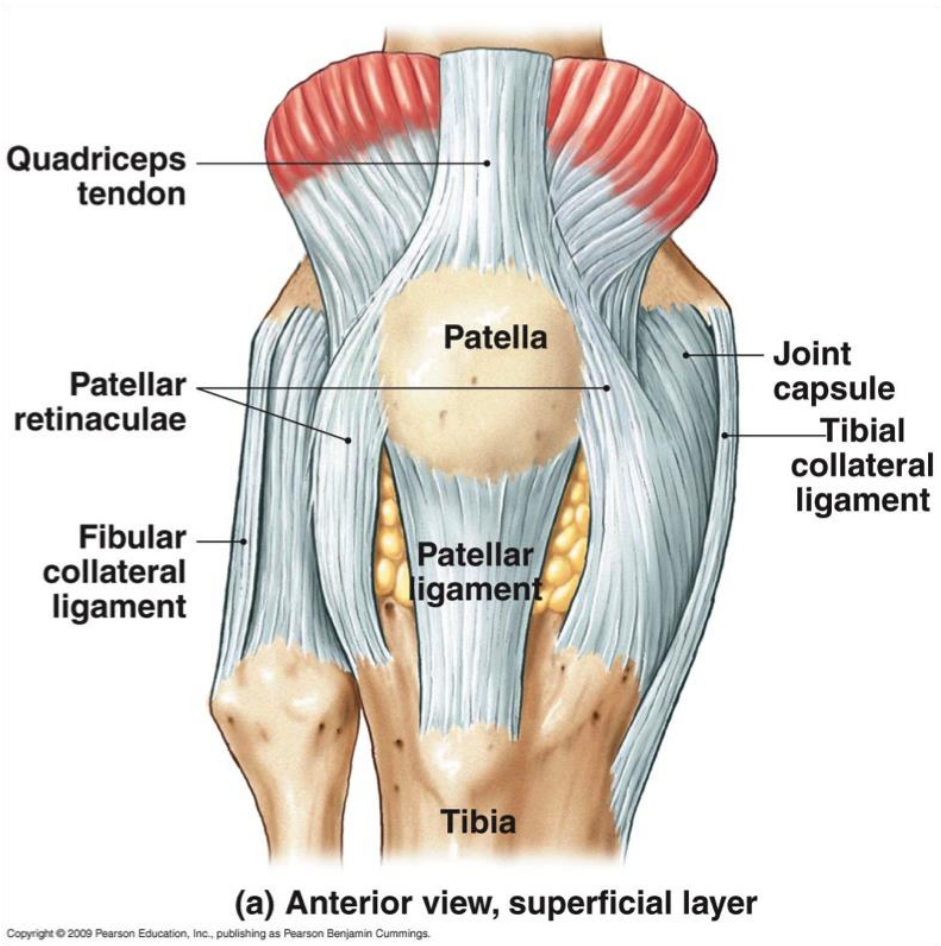
From ligaments, bones and muscles



To cytoskeleton fibers

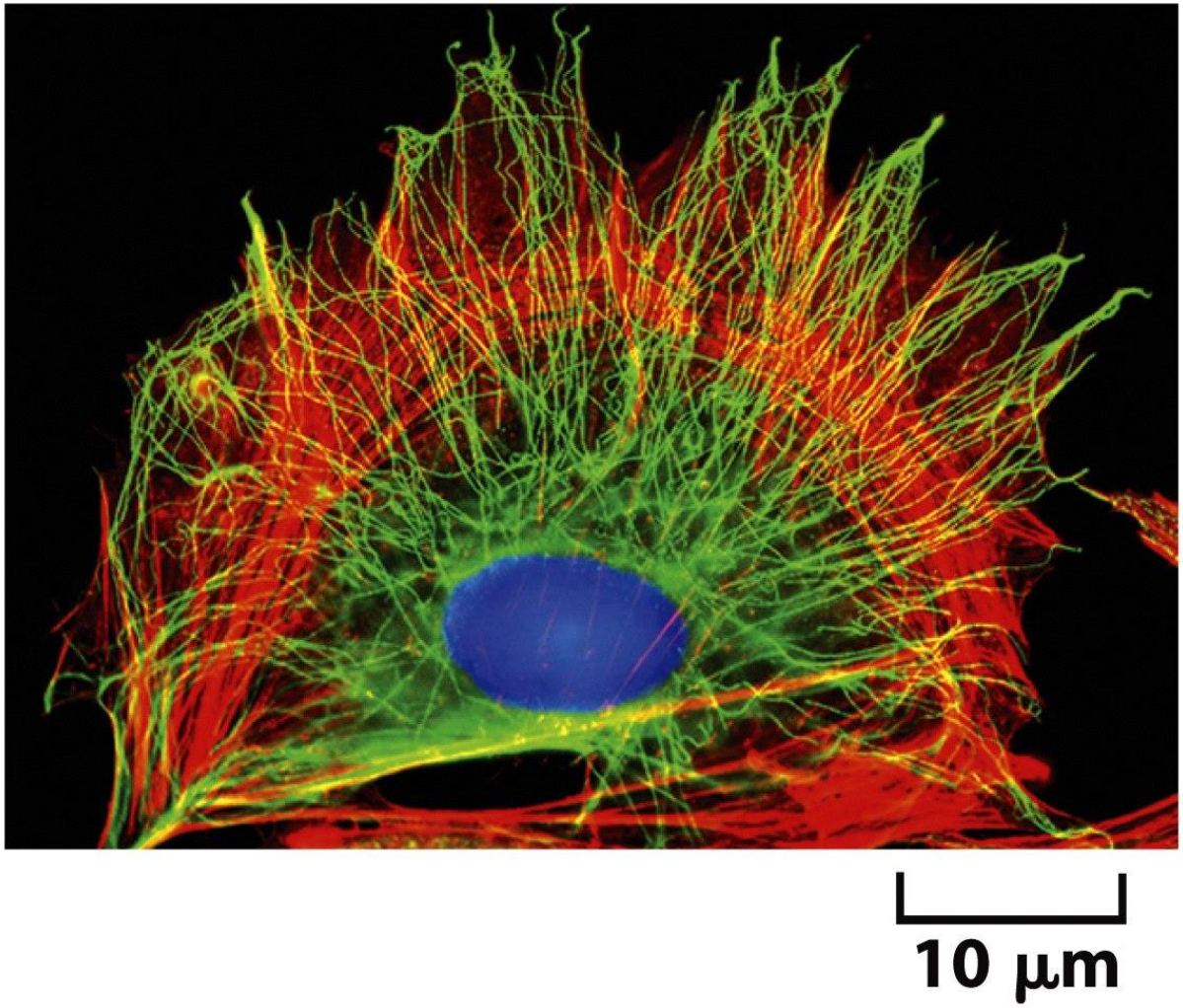


Figure 16-1 *Molecular Biology of the Cell* (© Garland Science 2008)

The Cytoskeleton (CSK)

THE CELL – a complex system of filaments:

I. SHAPE

II. MOVE

- crawling of fibroblasts and RBC, muscle cell contraction;
- intracellular traffic of organelles;
- cell division;

III. STRENGHT

- support the plasma membrane;
- provides the mechanical linkage (cell-cell, cell-ECM).

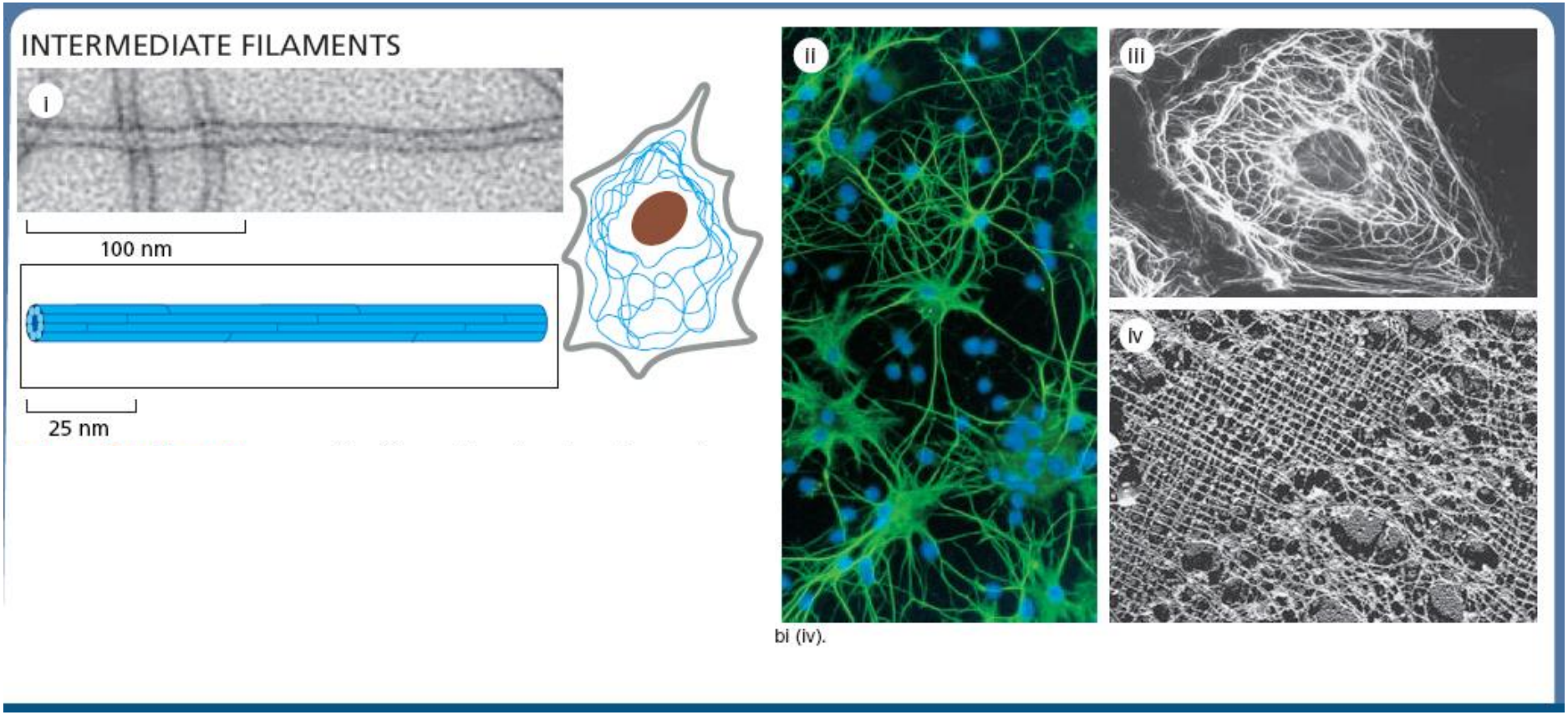
The Cytoskeleton (CSK)

Three types of proteins => 3 types of filaments:

- **Intermediate filaments - 10nm**– mechanical strength;
- **Microtubules - 25nm**– position of organelles, IC traffic;
- **Actin filaments – 5-9nm**– shape and locomotion.

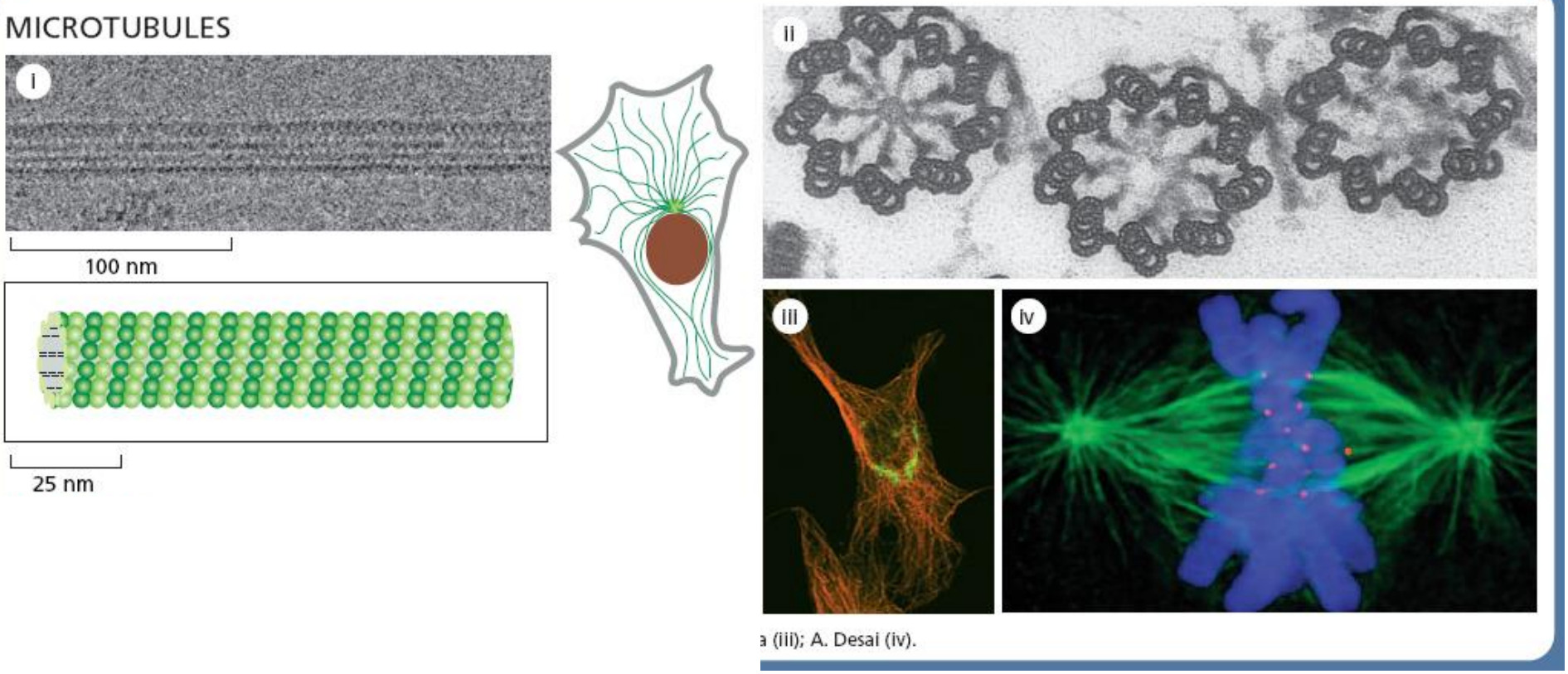
+ large set of **accessory proteins (including motor p.)**

Distinct:
- mechanical properties;
- dynamics;
- biological roles.

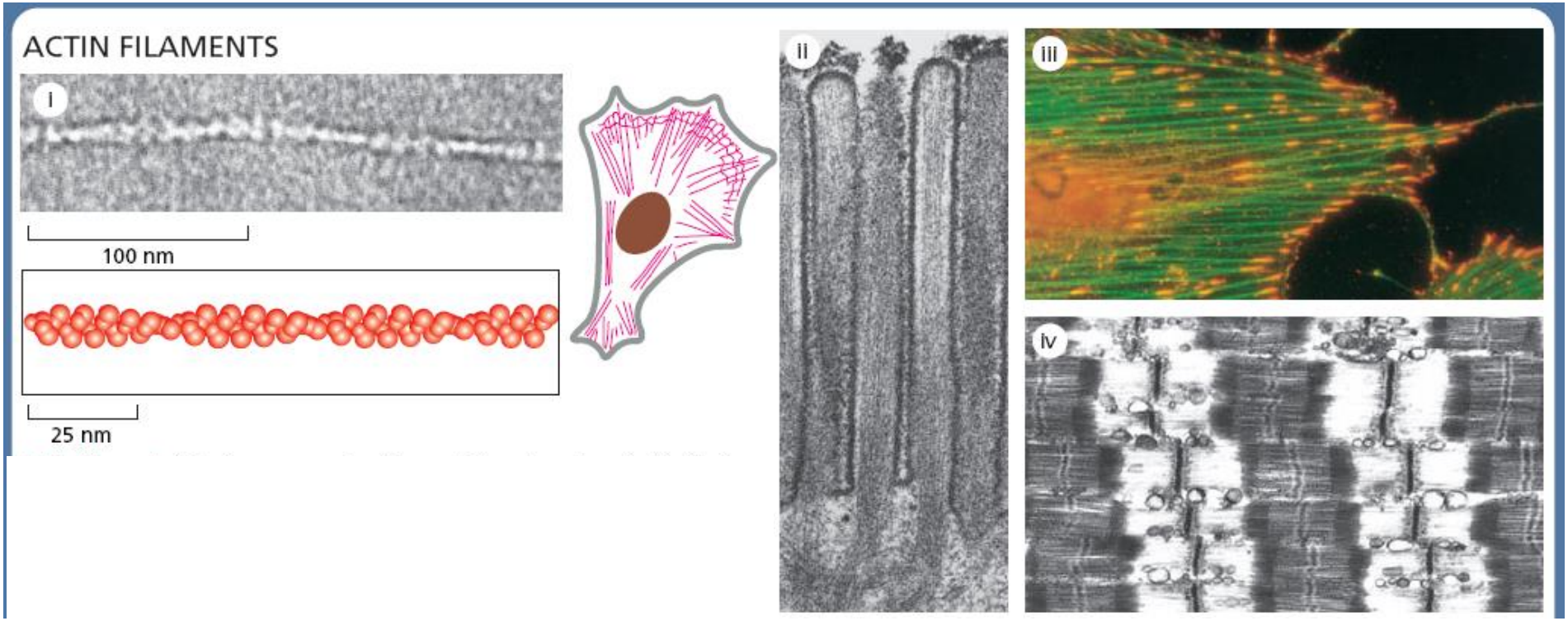


bi (iv).

