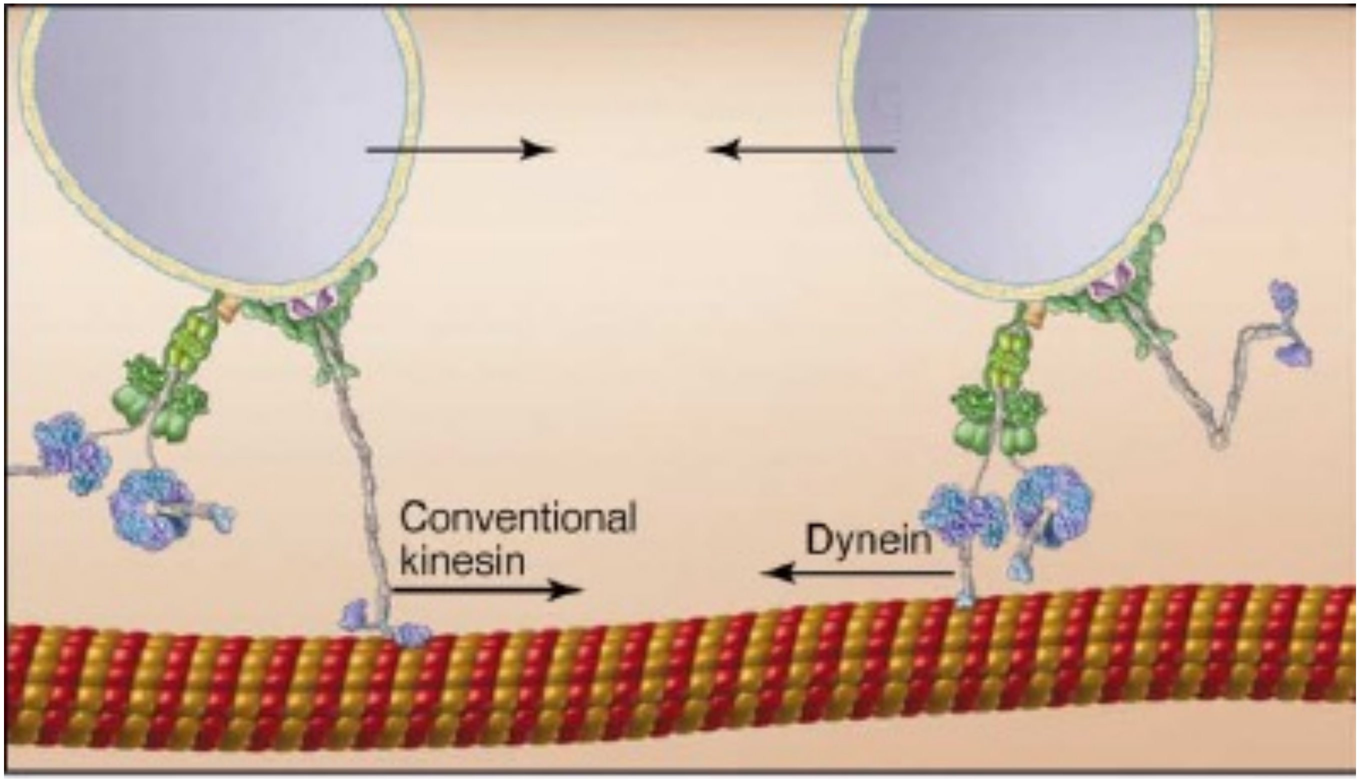
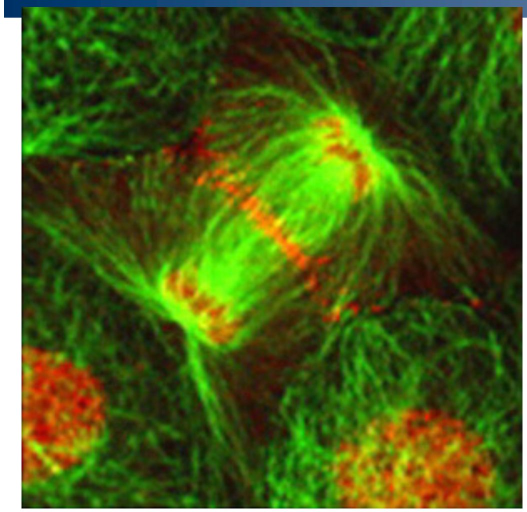
Molecular Motors



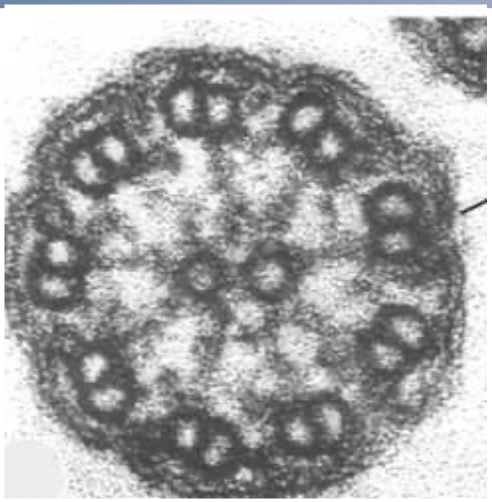
Rob Phillips
California Institute of Technology

