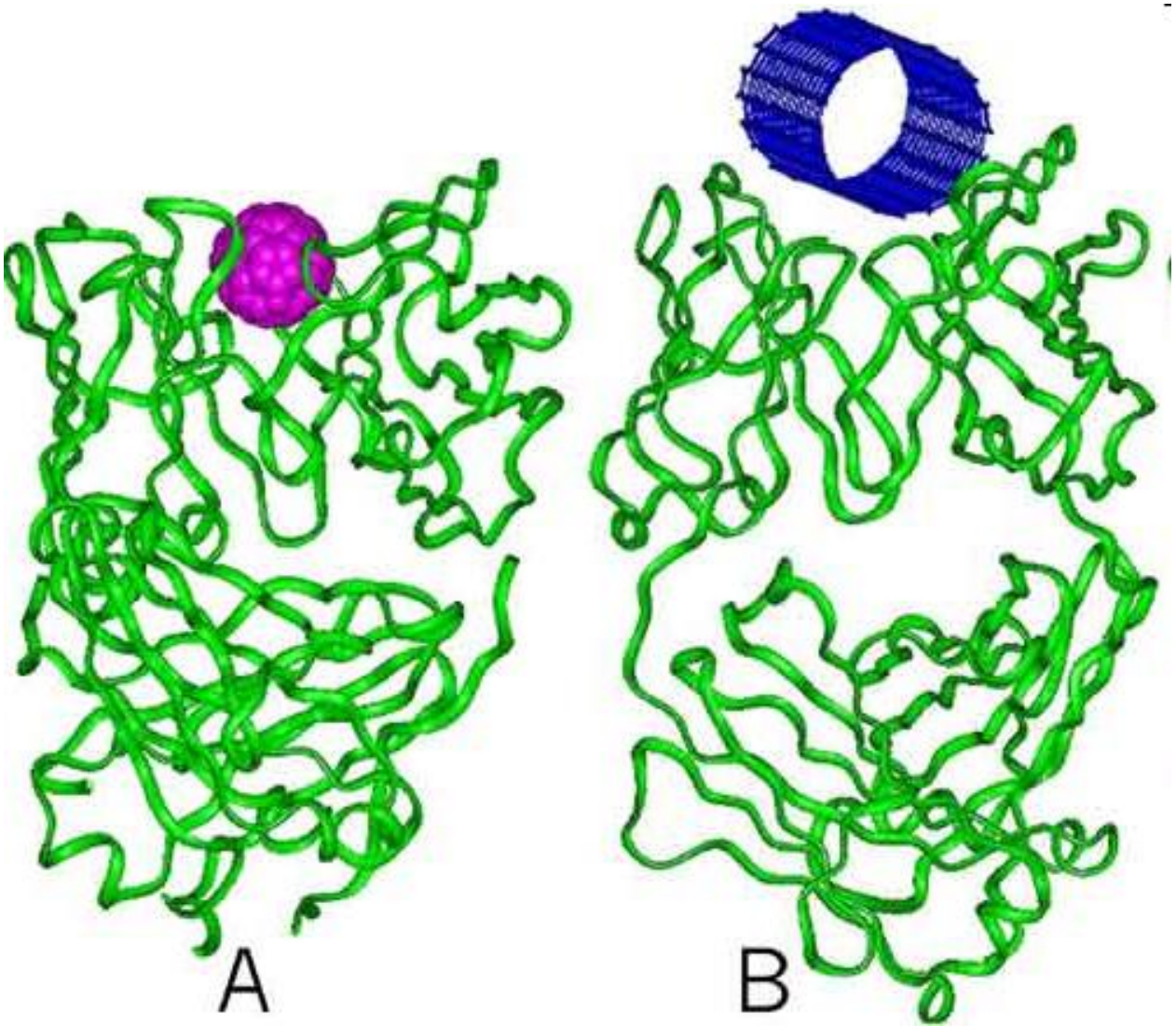


Figure 24–34. Molecular Biology of the Cell, 4th Edition.

Antibodies of interest



Braden B C, Goldbaum F A, Chen B-X, Kirschner A N, Wilson S R and Erlanger B F 2000 *Proc. Natl. Acad. Sci. USA* **97** 12193-12197