Intermediate filaments are ropelike fibers with a diameter of around 10 nm; they are made of intermediate filament proteins, which constitute a large and heterogeneous family. One type of intermediate filament forms a meshwork called the nuclear lamina just beneath the inner nuclear membrane. Other types extend across the cytoplasm, giving cells mechanical strength. In an epithelial tissue, they span the cytoplasm from one cell-cell junction to another, thereby strengthening the entire epithelium.



Microtubules are long, hollow cylinders made of the protein tubulin. With an outer diameter of 25 nm, they are much more rigid than actin filaments. Microtubules are long and straight and typically have one end attached to a single microtubule-organizing center (MTOC) called a *centrosome*.



Actin filaments (also known as *microfilaments*) are two-stranded helical polymers of the protein actin. They appear as flexible structures, with a diameter of 5–9 nm, and they are organized into a variety of linear bundles, two-dimensional networks, and three-dimensional gels. Although actin filaments are dispersed throughout the cell, they are most highly concentrated in the *cortex*, just beneath the plasma membrane.

The Cytoskeleton (CSK) fibers

1. Dynamic and adaptable

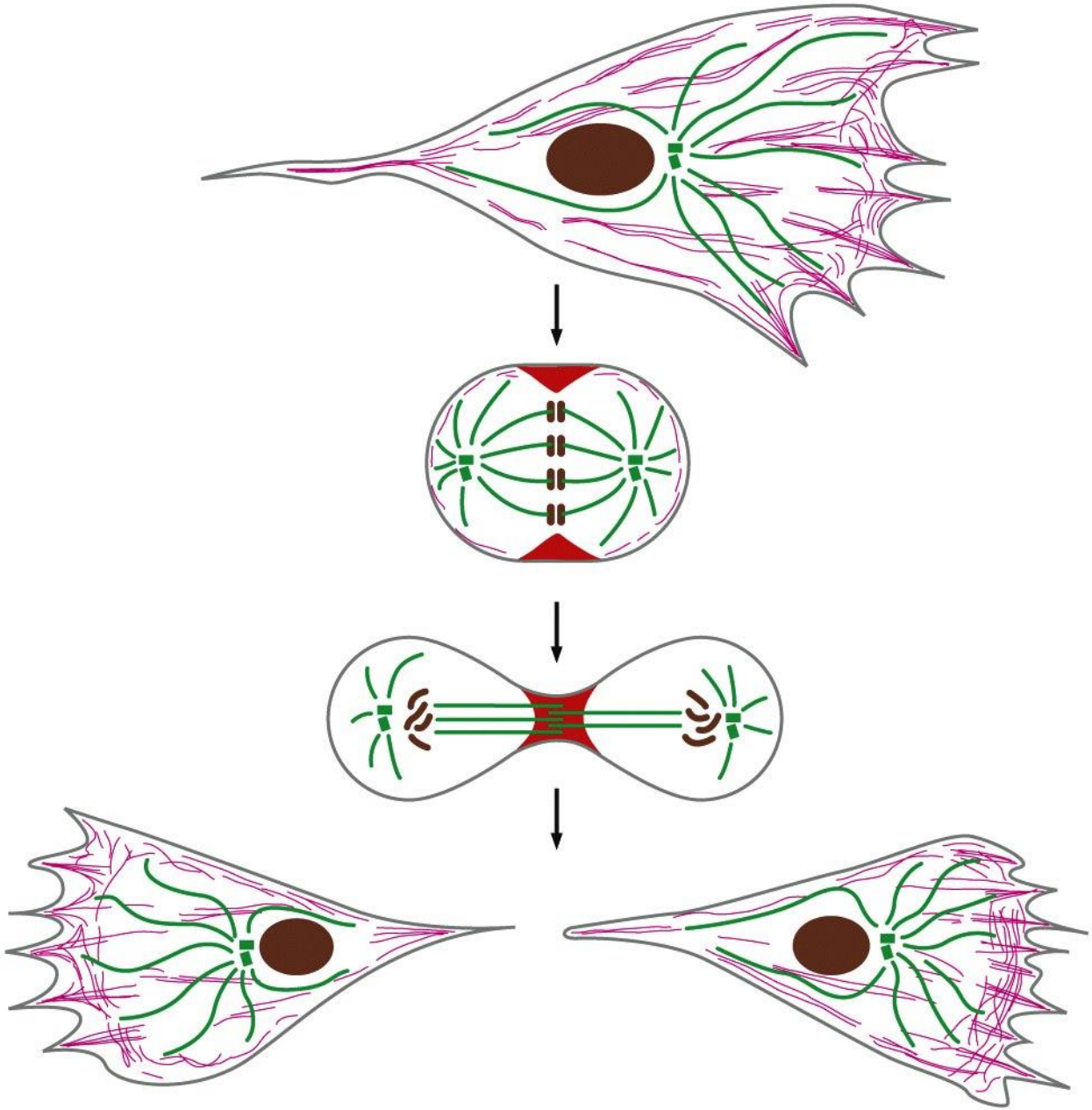


Figure 16-2 *Molecular Biology of the Cell* (© Garland Science 2008)

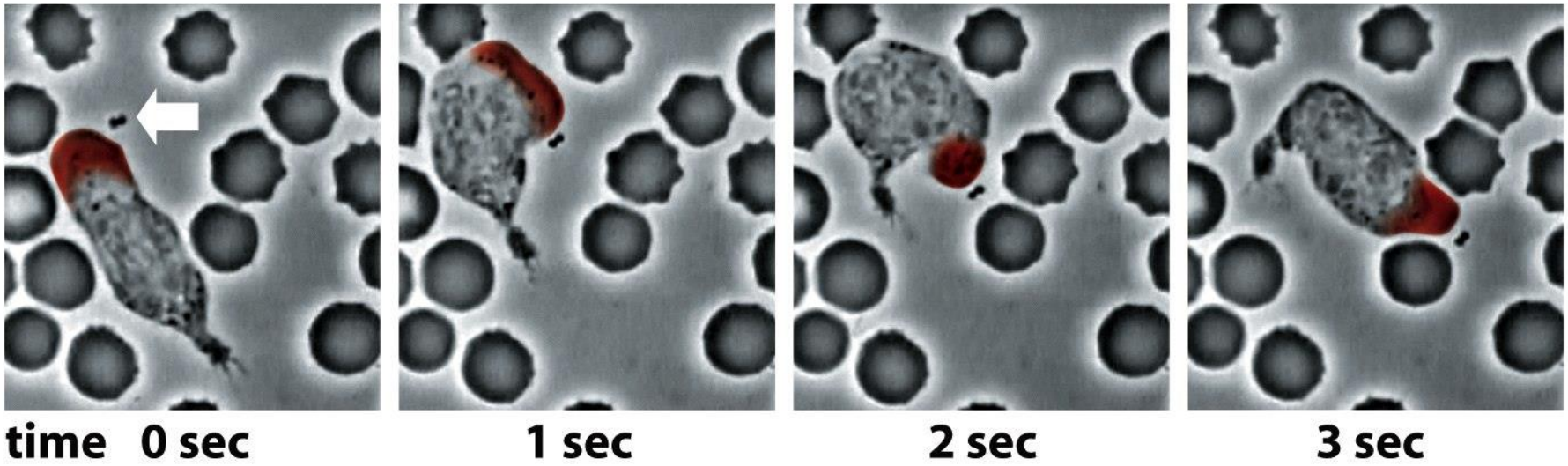


Figure 16-4 *Molecular Biology of the Cell* (© Garland Science 2008)

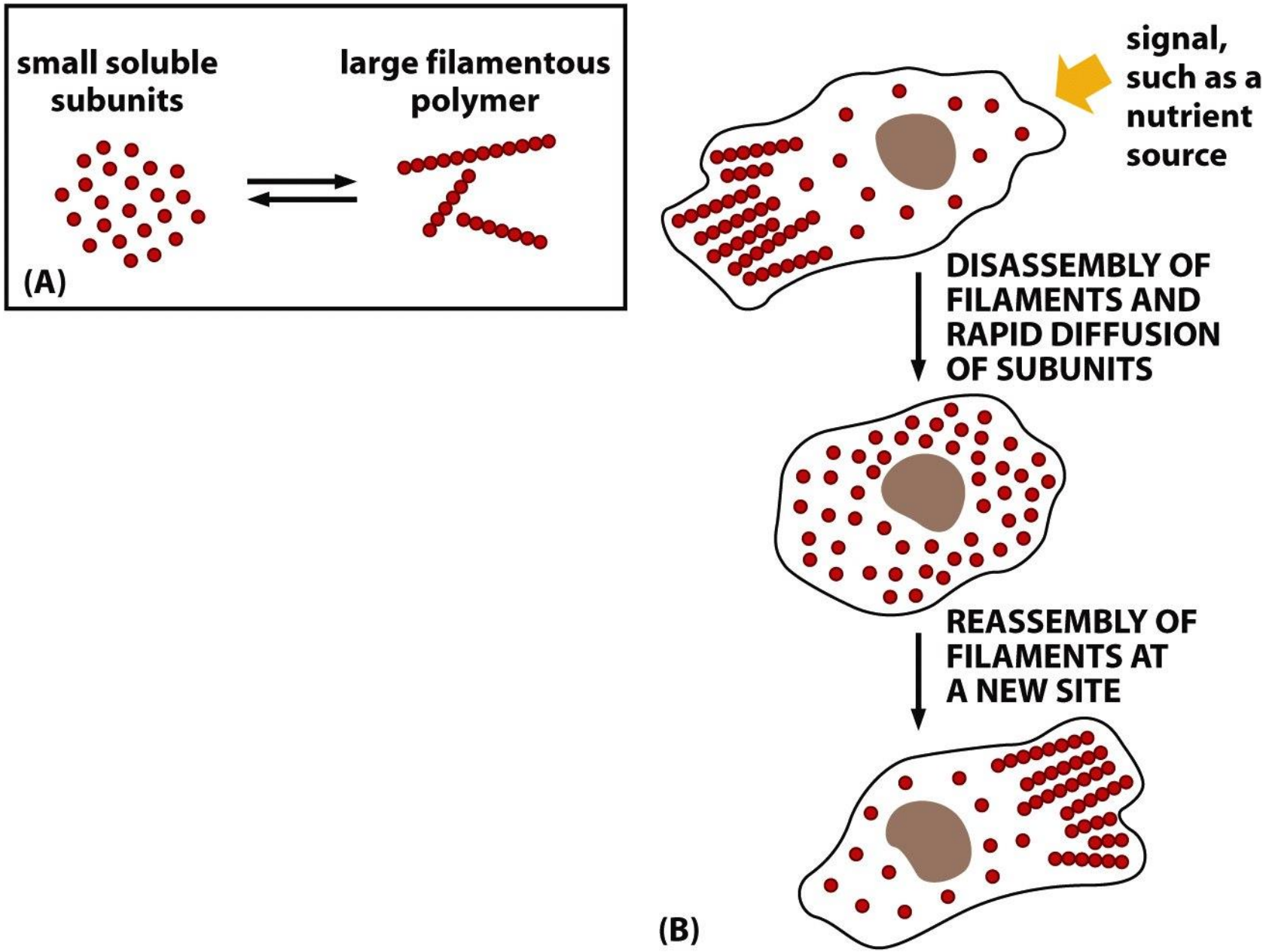


Figure 16-7 *Molecular Biology of the Cell* (© Garland Science 2008)

The Cytoskeleton (CSK) fibers

2. can also form stable structure

- large-scale structures for cell organization;
- microvilli and cilia;
- large-scale cellular polarity;
- strong adhesive contacts between cells.

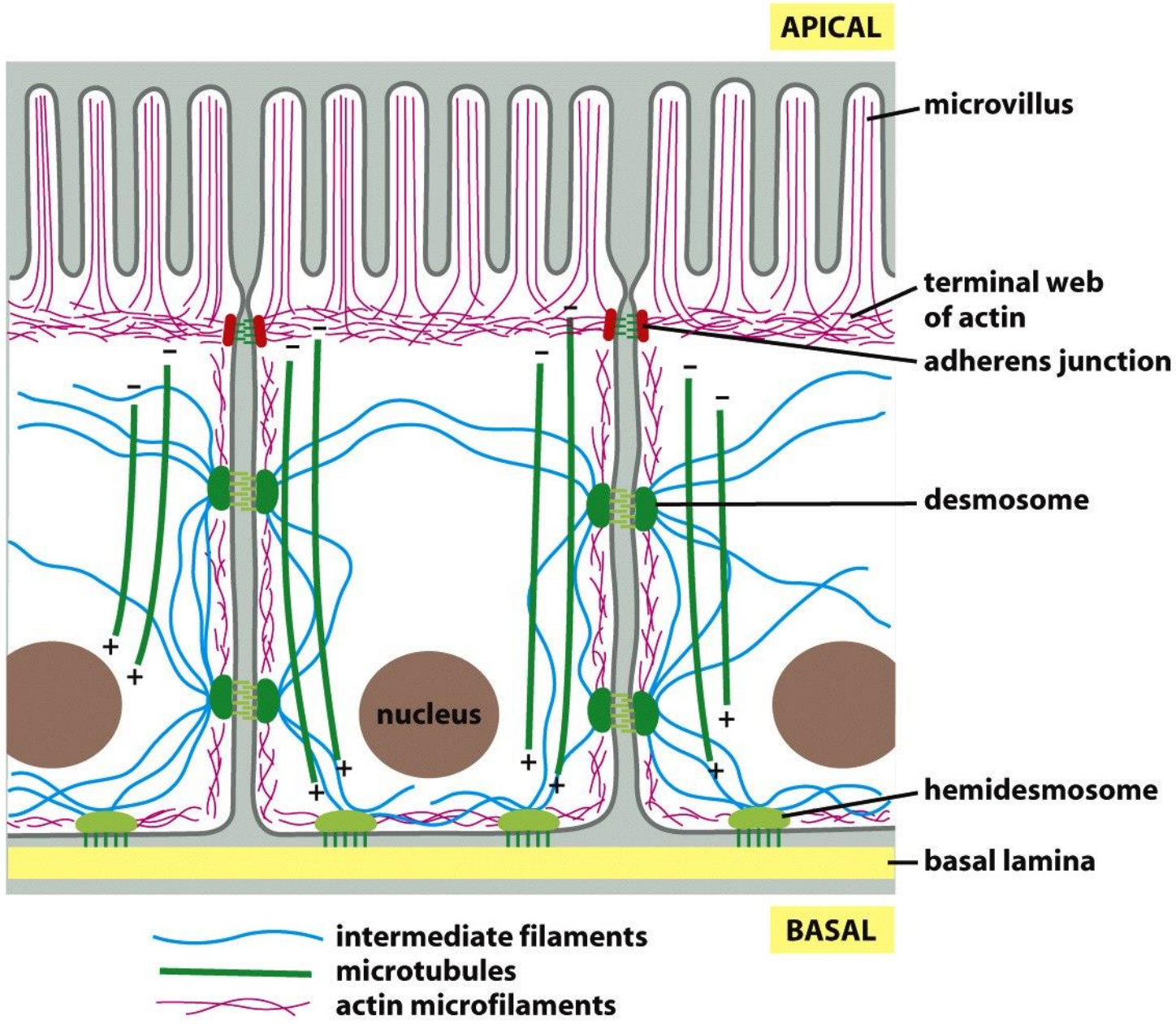


Figure 16-5 *Molecular Biology of the Cell* (© Garland Science 2008)

The Cytoskeleton (CSK) fibers

are constructed from smaller protein subunits:

- **Intermediate filaments –** many types of subunits;
- **Microtubules –** tubulin subunits;
- **Actin filaments** – actin subunits.

Proprieties:

- self associate: end-to-end and side-to-side protein contacts;
- weak noncovalent interactions;
- CSK fibers – polymers: assemble and disassembly rapidly.

Important roles – Accessory proteins!!!