Edited by John Reif

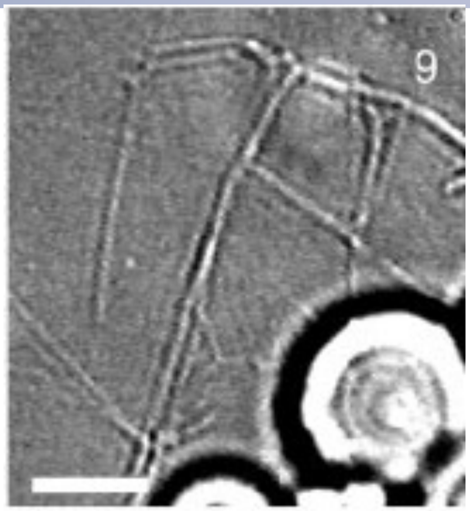
Molecular Motors of Cells



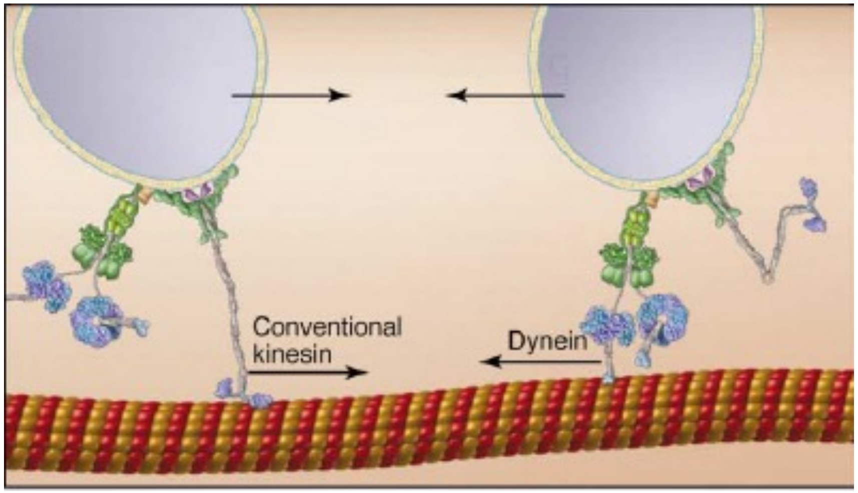
Mitotic Spindle Organization



Cilia and Flagella Assembly and Dynamics