MICROTUBULES

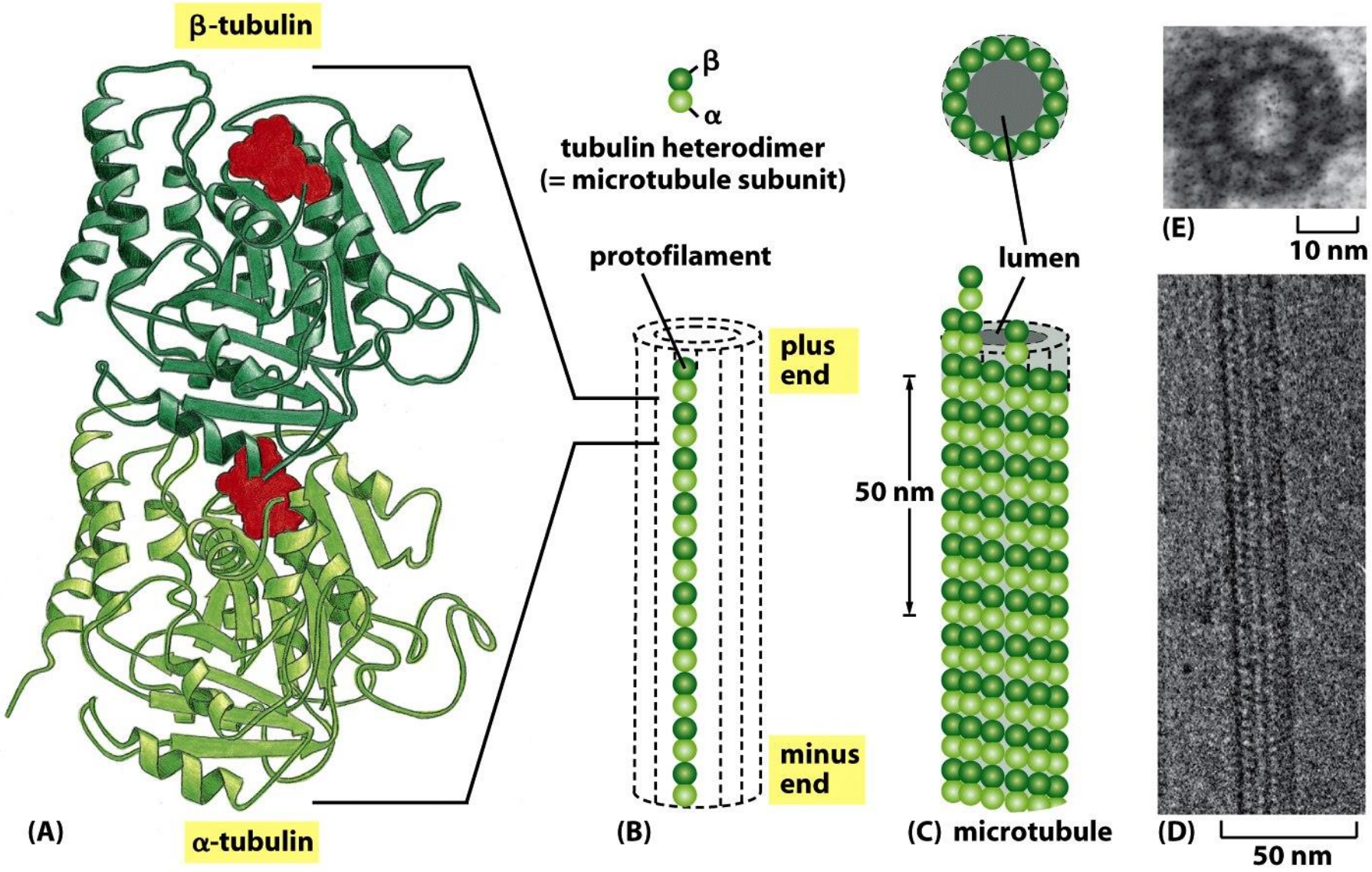


Figure 16-11 *Molecular Biology of the Cell* (© Garland Science 2008)

ATP binding site

ACTIN FILAMENTS

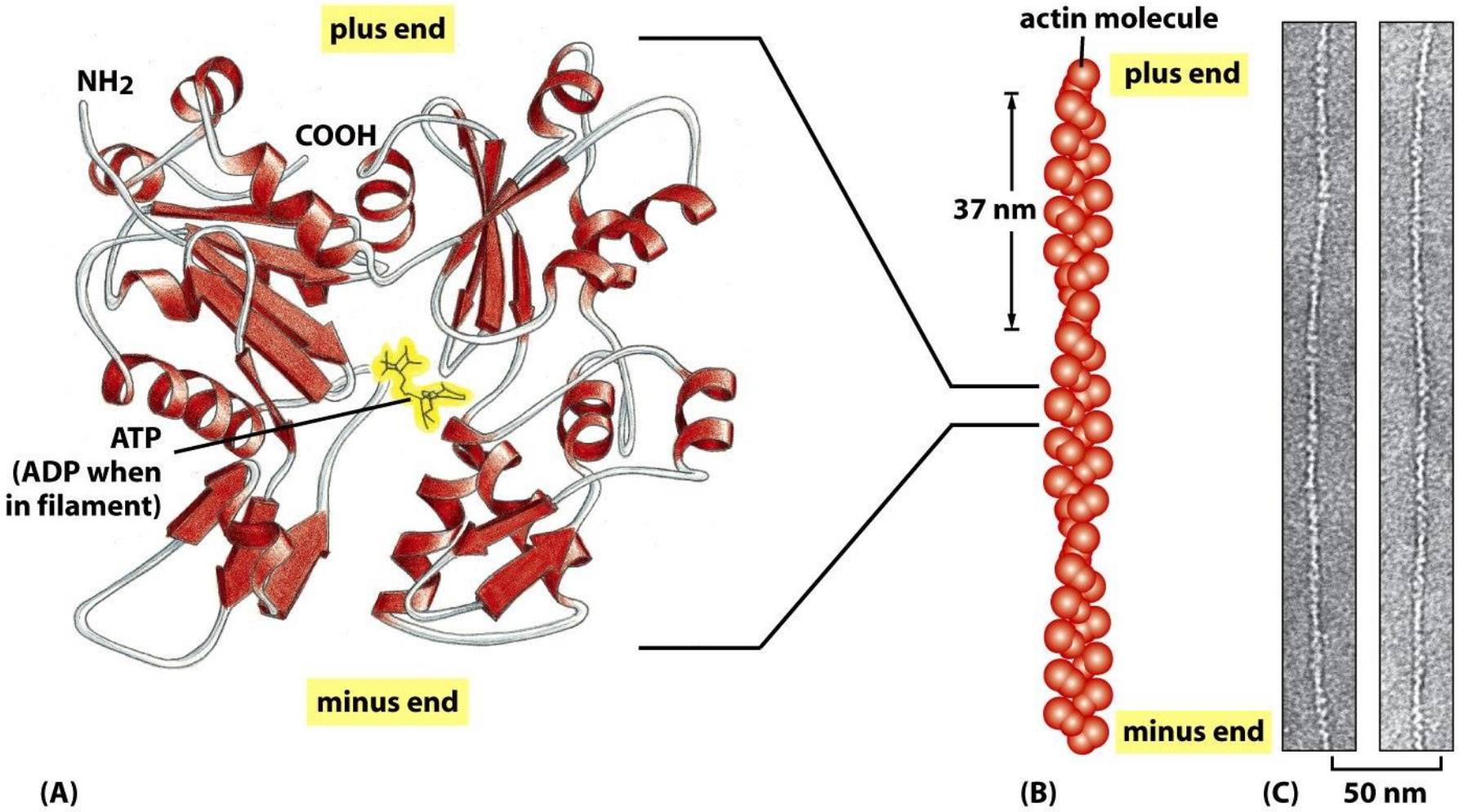
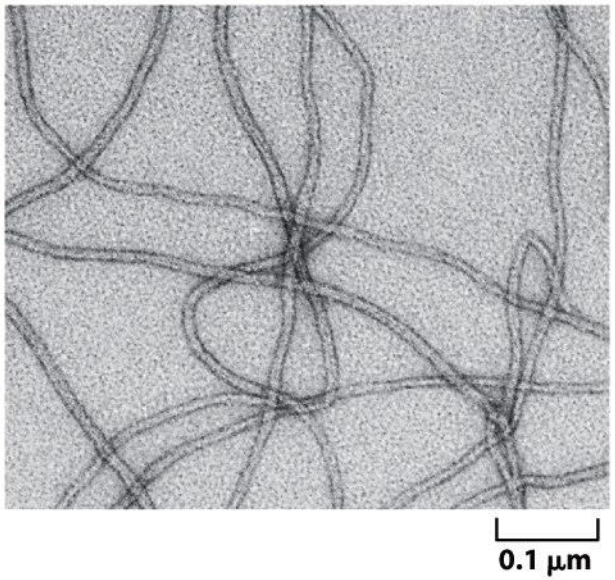
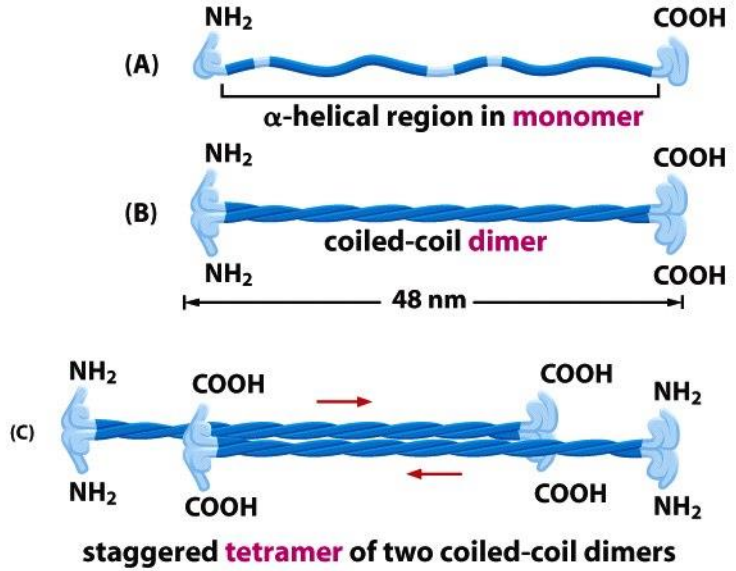


Figure 16-12 *Molecular Biology of the Cell* (© Garland Science 2008)

INTERMEDIATE FILAMENTS





NO GTP/ATP binding site!!!

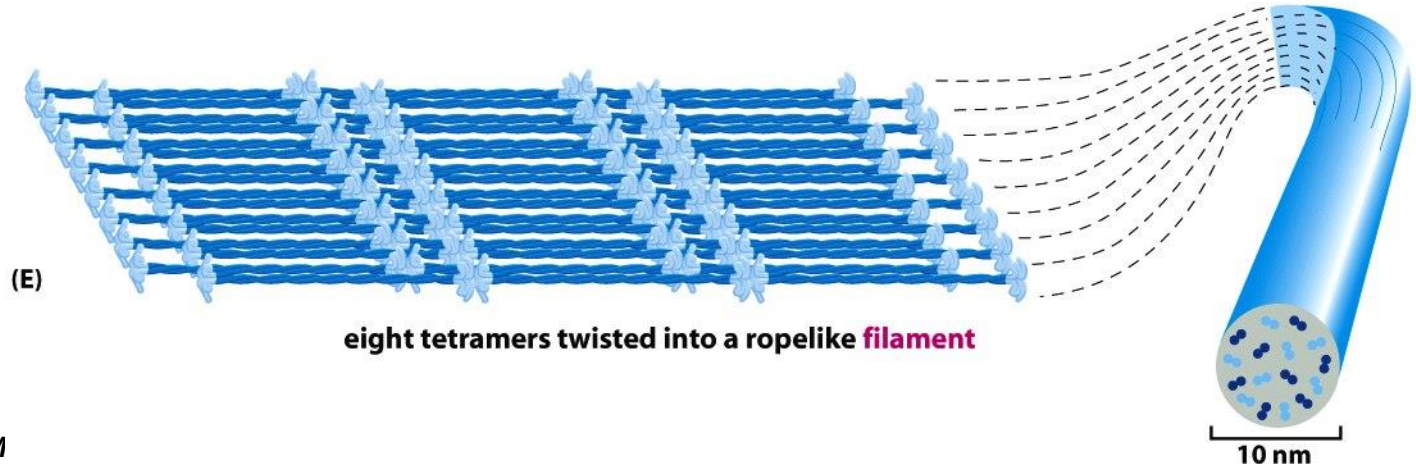


Figure 16-19 *M*

The Tubulin and Actin Subunits Assemble Head-to-Tail to Create Polar Filaments

- have two different ends (+&-) that grow at different rates;

- start with a nucleation step.
- the filament threadmilling and dynamic instability are consequences of nucleotide (GTP and ATP) hydrolisys by tubulin and actin;

**** The intermediate filaments do not have a GTP/ATP binding site!!!***

MICROTUBULES

MICROTUBULES

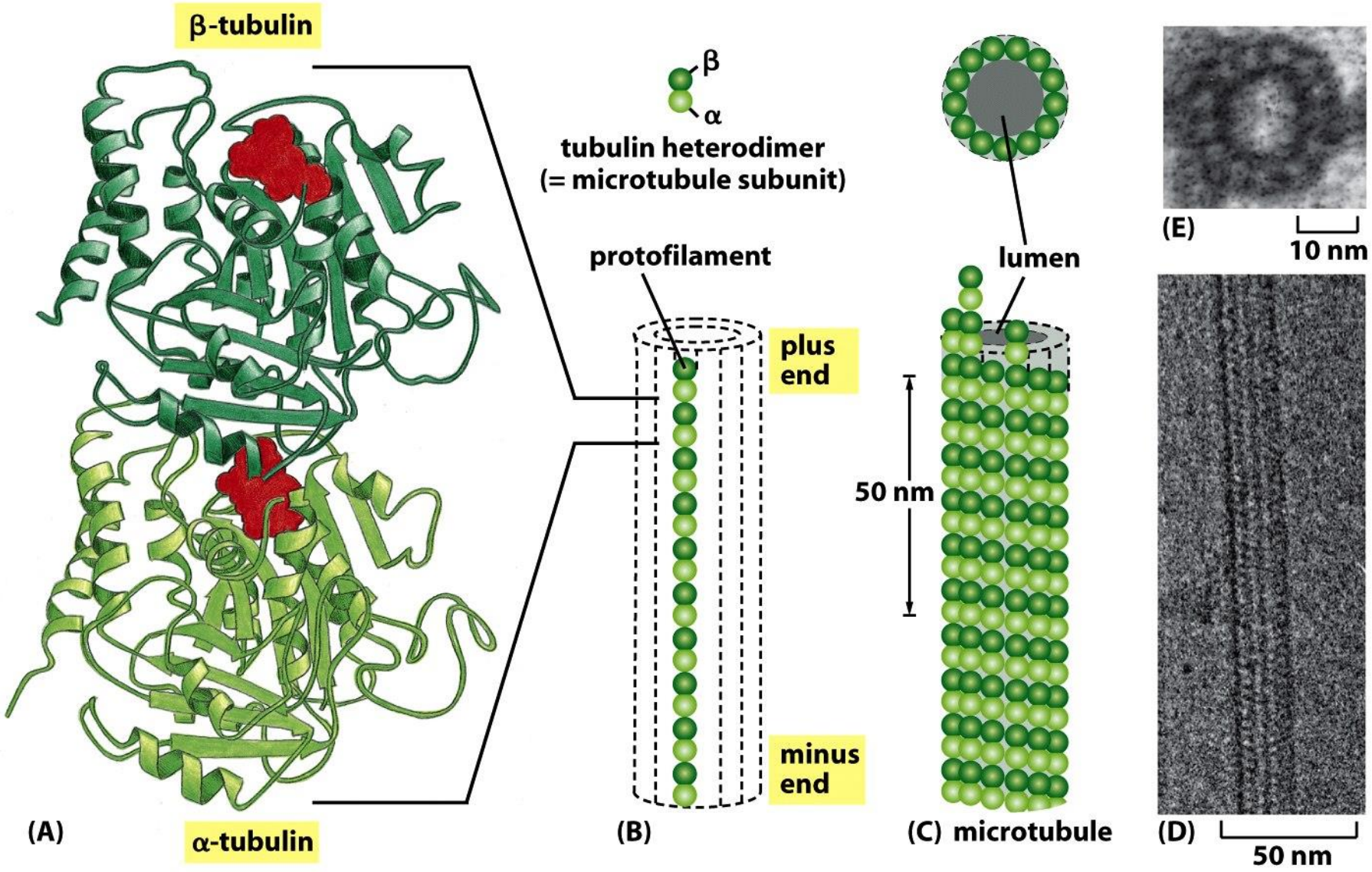
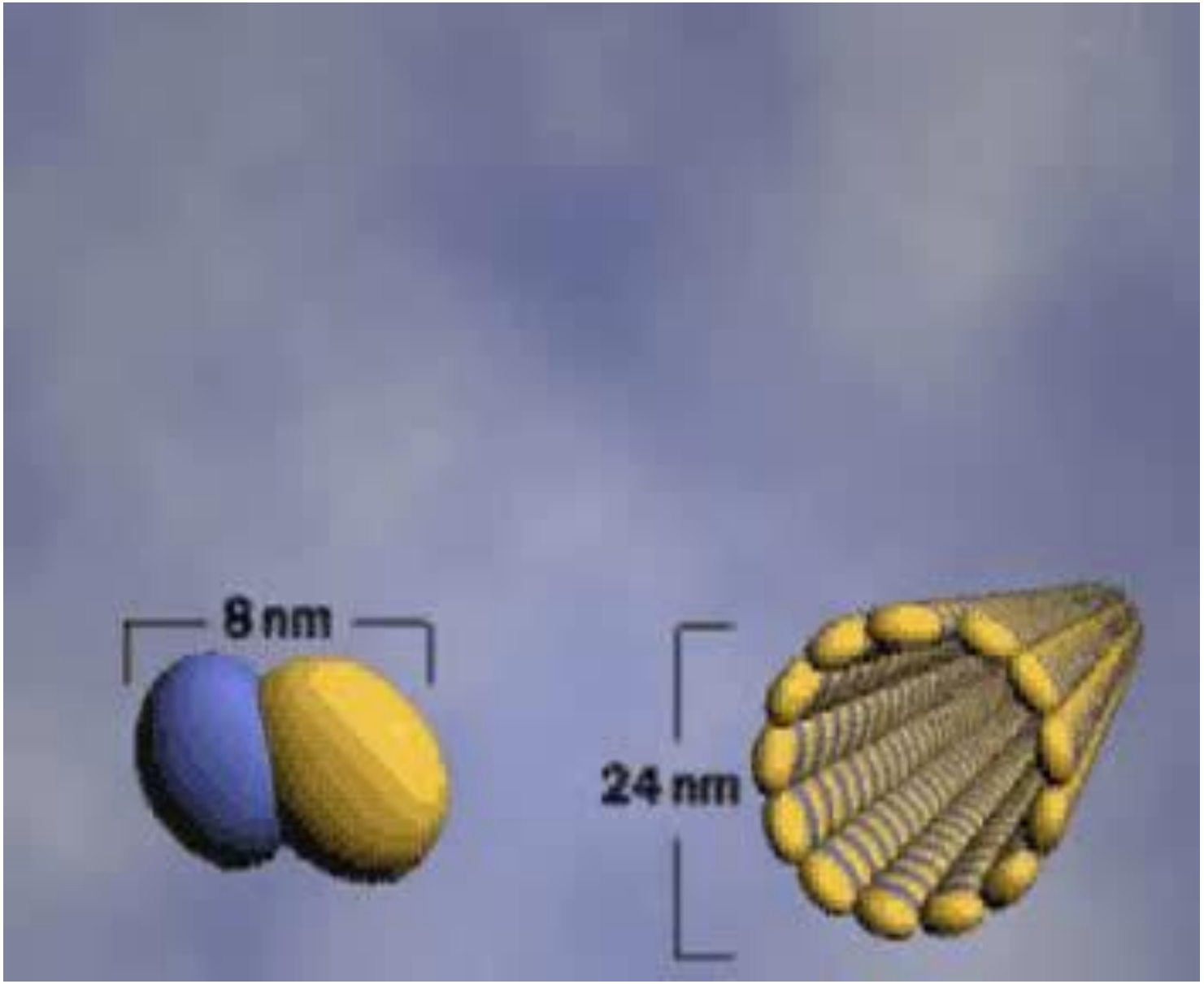


Figure 16-11 *Molecular Biology of the Cell* (© Garland Science 2008)

MICROTUBULES



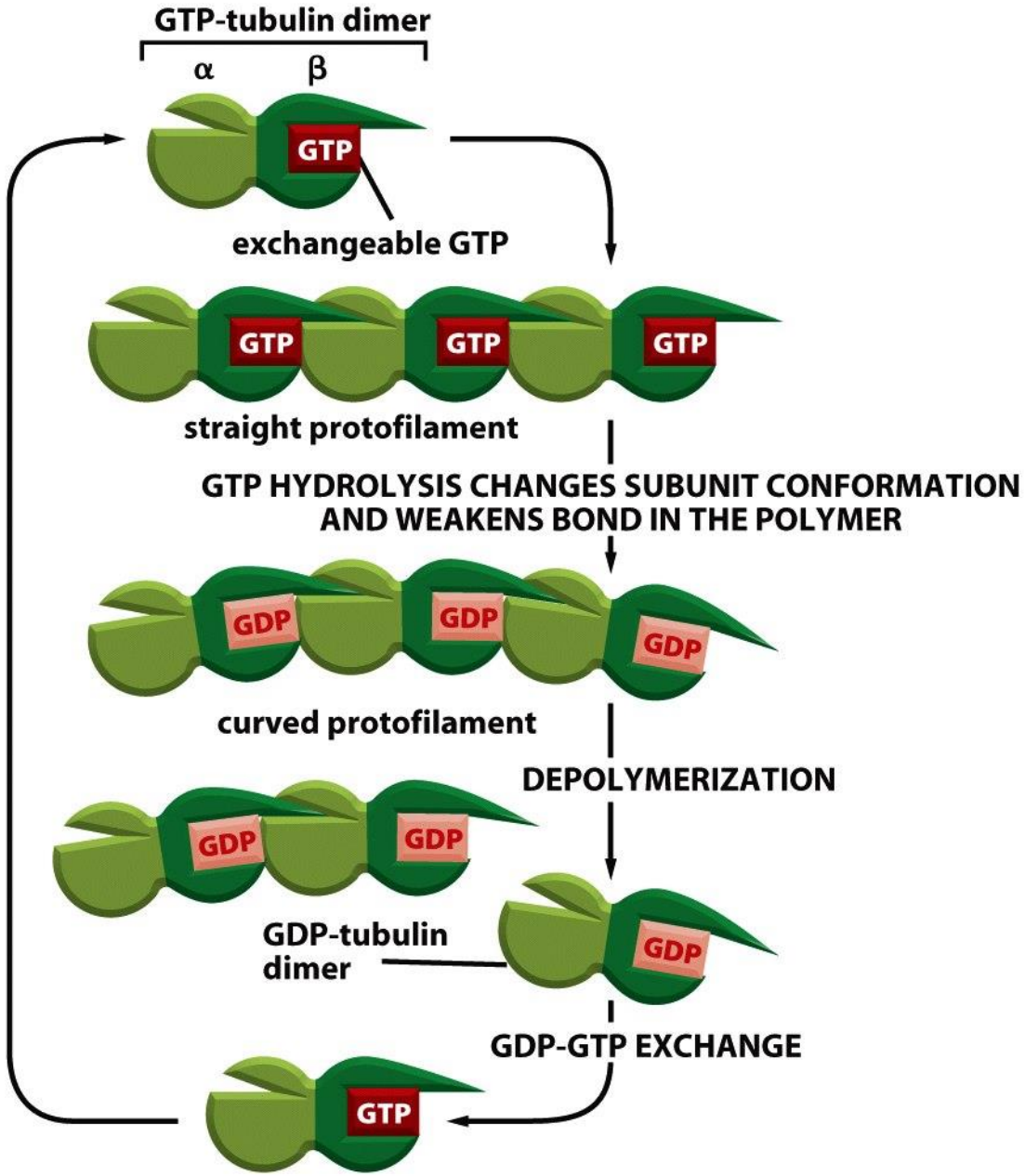


Figure 16-16b *Molecular Biology of the Cell* (© Garland Science 2008)

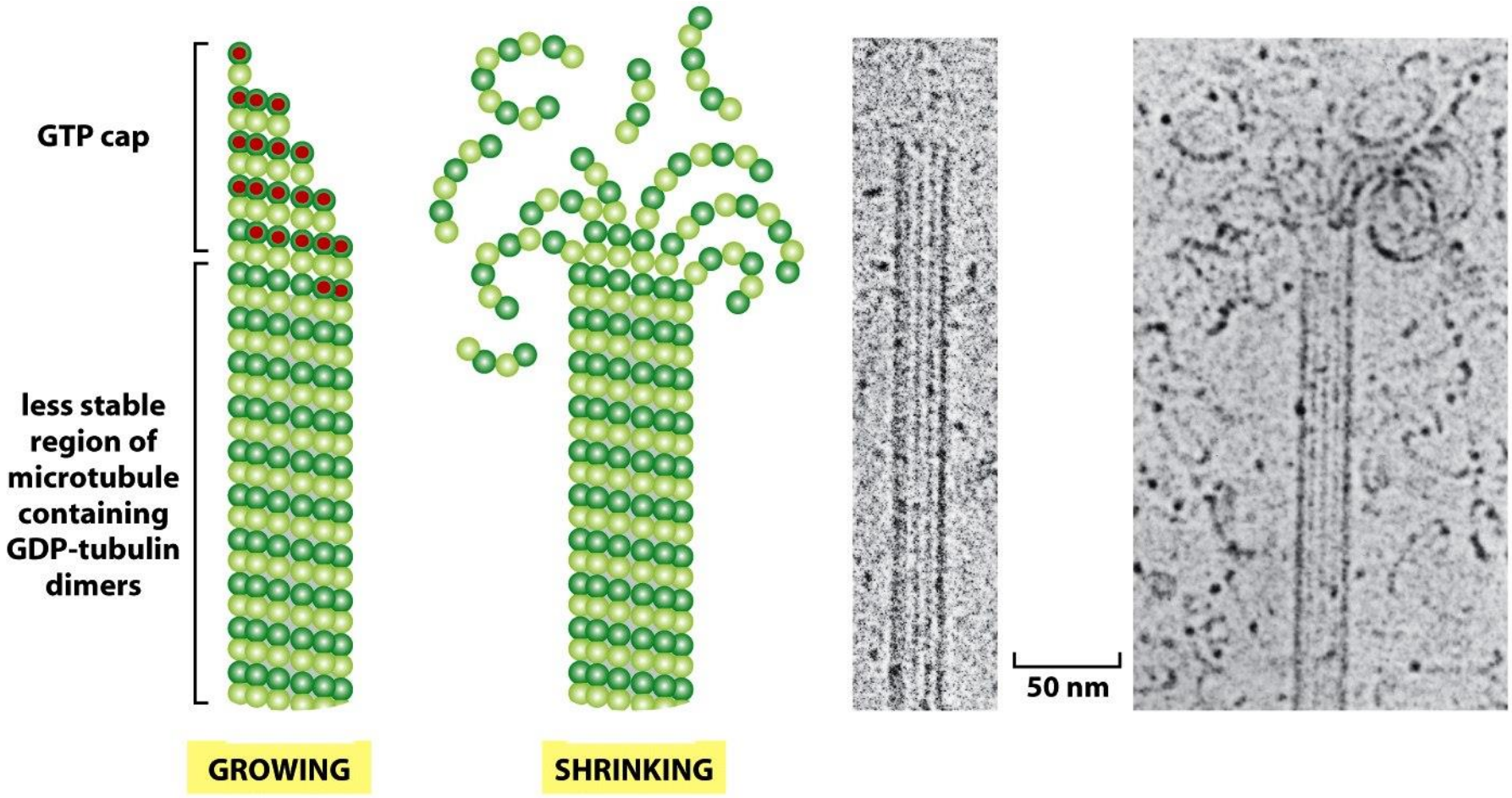


Figure 16-16c *Molecular Biology of the Cell* (© Garland Science 2008)

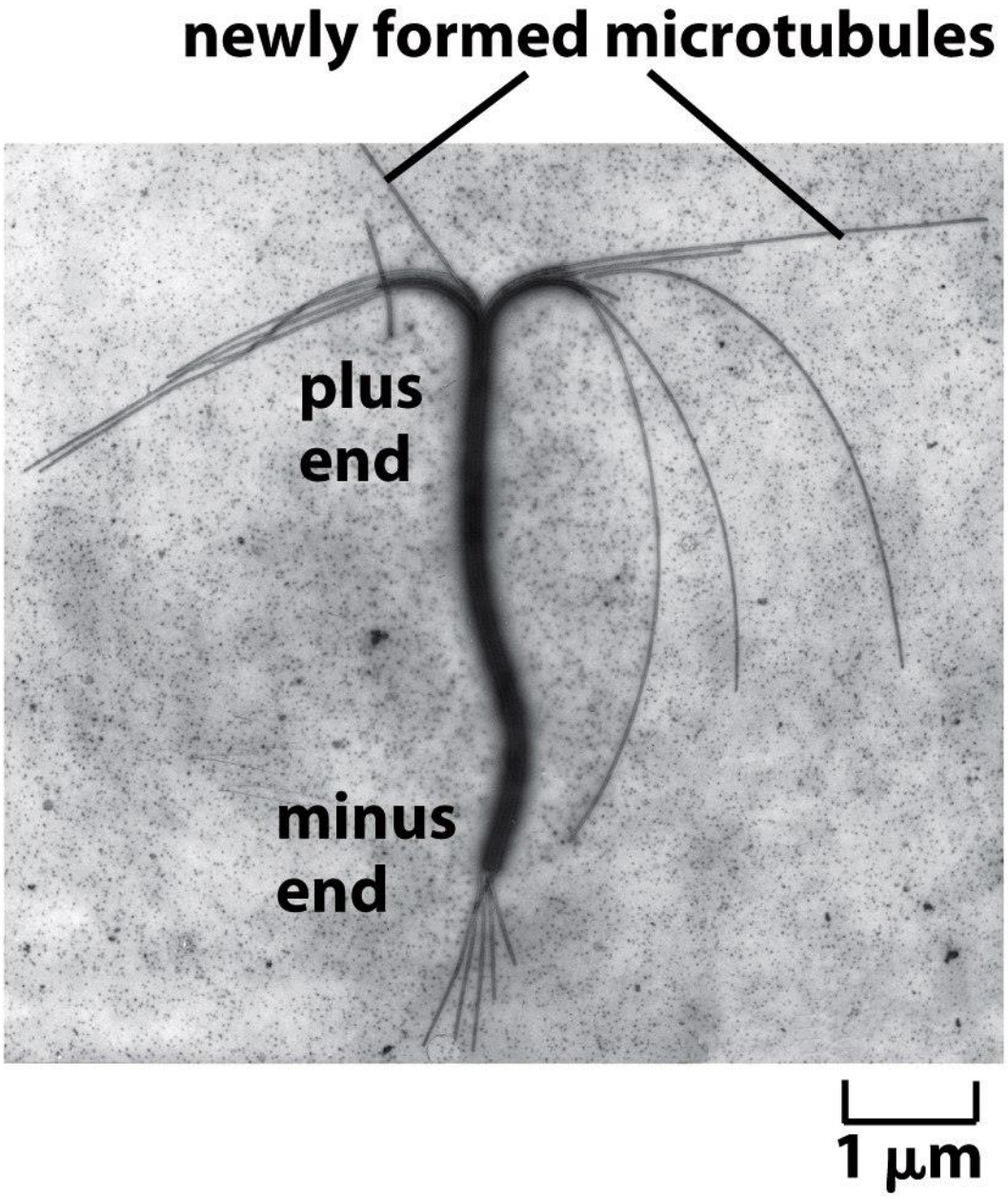
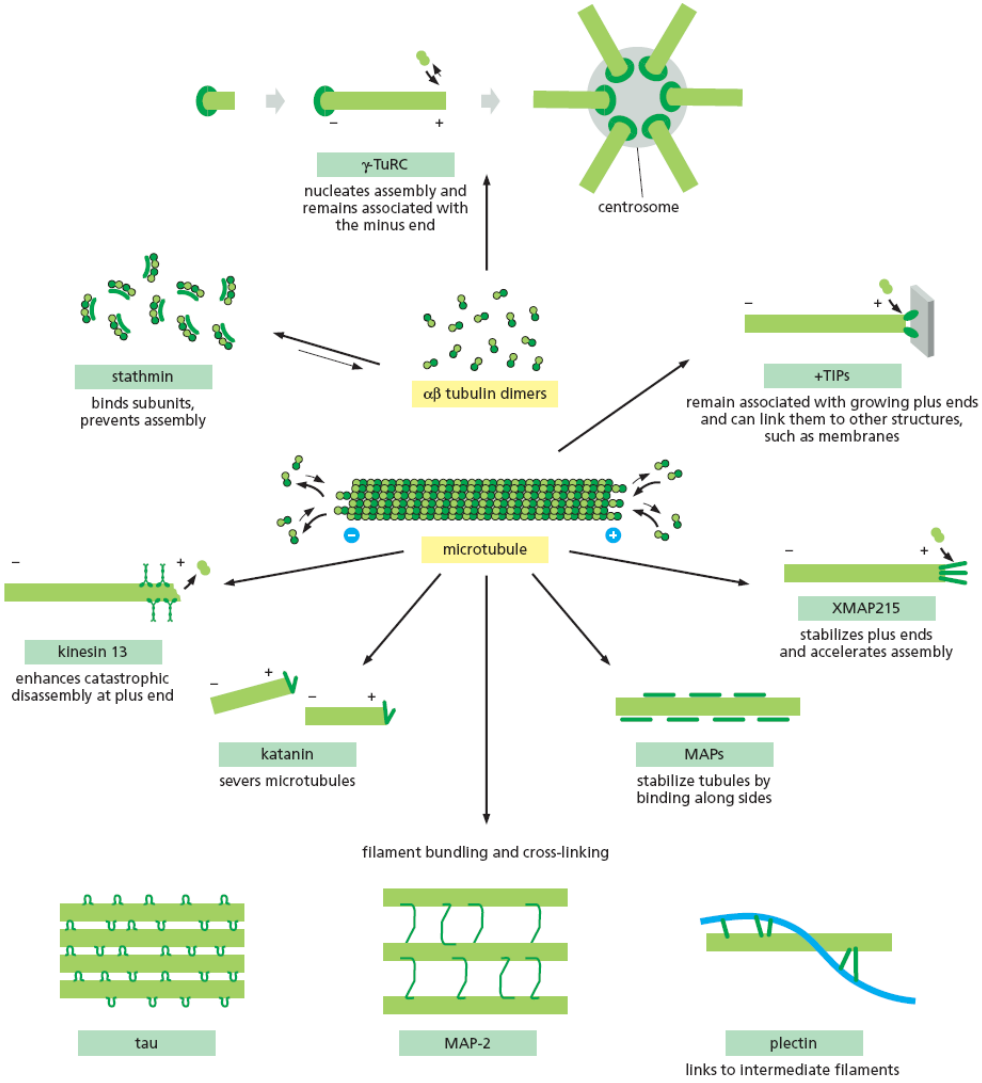
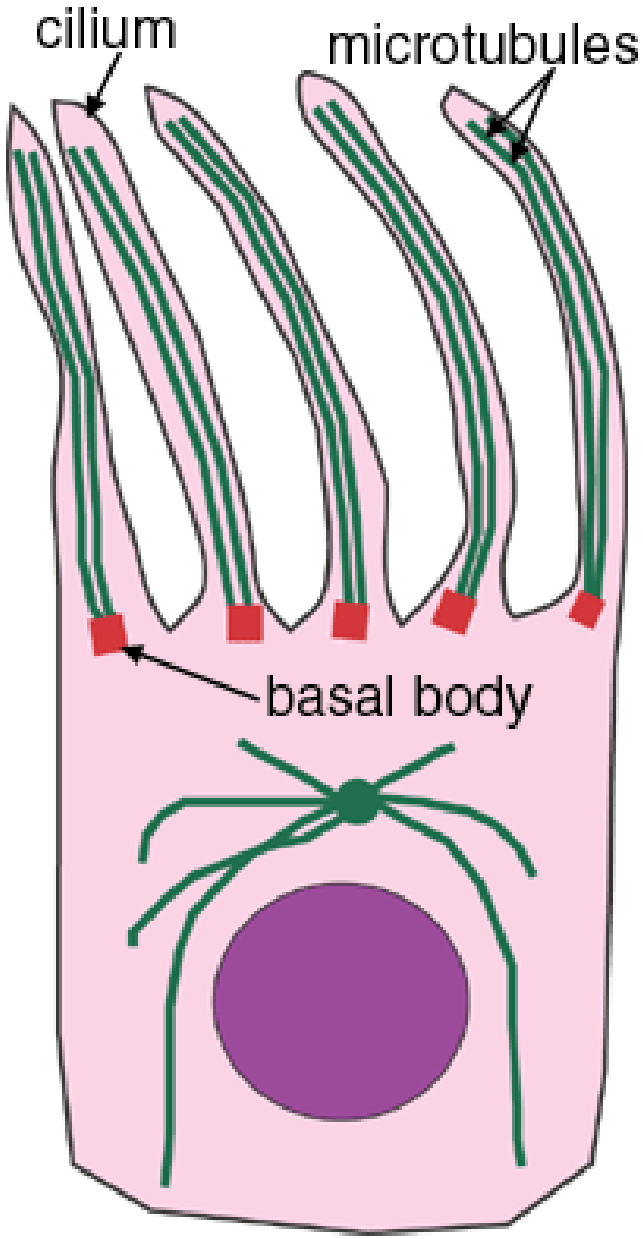