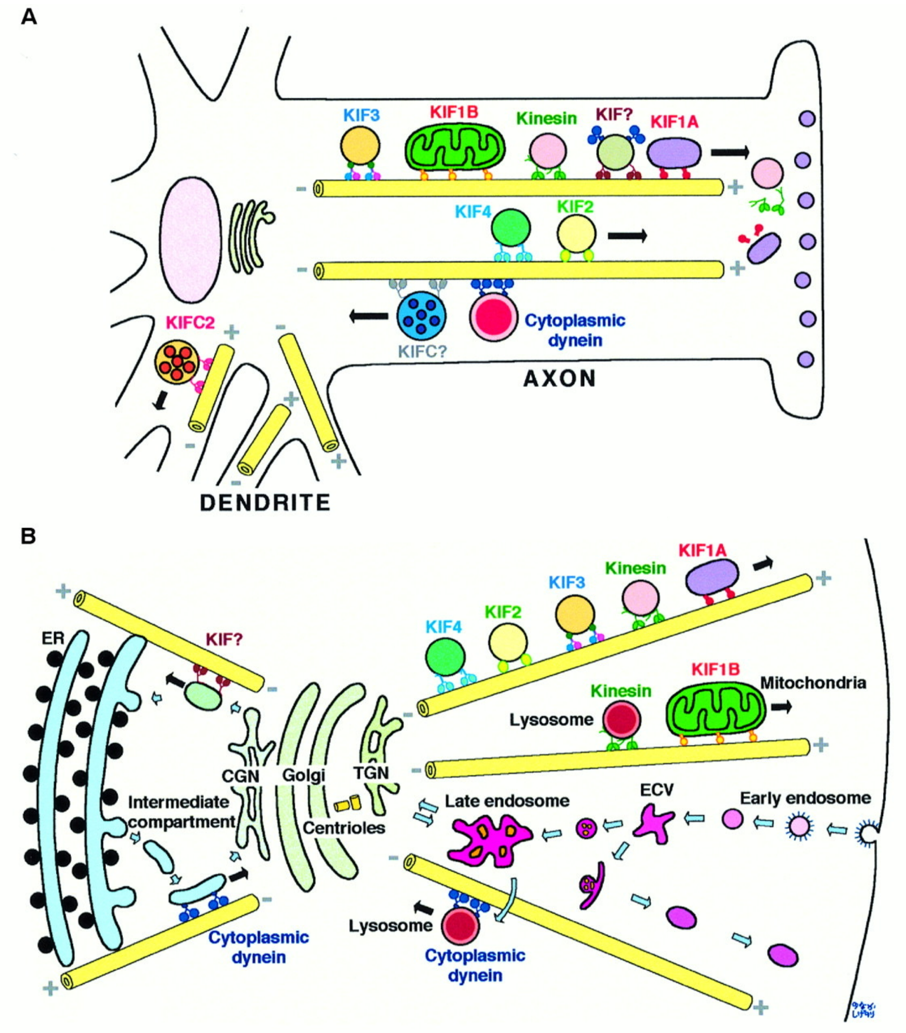
Formation of Golgi and ER Networks

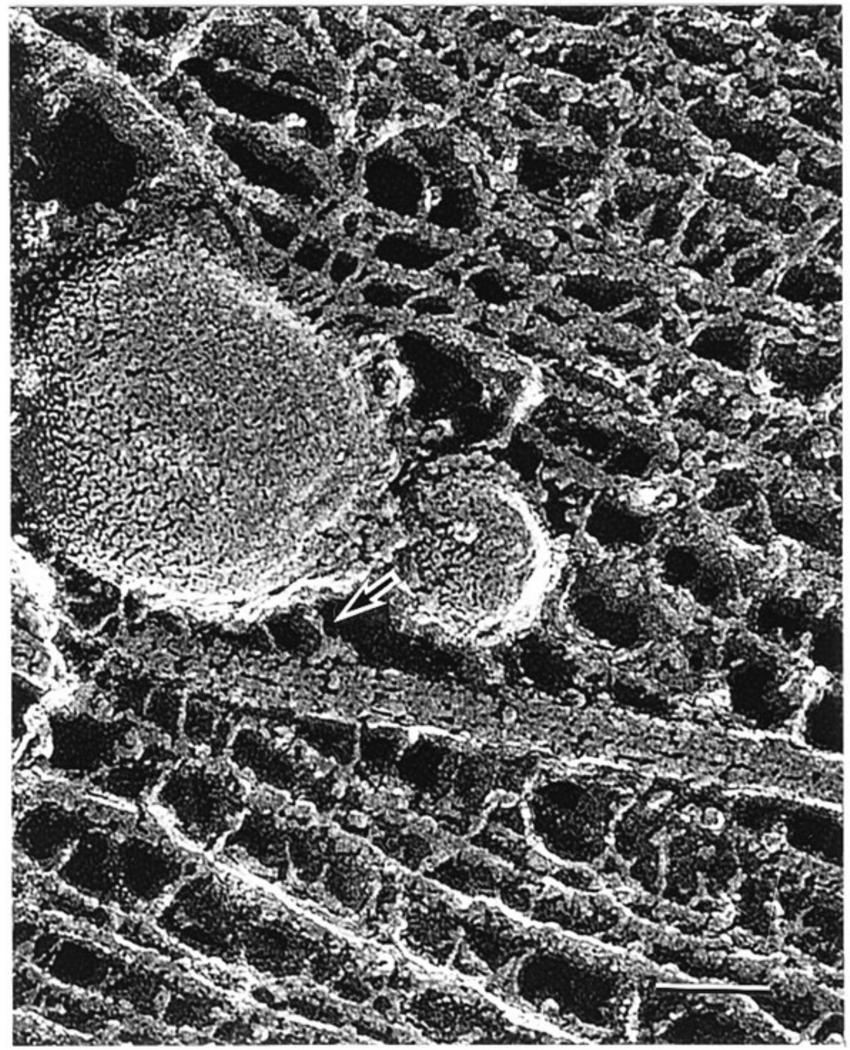


Vesicle Transport

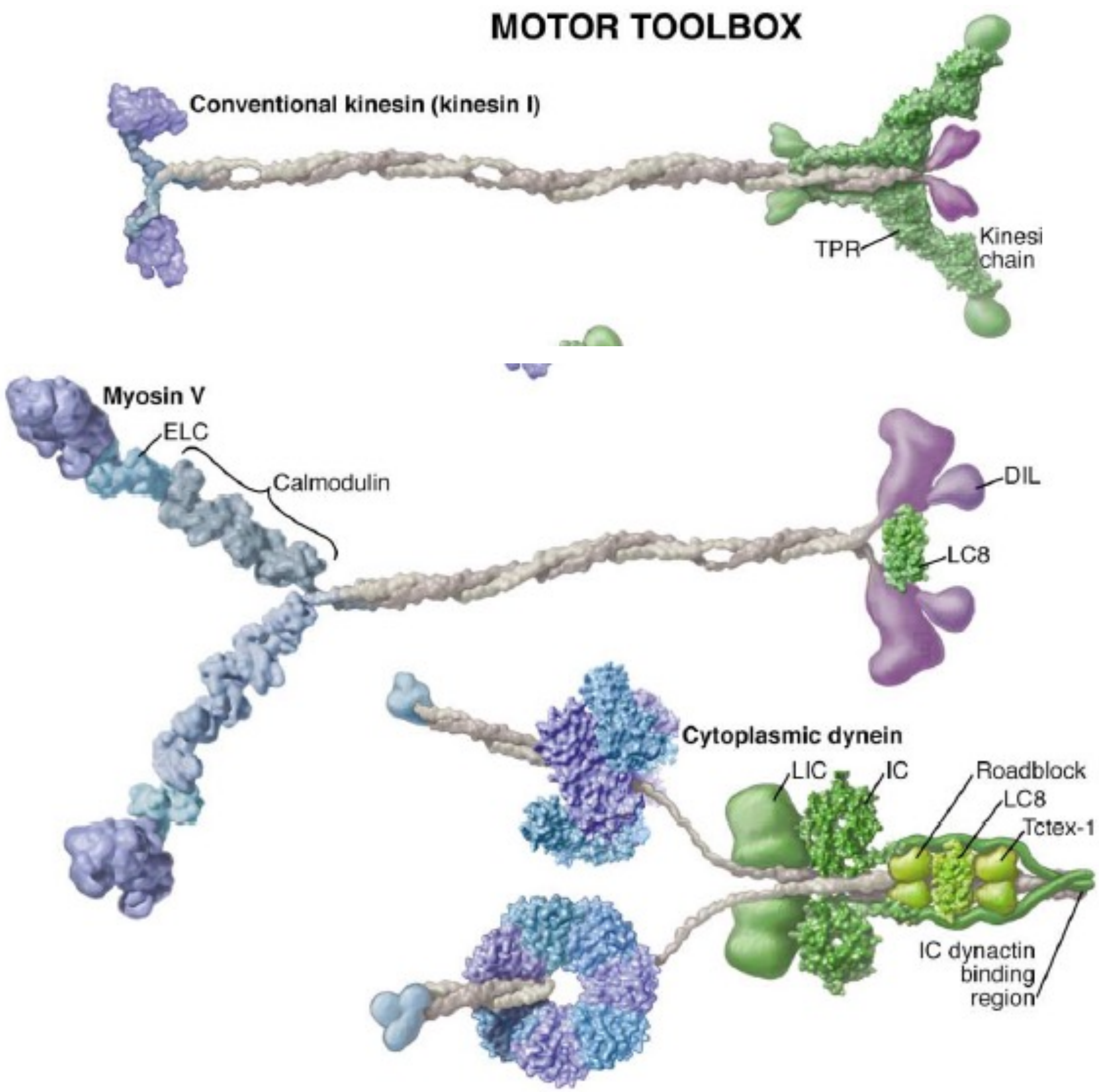
Organellar Transport

(Hirokawa, Science 1998)