Figure 16-13 ***Molecular Biology of the Cell*** **(© Garland Science 2008)**



Some of the major accessory proteins of the microtubule cytoskeleton. Except for two classes of motor proteins, to be discussed in a later section, an example of each major type is shown. Each of these is discussed in the text. However, most cells contain more than a hundred different microtubule-binding proteins, and—as for the actin-associated proteins—it is likely that there are important types of microtubule-associated proteins that are not yet recognized.


cilium
microtubules
basal body

CENTROSOMES

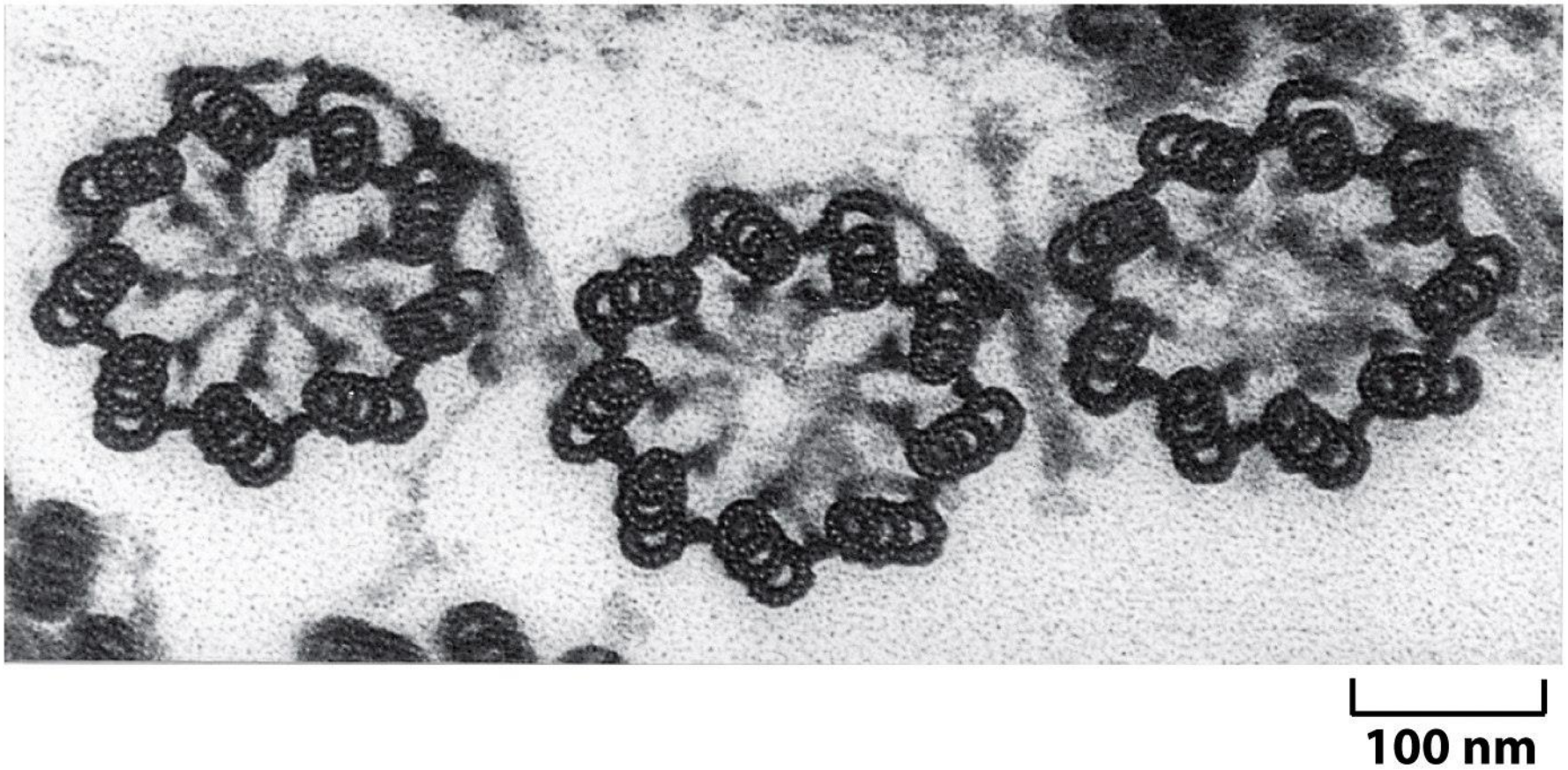


Figure 16-84a ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

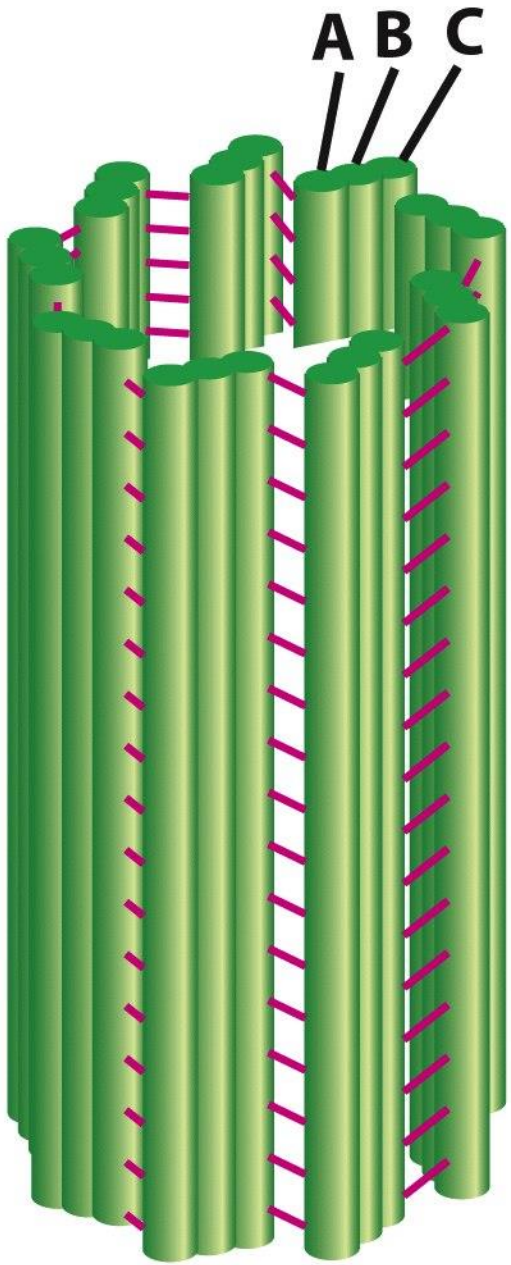


Figure 16-84b ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

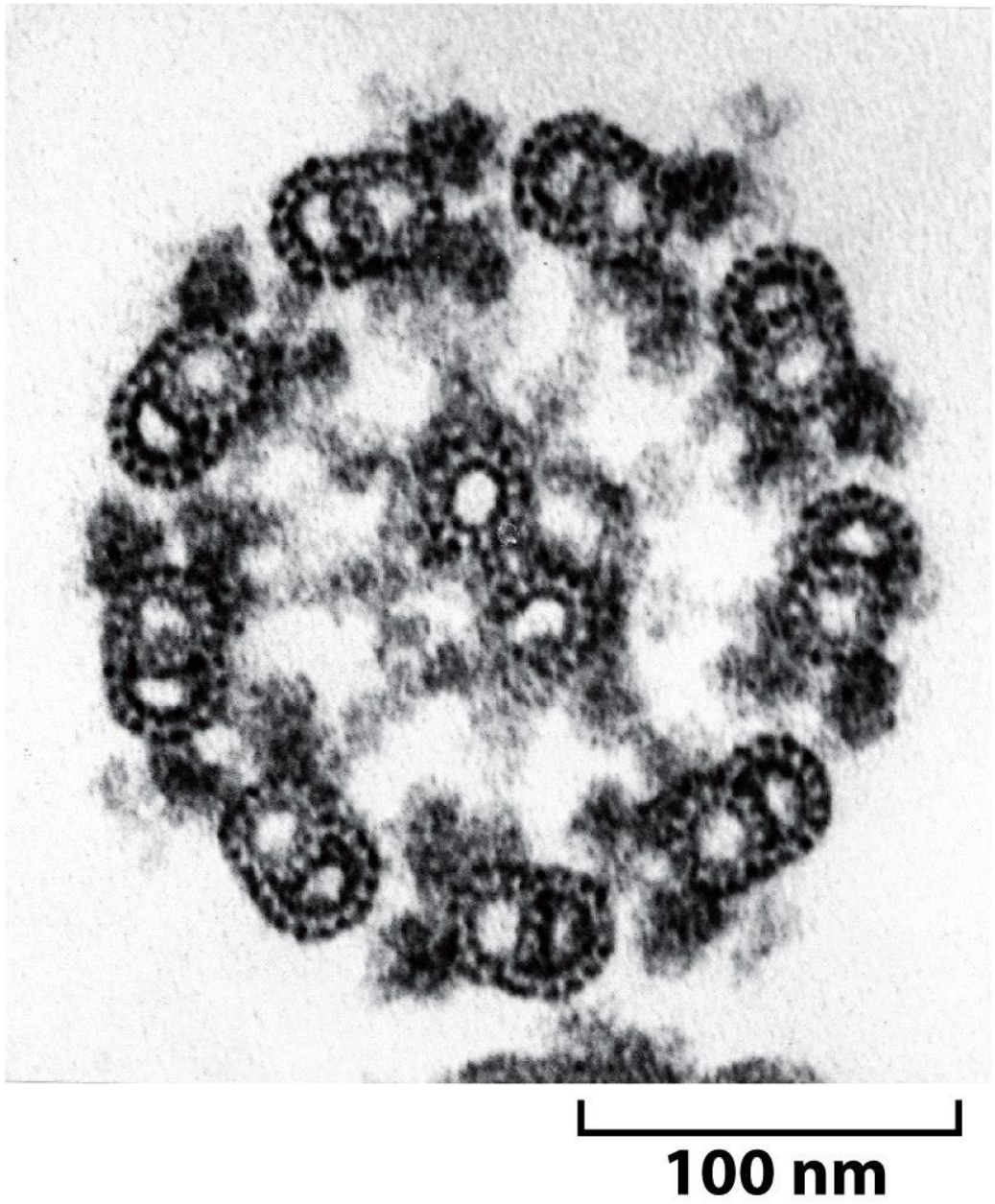


Figure 16-81a ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

9+2 arrangement

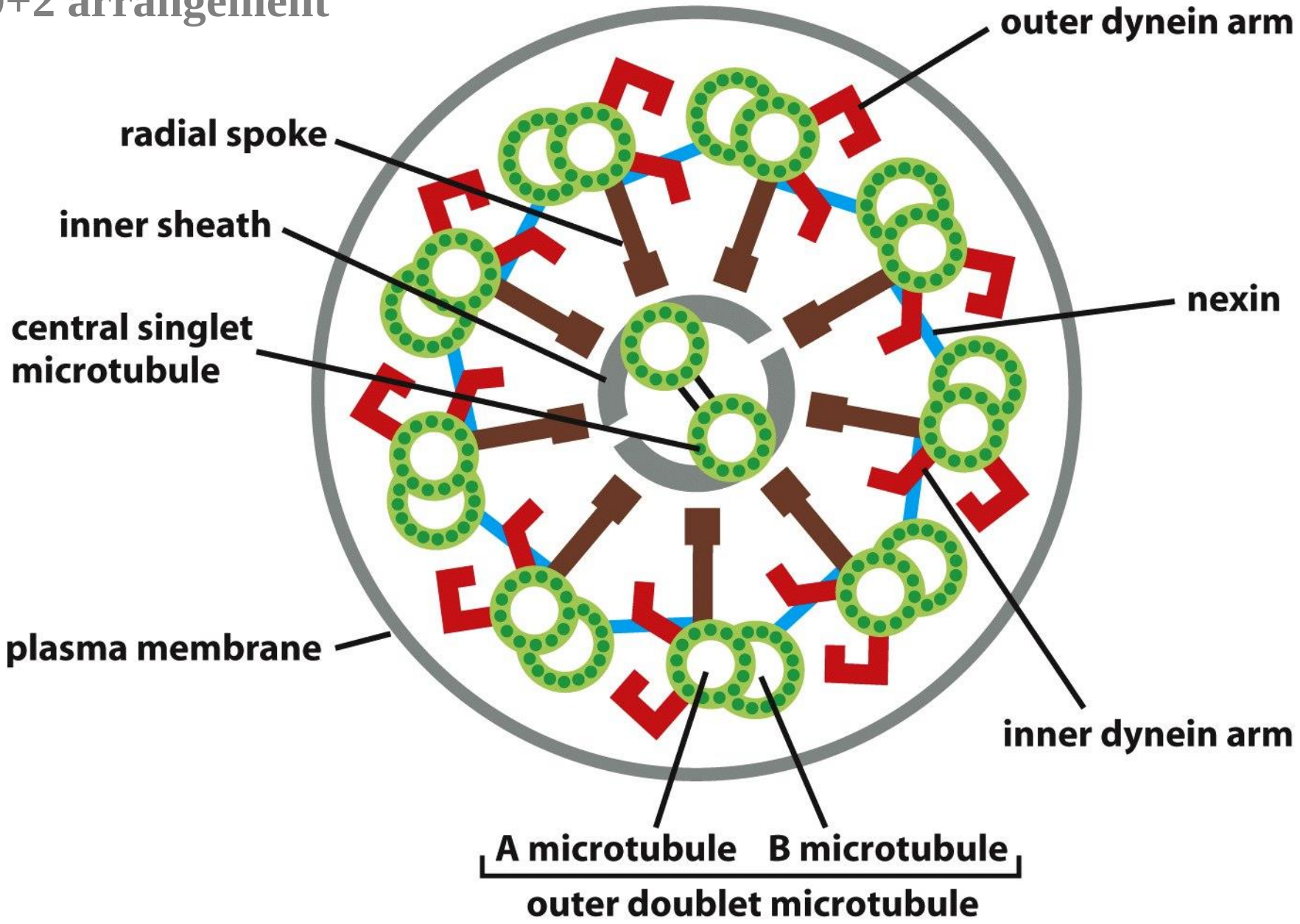


Figure 16-81b ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

Ciliary dynein

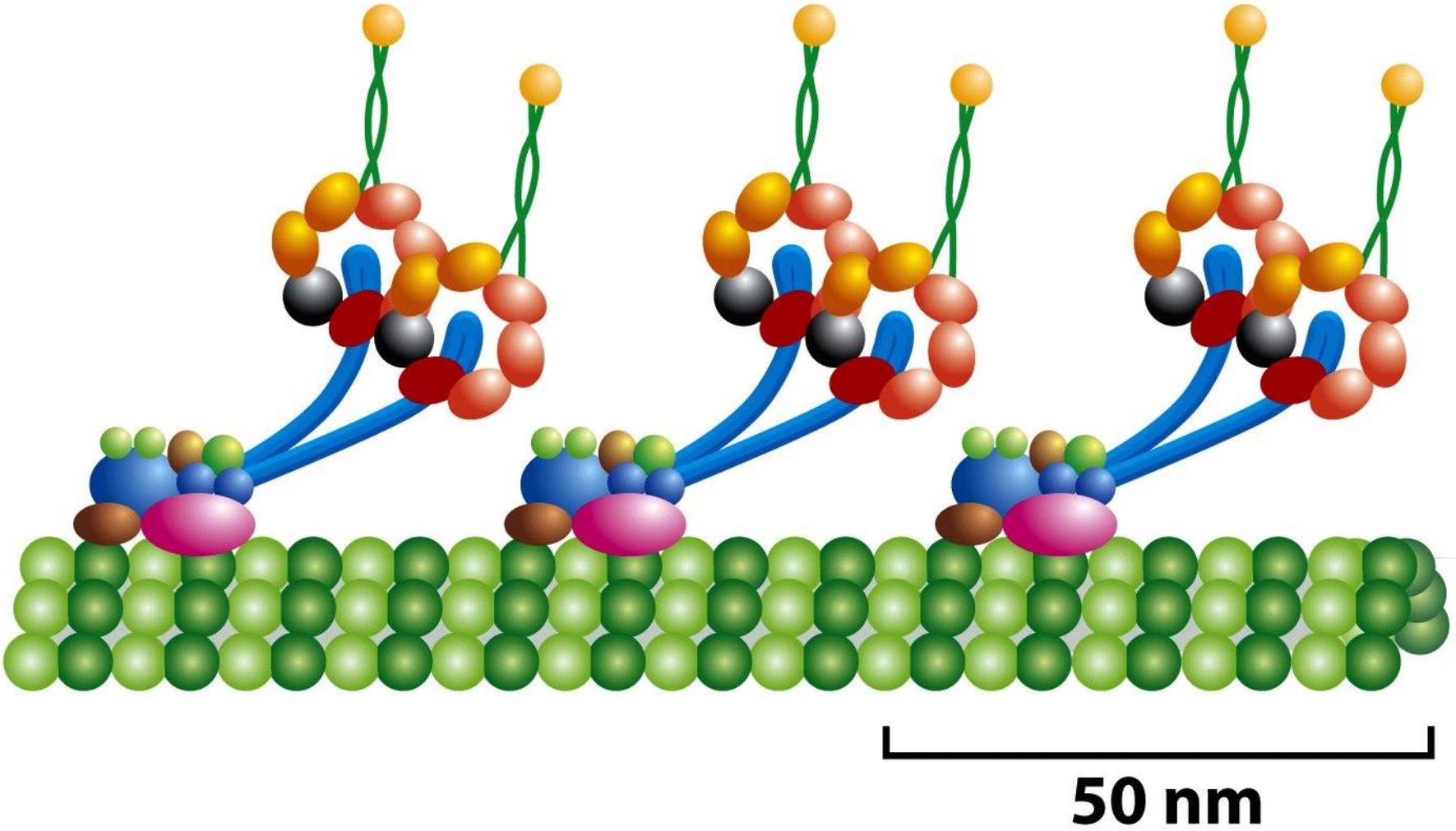