Translational Molecular Motors



Kinesin

Speed: 850 nm/s
ATPase: 44.0 1/s

Myosin V

Speed: 350 nm/s
ATPase: 5.0 1/s

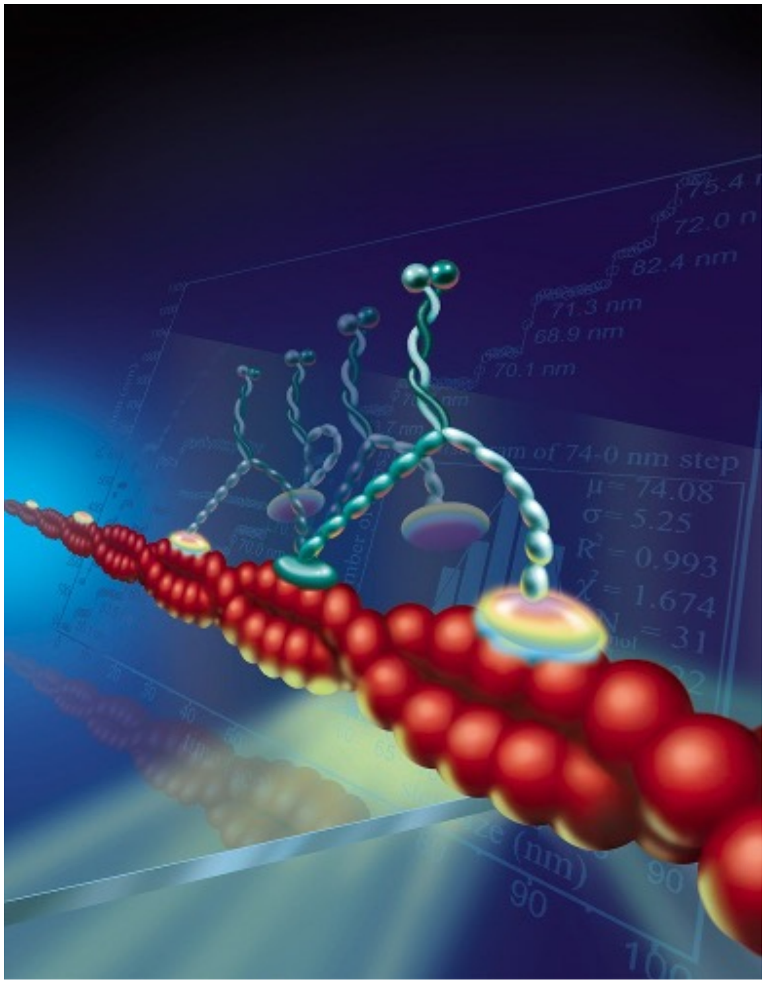
Dynein

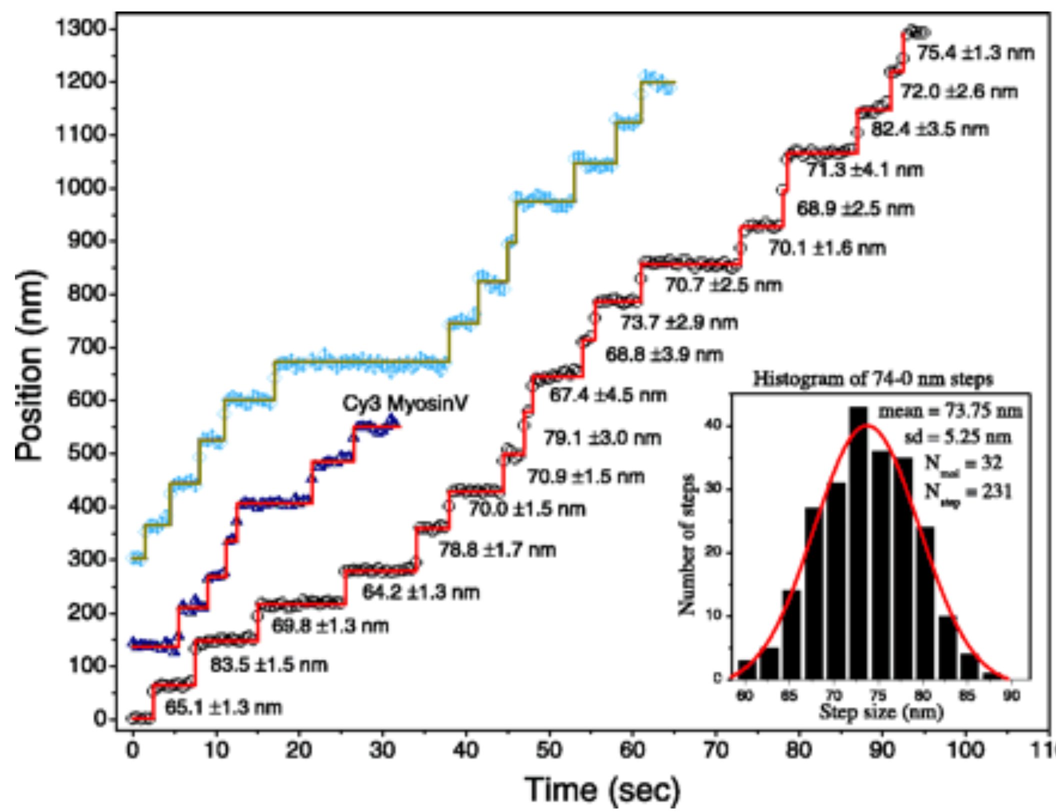
Speed: -1250 nm/s
ATPase: 2.0 1/s

****ALL INVOLVED IN VESICLE TRANSPORT****

Dynamics of Kinosin Molecular Motor

Science, Vol 300, Issue 5628, 2061-2065, 27 June 2003 - Yildiz et al.

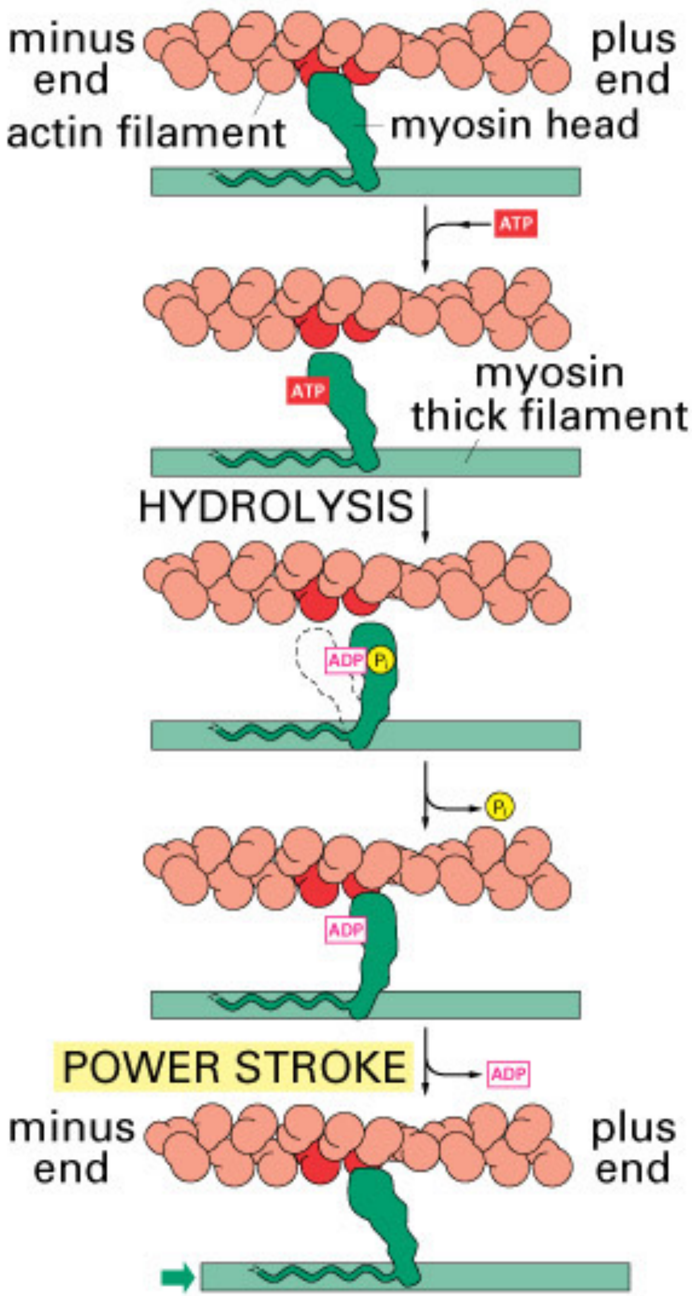




Kinesin walking on Actin Filament:

http://www.youtube.com/watch?v=y-uuk4Pr2i8

States of Kinesin



ATTACHED At the start of the cycle shown in this figure, a myosin head lacking a bound nucleotide is locked tightly onto an actin filament in a *rigor* configuration (so named because it is responsible for *rigor mortis*, the rigidity of death). In an actively contracting muscle, this state is very short-lived, being rapidly terminated by the binding of a molecule of ATP.

RELEASED A molecule of ATP binds to the large cleft on the "back" of the head (that is, on the side furthest from the actin filament) and immediately causes a slight change in the conformation of the domains that make up the actin-binding site. This reduces the affinity of the head for actin and allows it to move along the filament. (The space drawn here between the head and actin emphasizes this change, although in reality the head probably remains very close to the actin.)

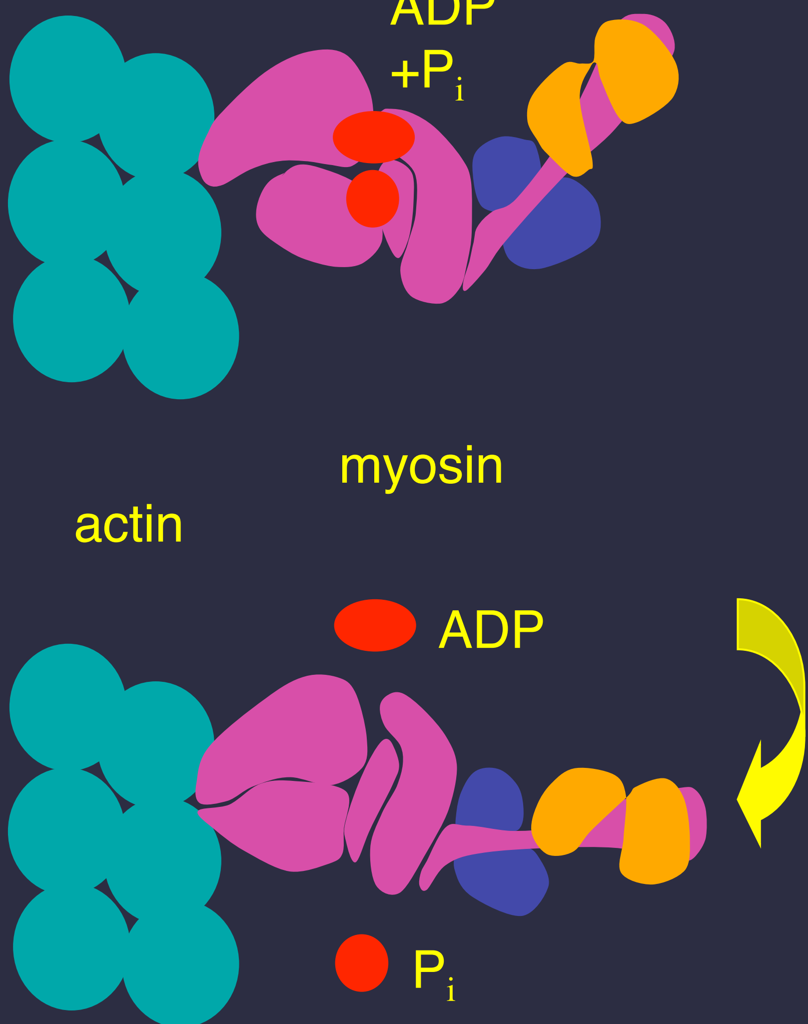
COCKED The cleft closes like a clam shell around the ATP molecule, triggering a large shape change that causes the head to be displaced along the filament by a distance of about 5 nm. Hydrolysis of ATP occurs, but the ADP and inorganic phosphate (P_i) produced remain tightly bound to the protein.

FORCE-GENERATING A weak binding of the myosin head to a new site on the actin filament causes release of the inorganic phosphate produced by ATP hydrolysis, concomitantly with the tight binding of the head to actin. This release triggers the power stroke—the force-generating change in shape during which the head regains its original conformation. In the course of the power stroke, the head loses its bound ADP, thereby returning to the start of a new cycle.

ATTACHED At the end of the cycle, the myosin head is again locked tightly to the actin filament in a rigor configuration. Note that the head has moved to a new position on the actin filament.

Figure 17-45 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Myosin Power Stroke



Mechano-chemical cycle:

M*ATP

M*ADP*Pi

M

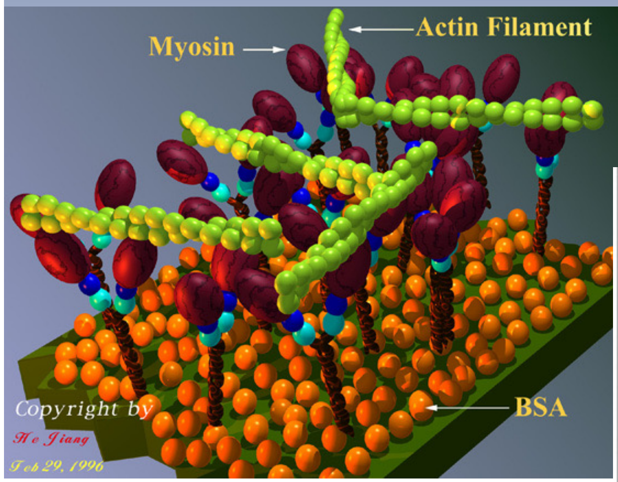
attach

working stroke

detach

recovery stroke

Gliding Motility of Actin Filaments over Surface-attached Myosin



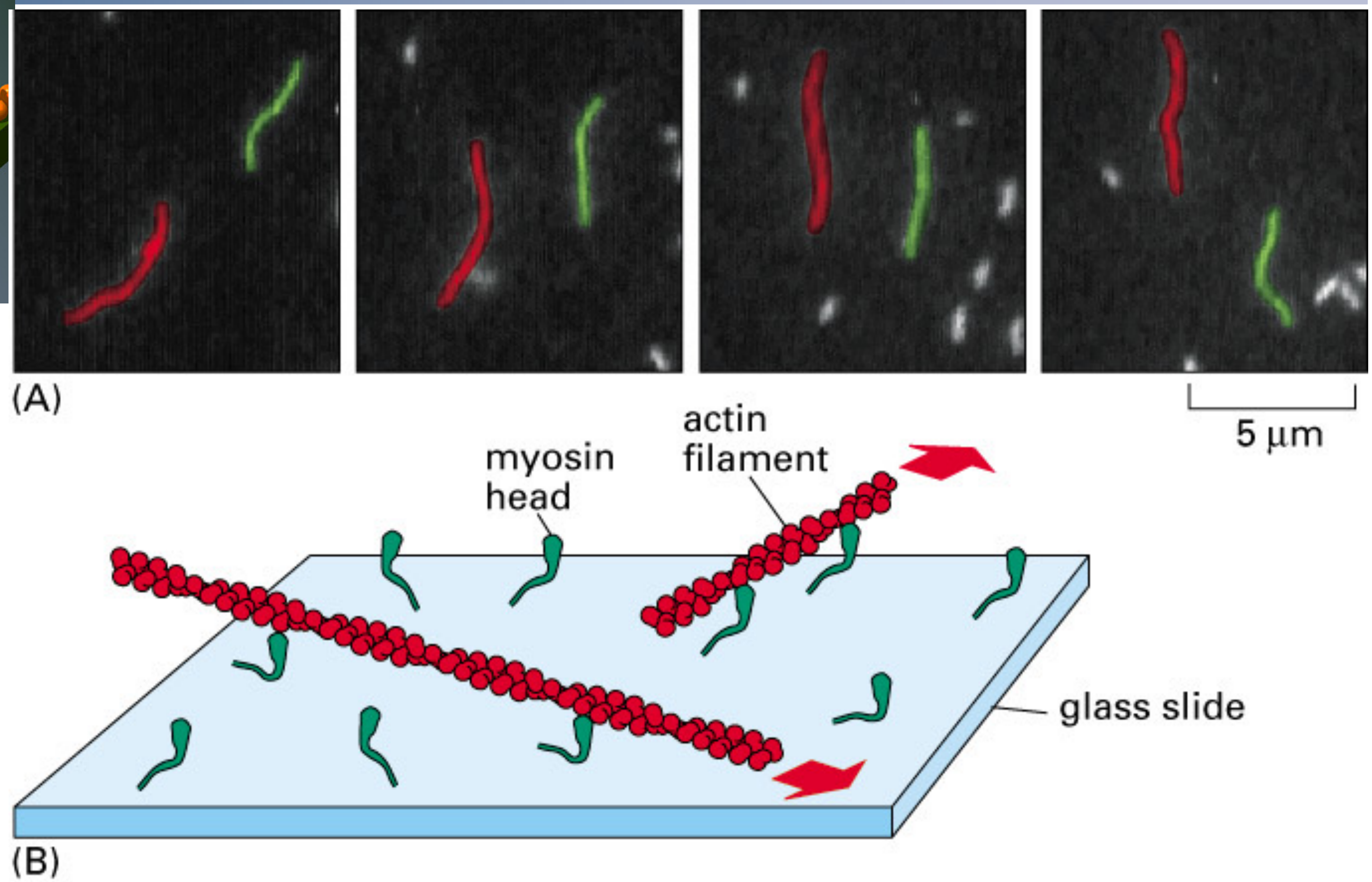


Figure 16–53. Molecular Biology of the Cell, 4th Edition.