Figure 16-82a ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

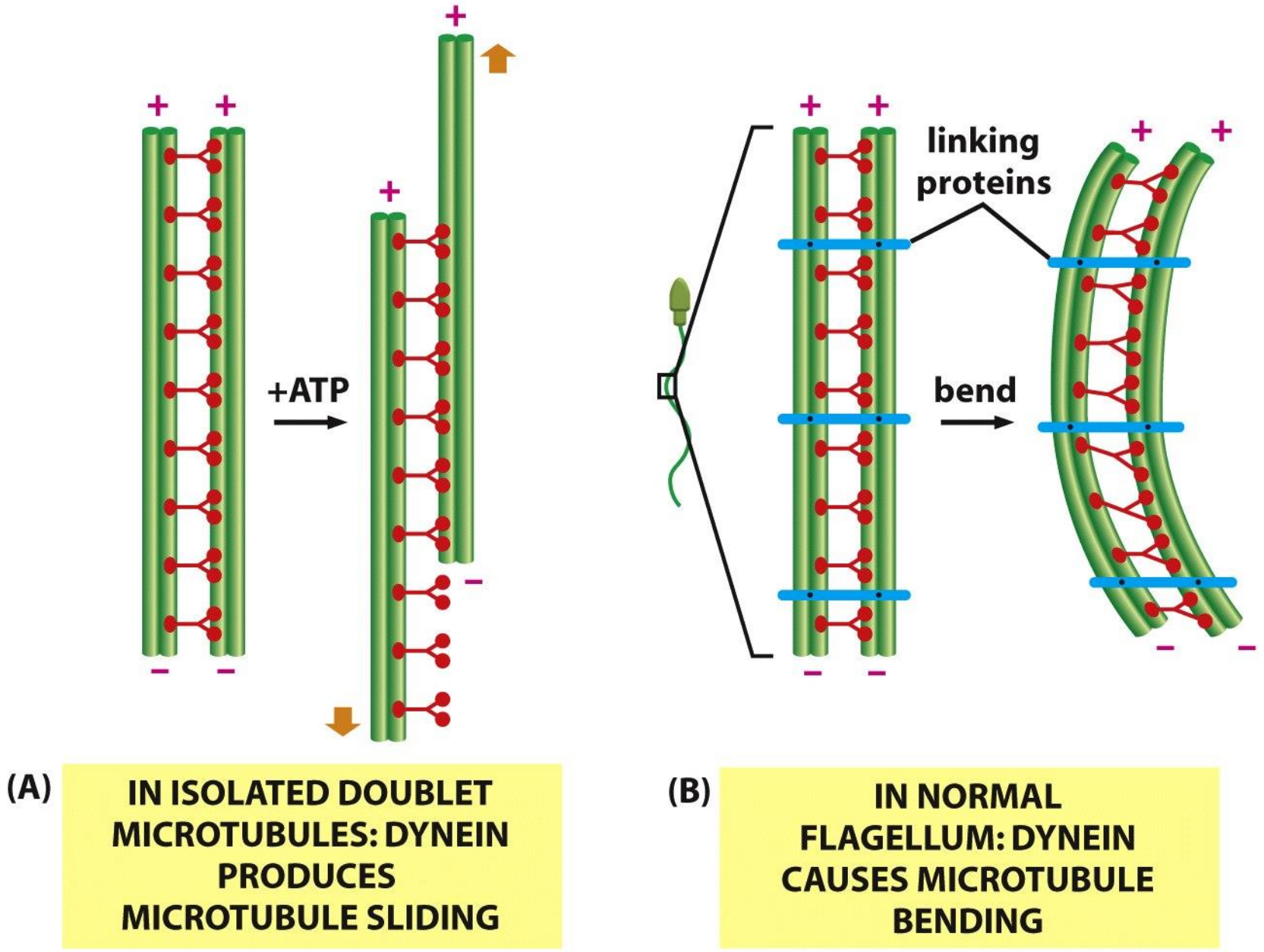


Figure 16-83 ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

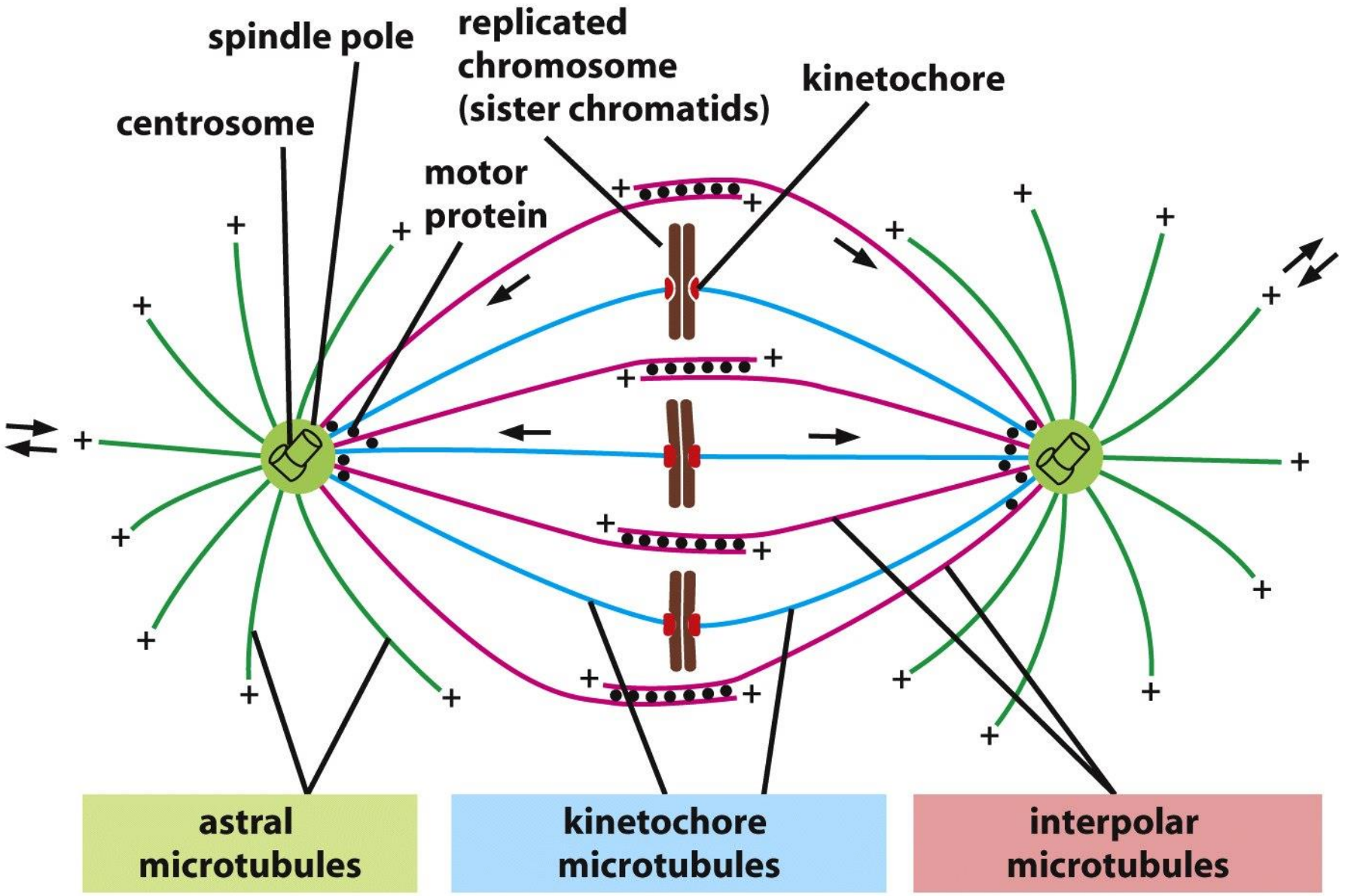


Figure 16-85a *Molecular Biology of the Cell* **(© Garland Science 2008)**

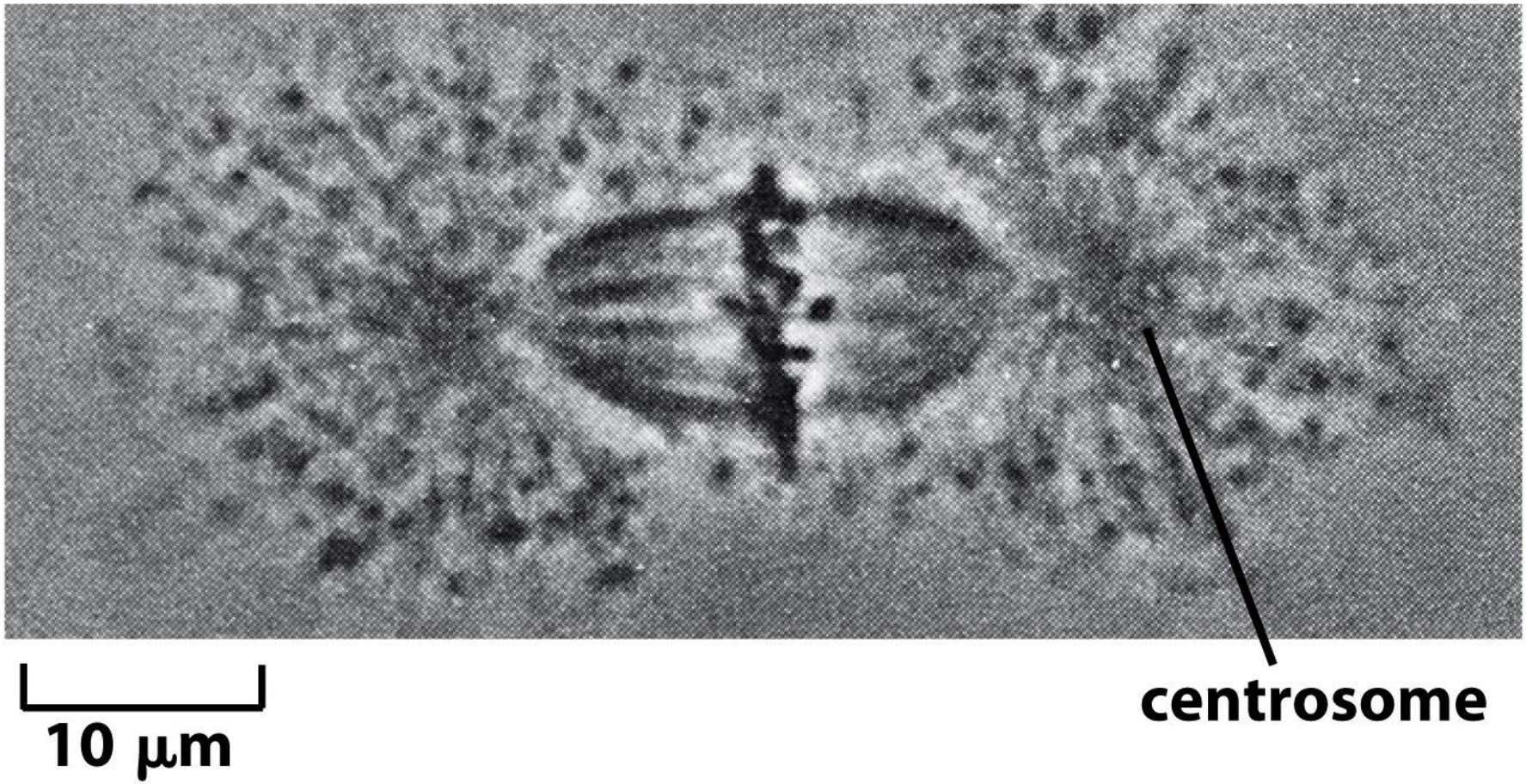


Figure 16-85b ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

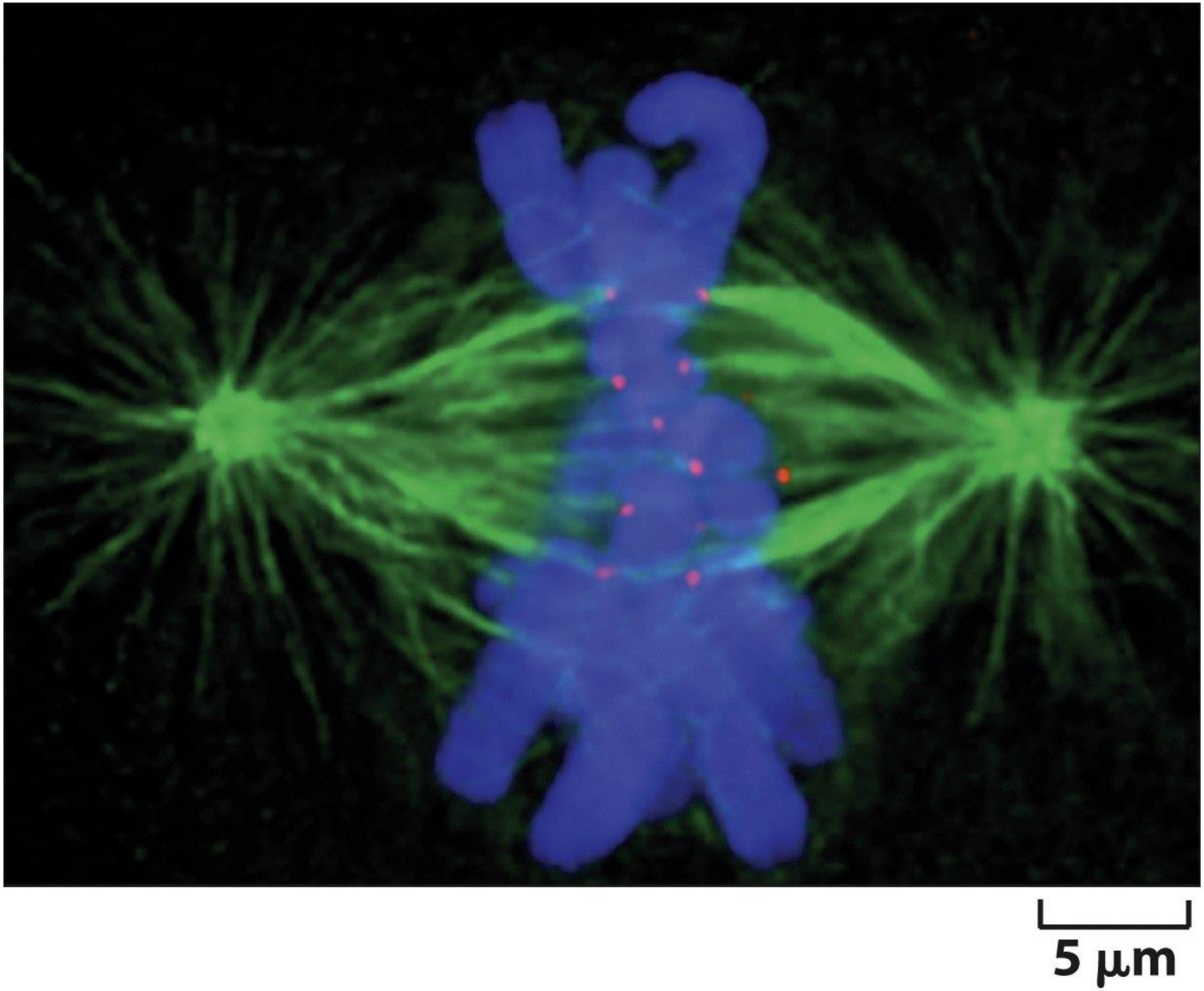
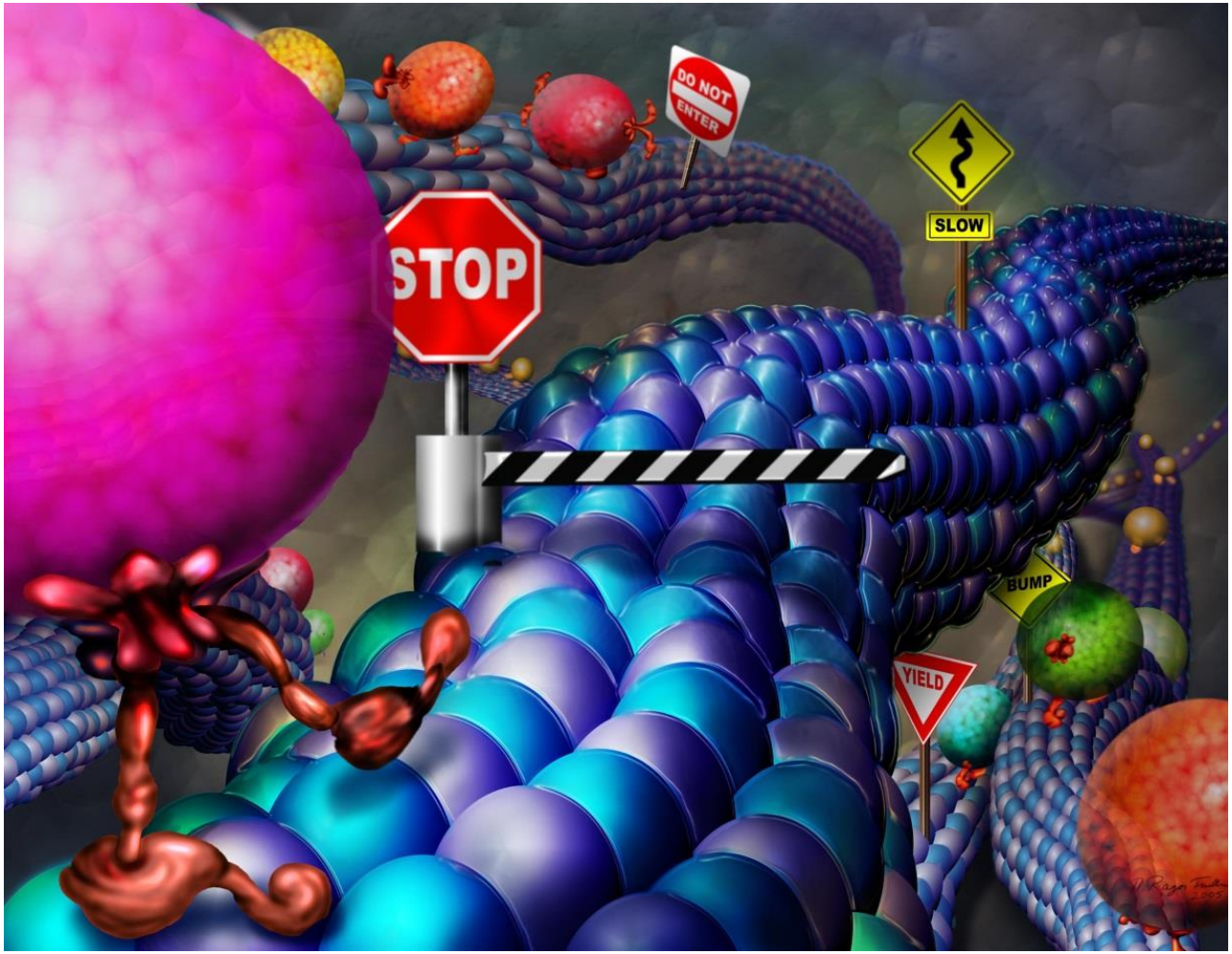
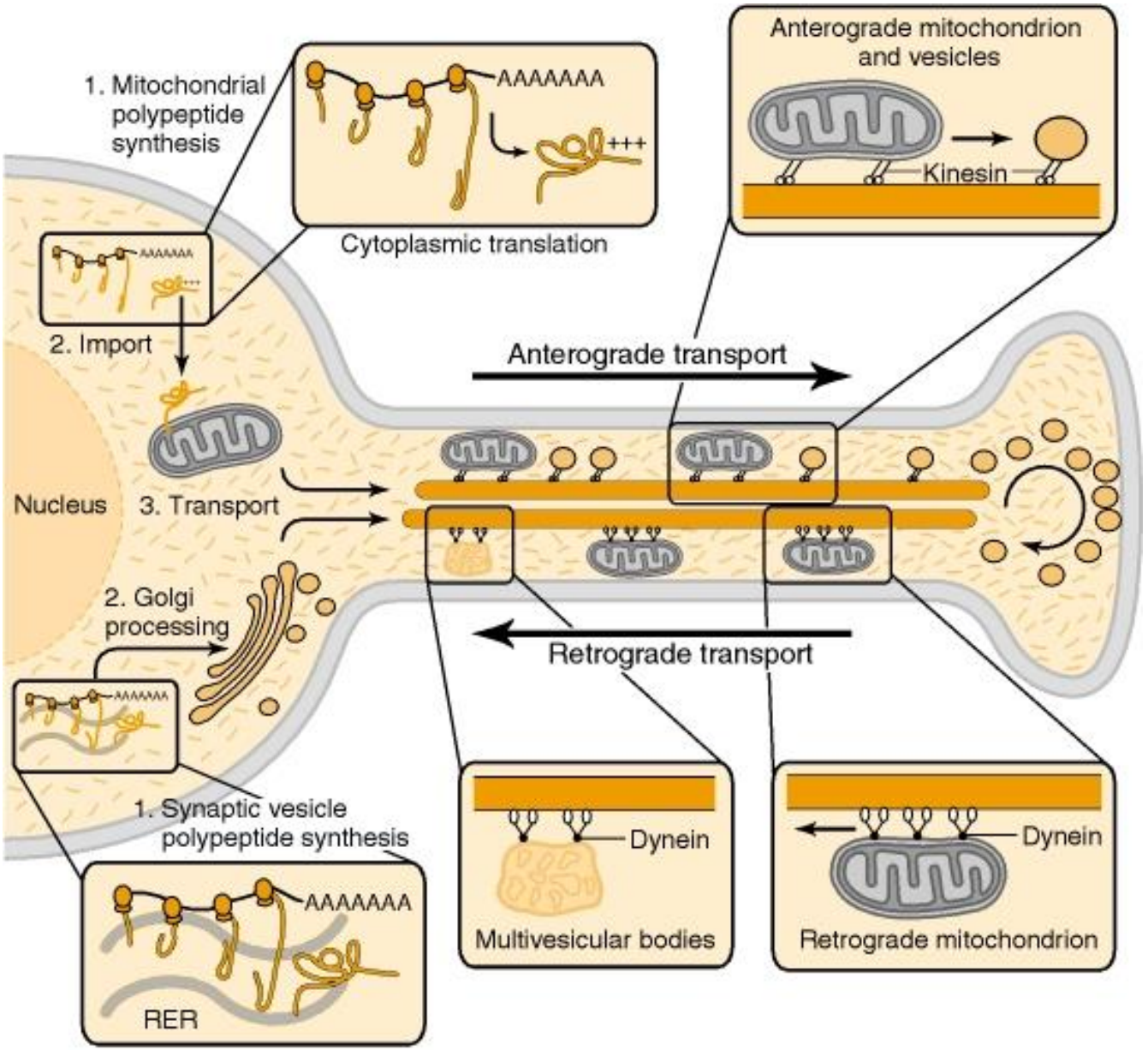