Actine Filament Mobility over surface-attached Myosin

https://www.youtube.com/watch?v=Mmag_PKiRQA

Translational Motors: Muscles using Myosin & Actin

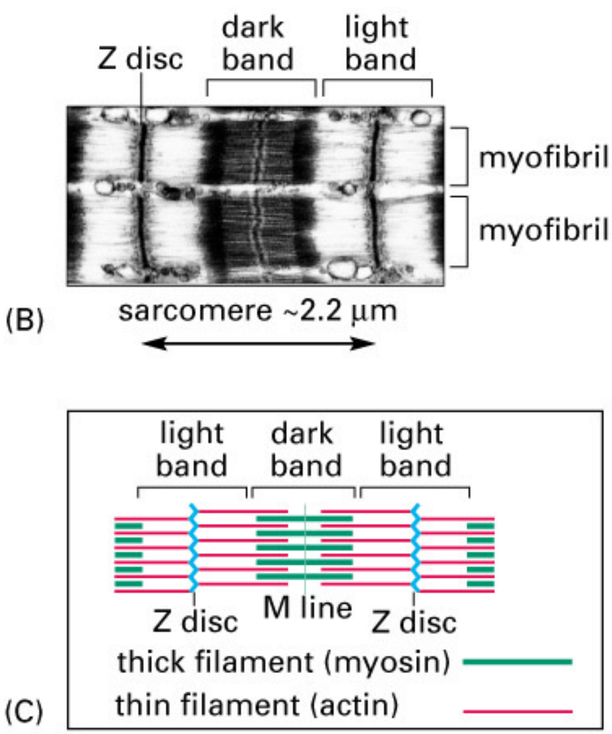
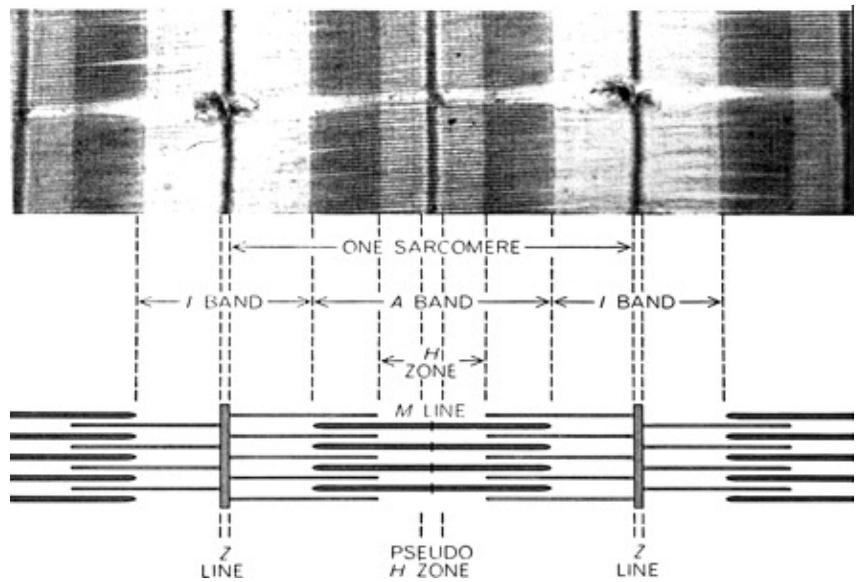


Figure 16–69 part 2 of 2. Molecular Biology of the Cell, 4



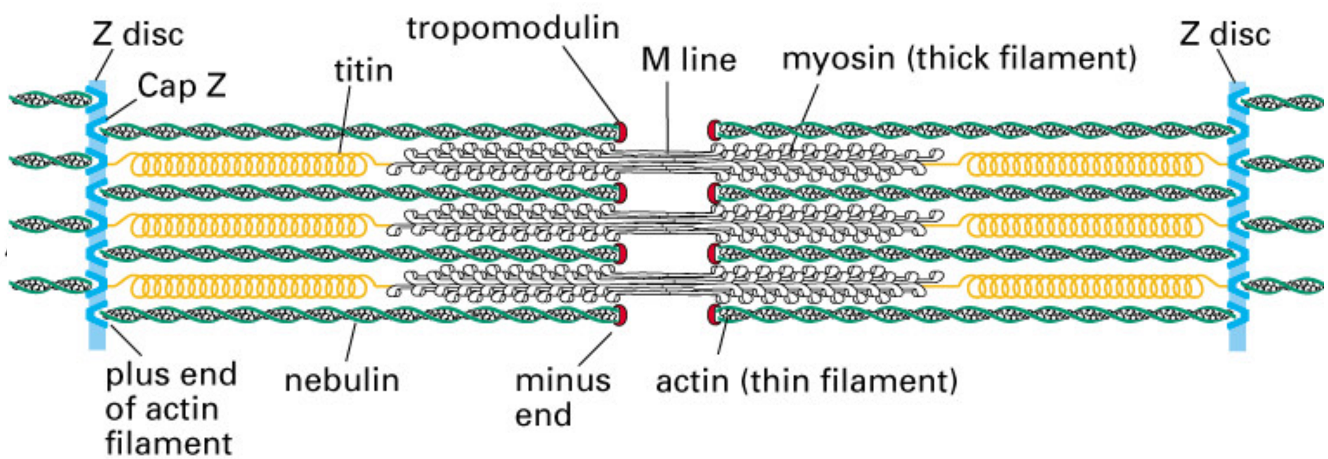


Figure 16–72. Molecular Biology of the Cell, 4th Edition.

Dynein: A molecular Motor that Make Sliding Movement Between Pairs of Microtubules

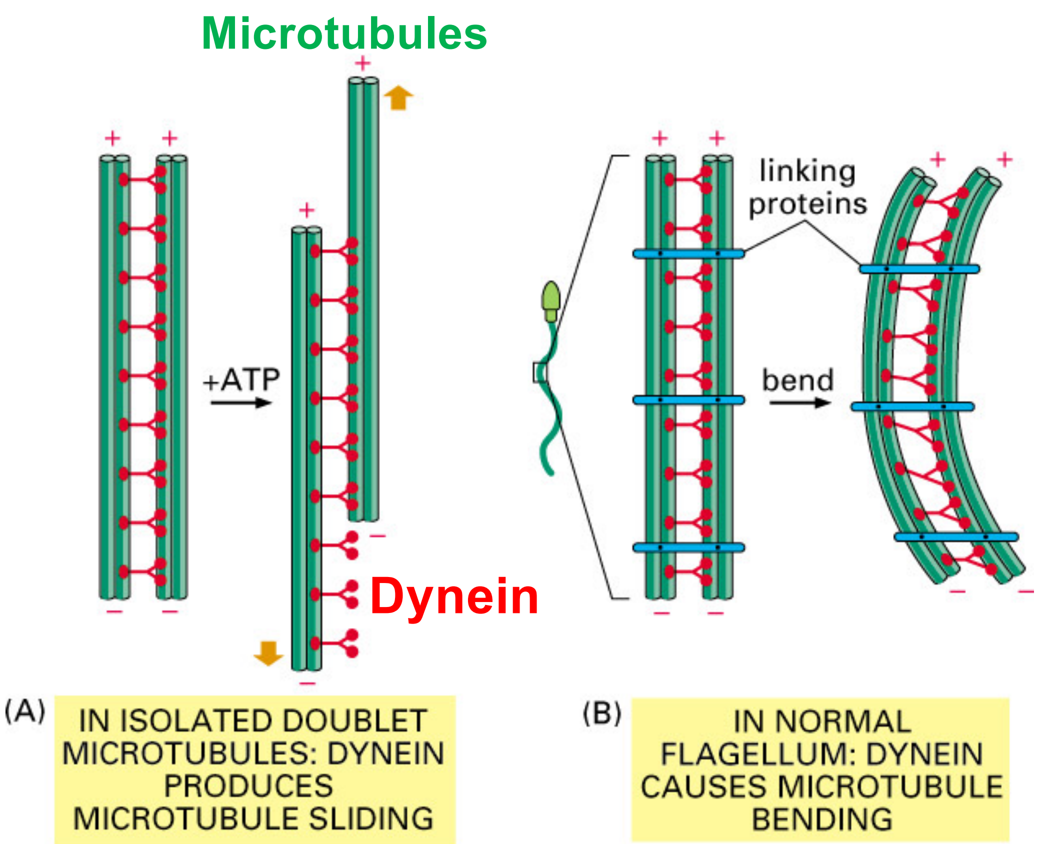


Figure 16–79. Molecular Biology of the Cell, 4th Edition.

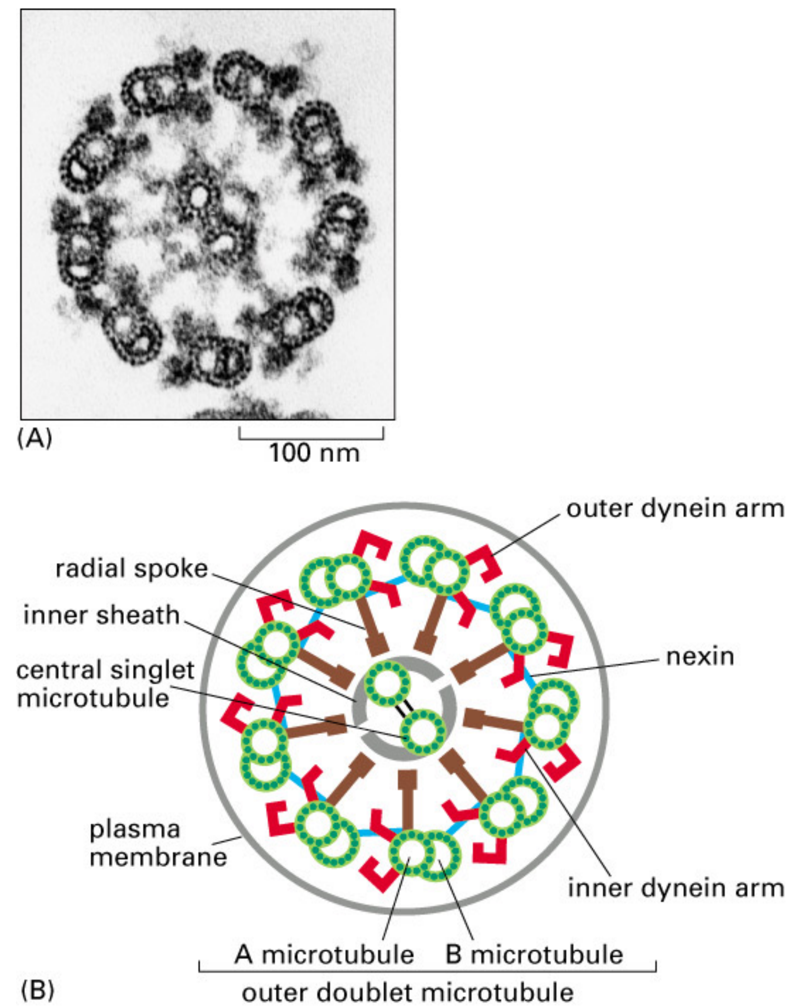
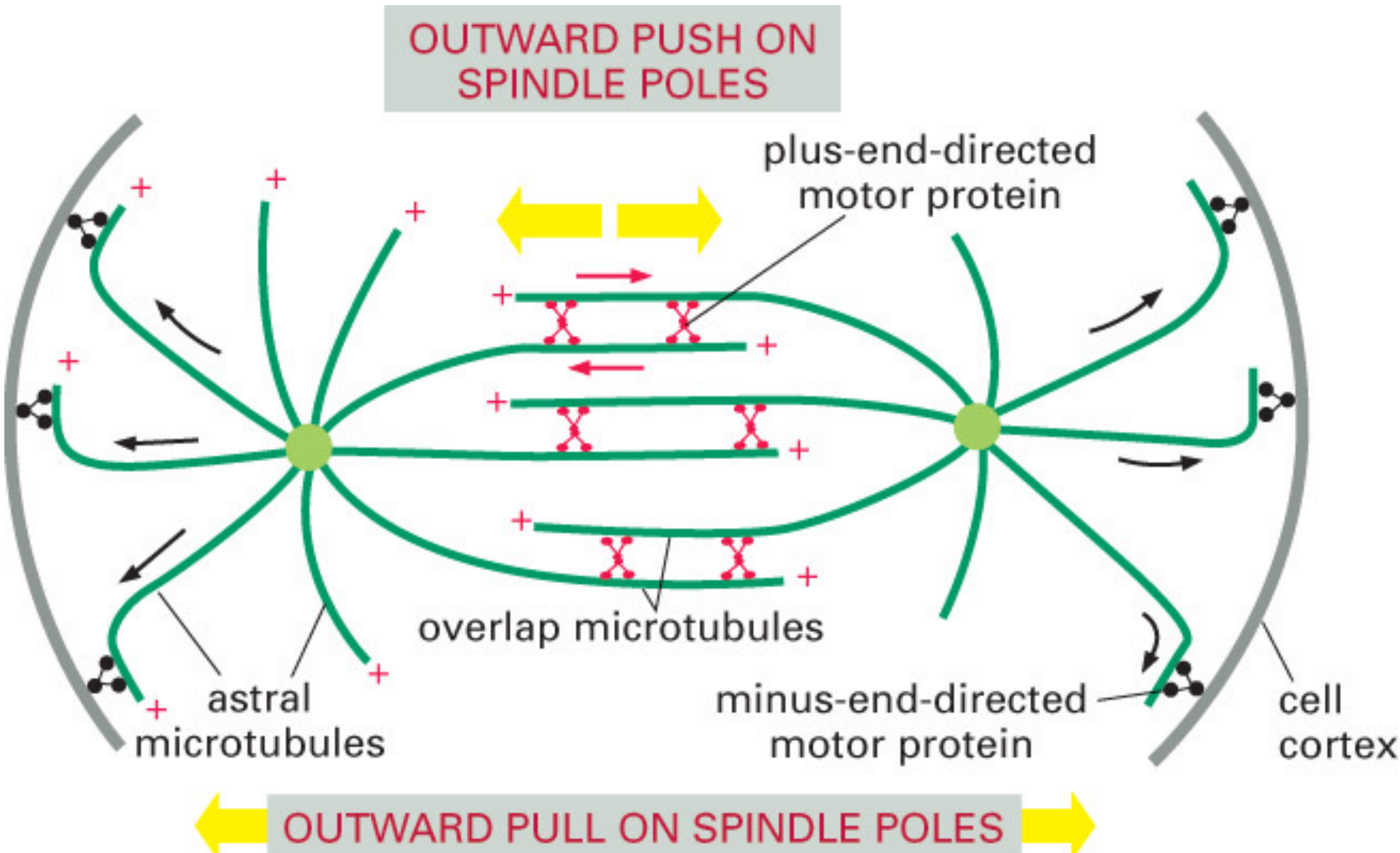


Figure 16–77. Molecular Biology of the Cell, 4th Edition.

Dynein: A molecular Motor that Make Sliding Movement Between Pairs of Microtubules



Dynein used to arrange Microtubules in Mitosis (Cell Division)

Figure 18–29. Molecular Biology of the Cell, 4th Edition.

Flagellum: A Rotary Molecular Motor

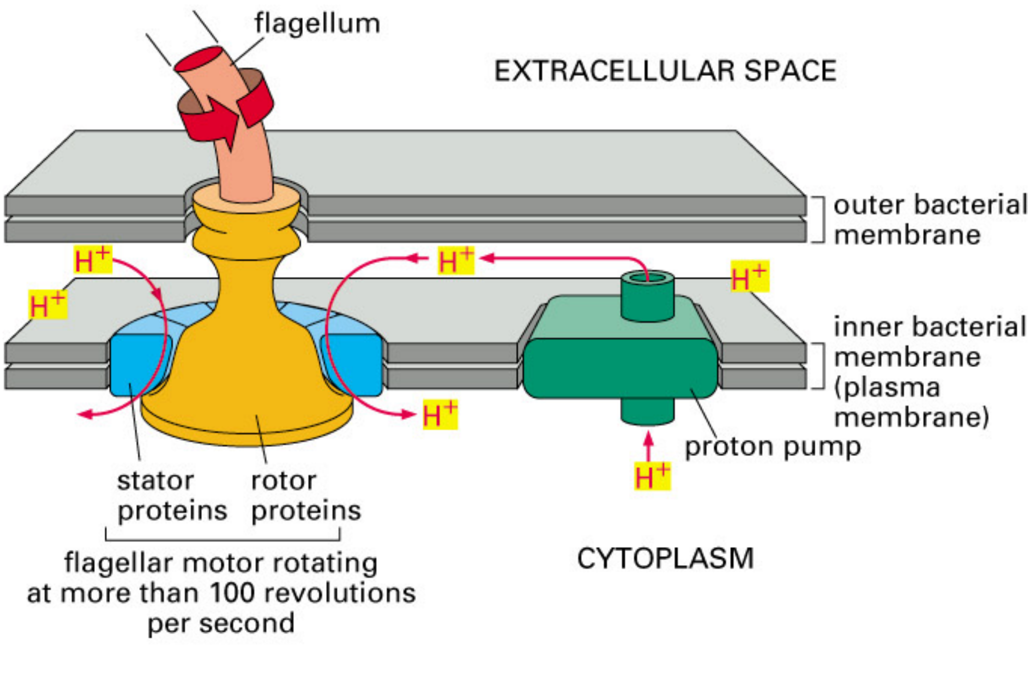


Figure 14–17. Molecular Biology of the Cell, 4th Edition.

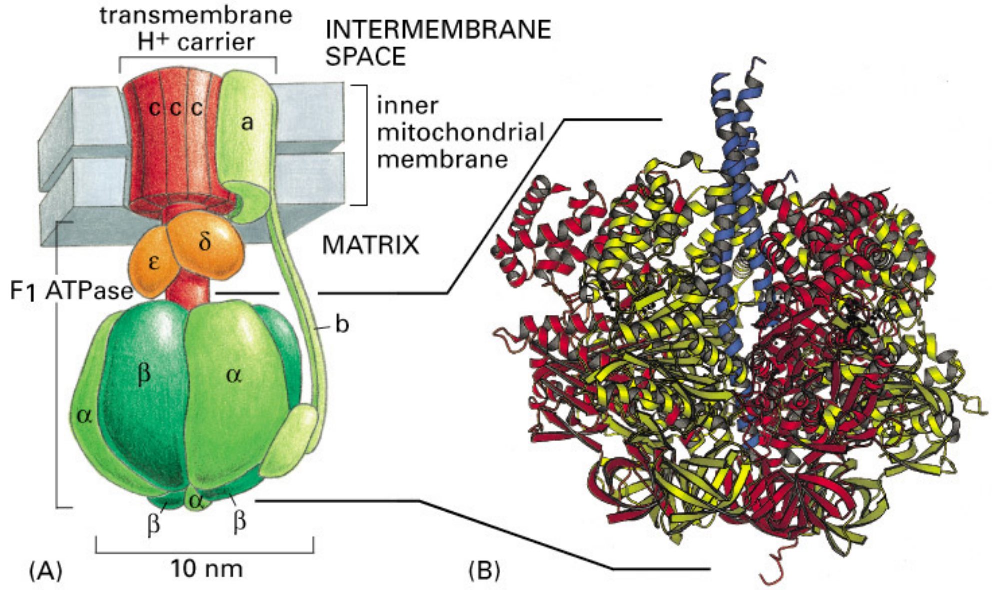


Figure 14–15. Molecular Biology of the Cell, 4th Edition.

Flagellum Motor: Show movie

https://www.youtube.com/watch?v=cwDRZGj2nnY

Membrane Rotator