Figure 16-85c ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

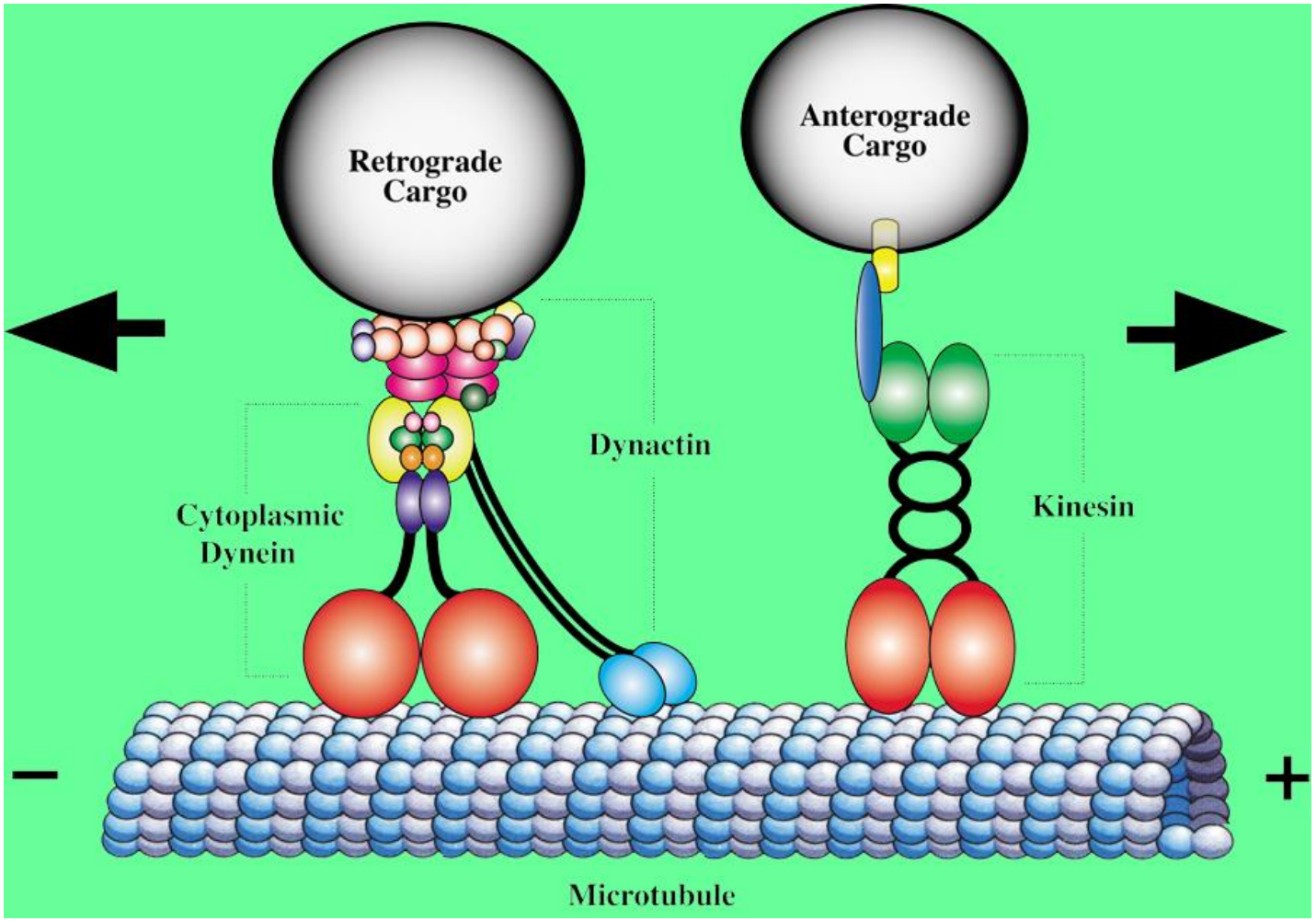
Microtubules and Intracellular Traffic



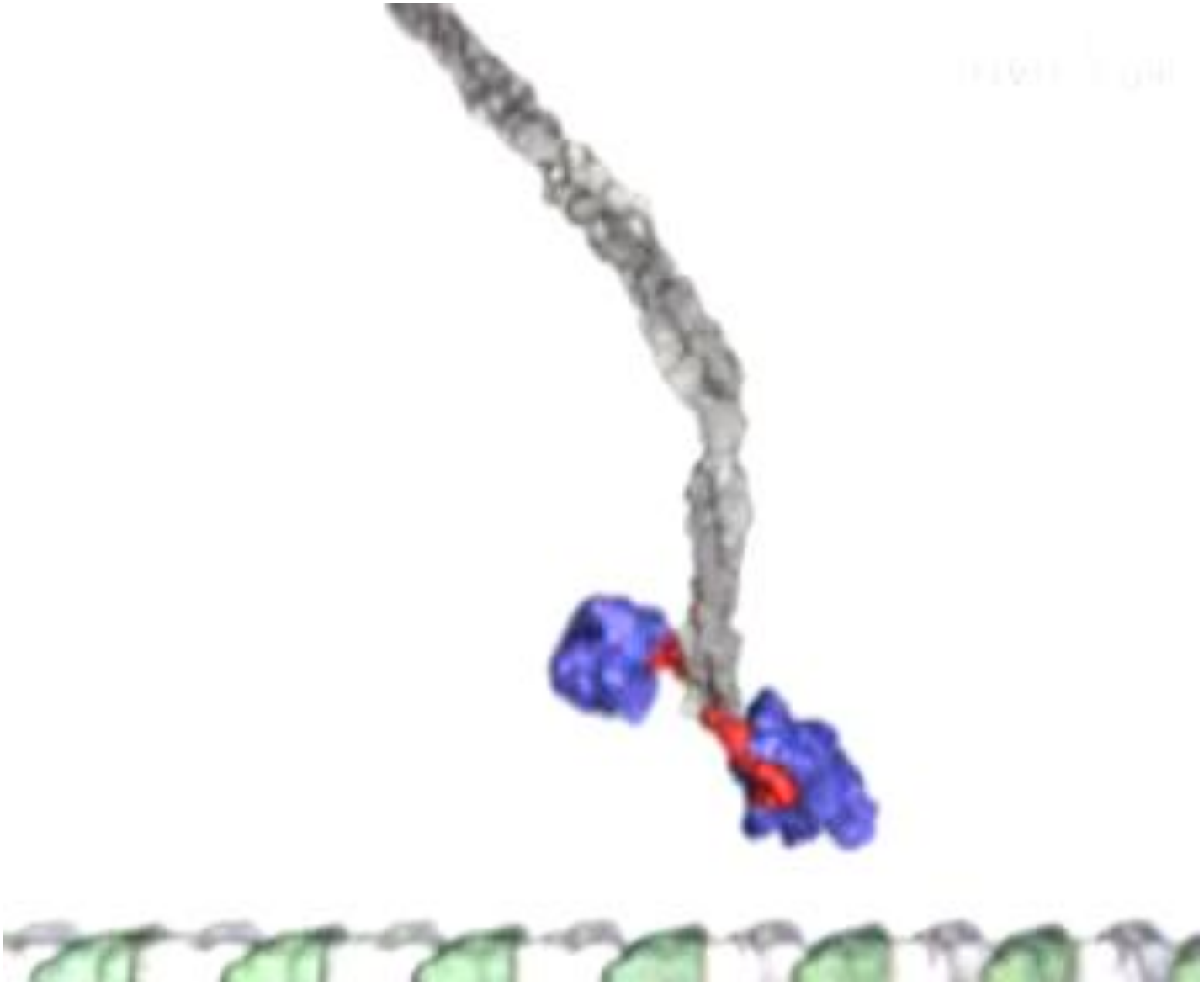
Axonal transport of microtubules



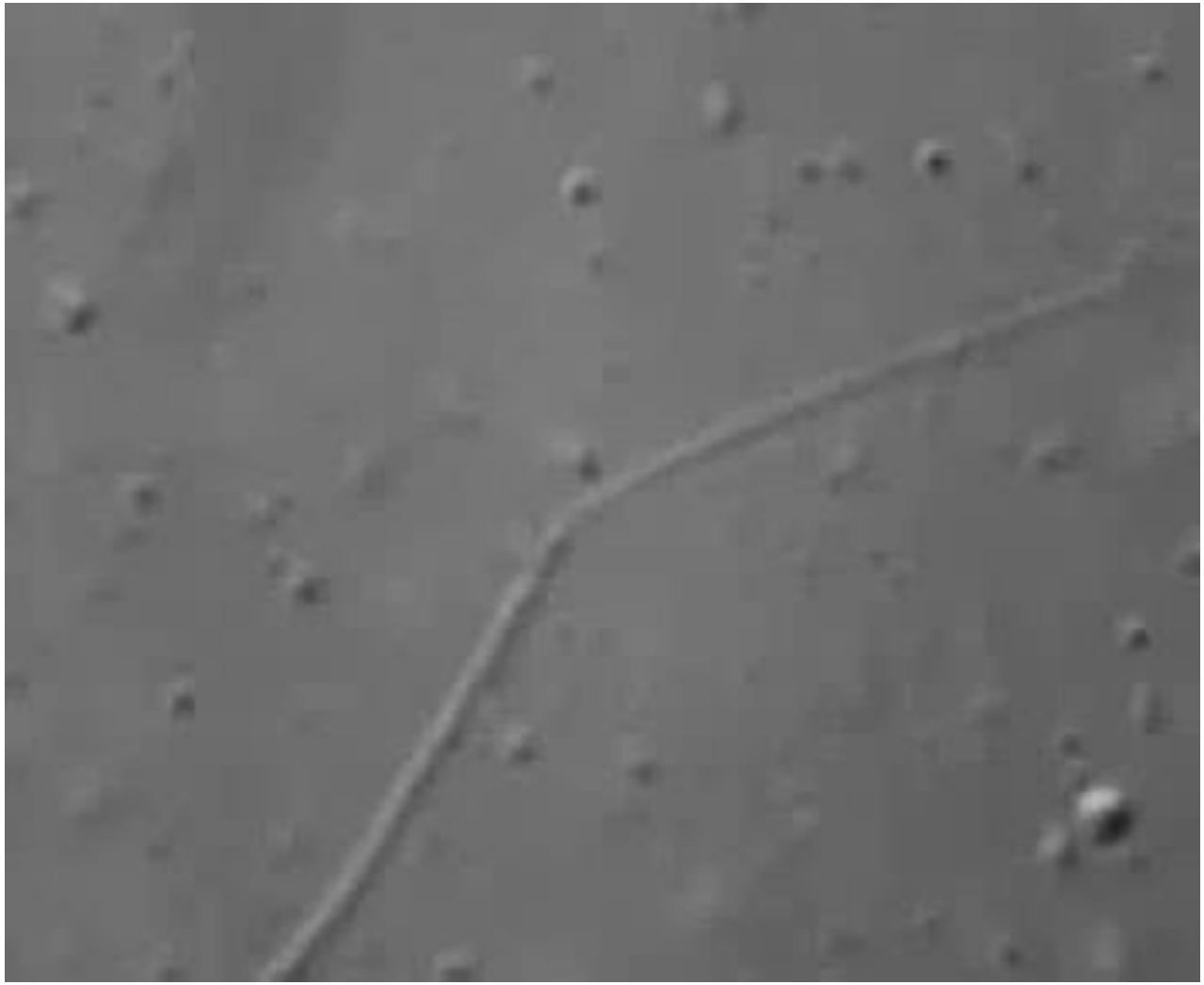
Accessory proteins - transport



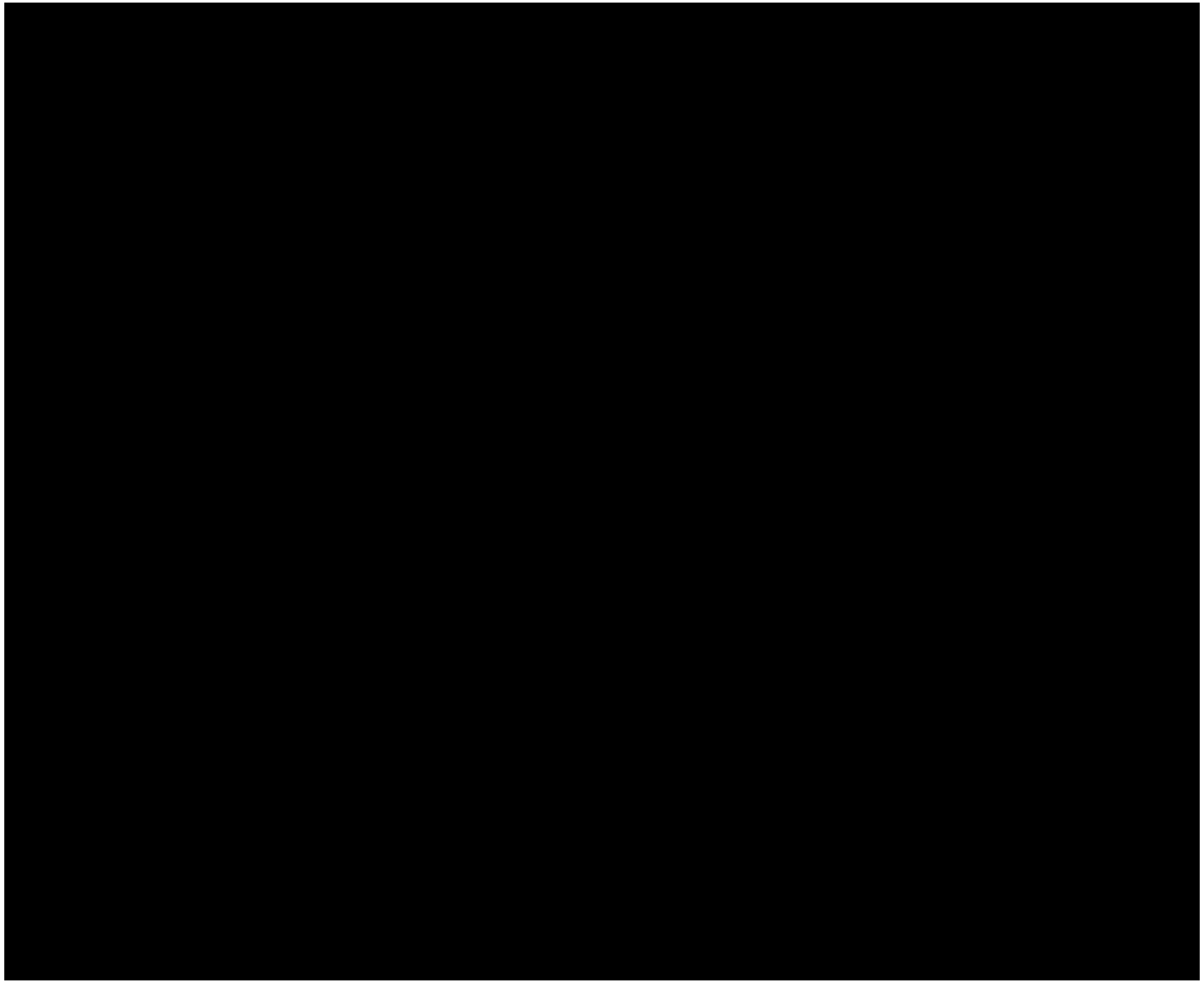
Kinesin



Organelle traffic



MICROTUBULS



ACTIN FILAMENTS

ACTIN FILAMENTS

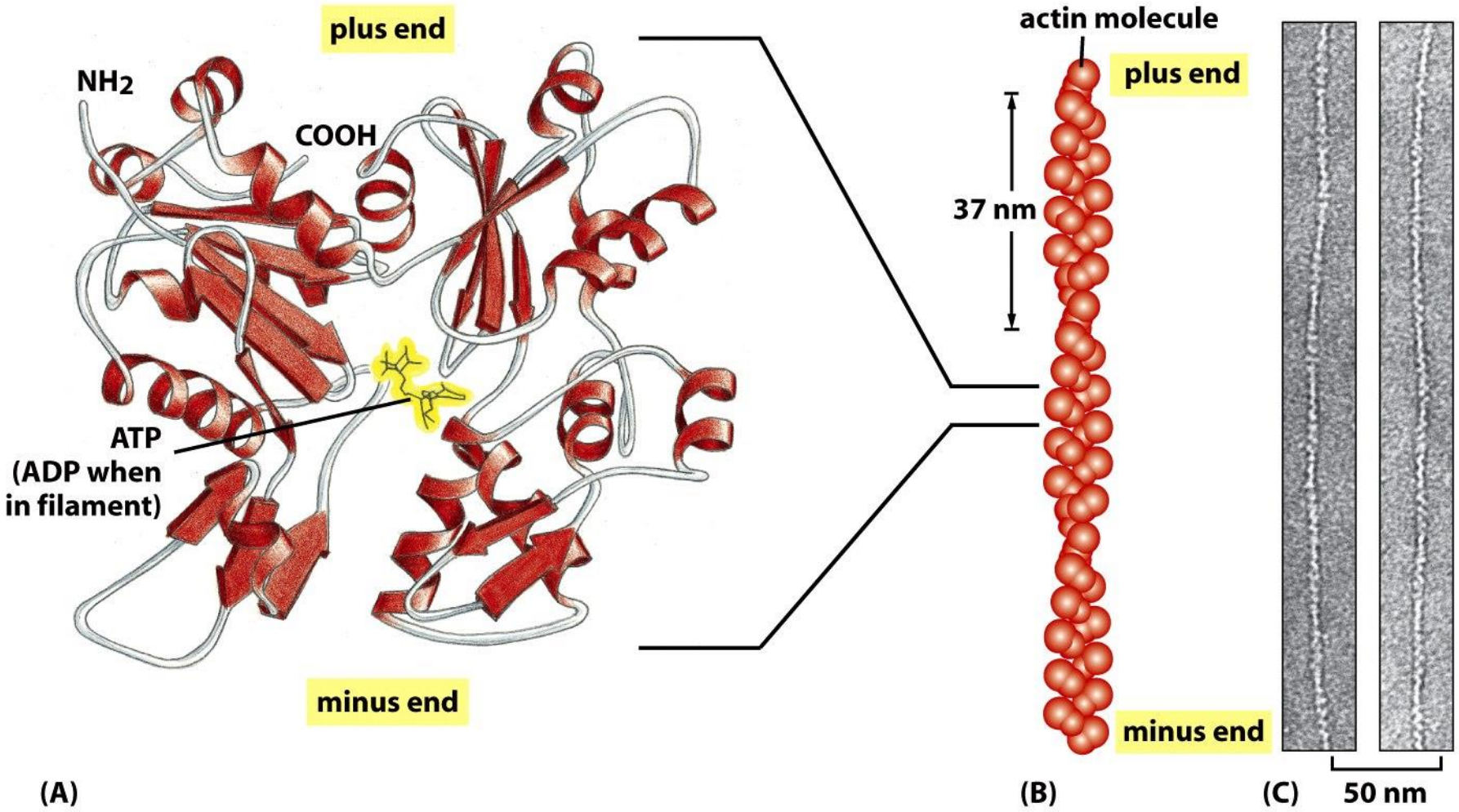
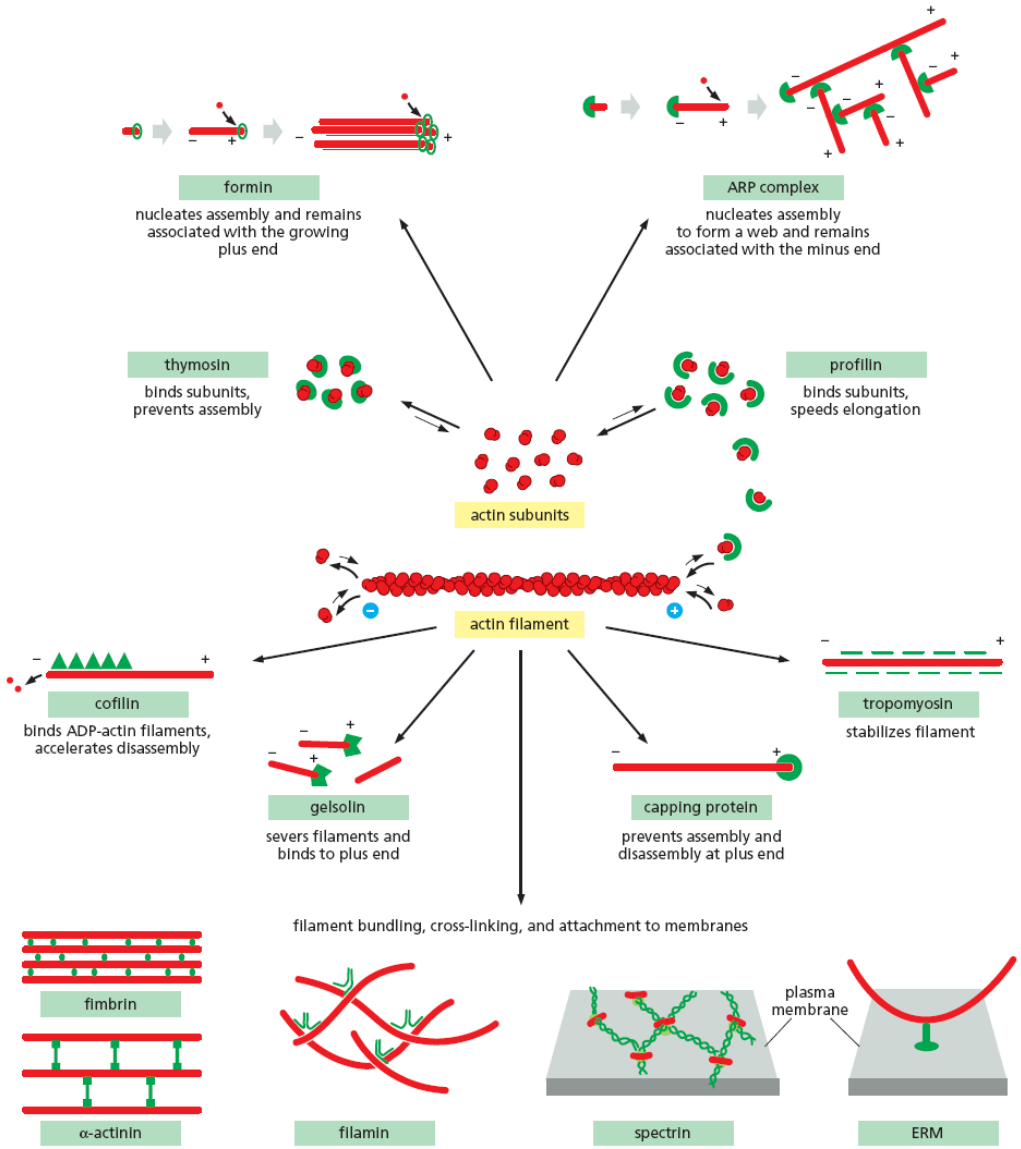


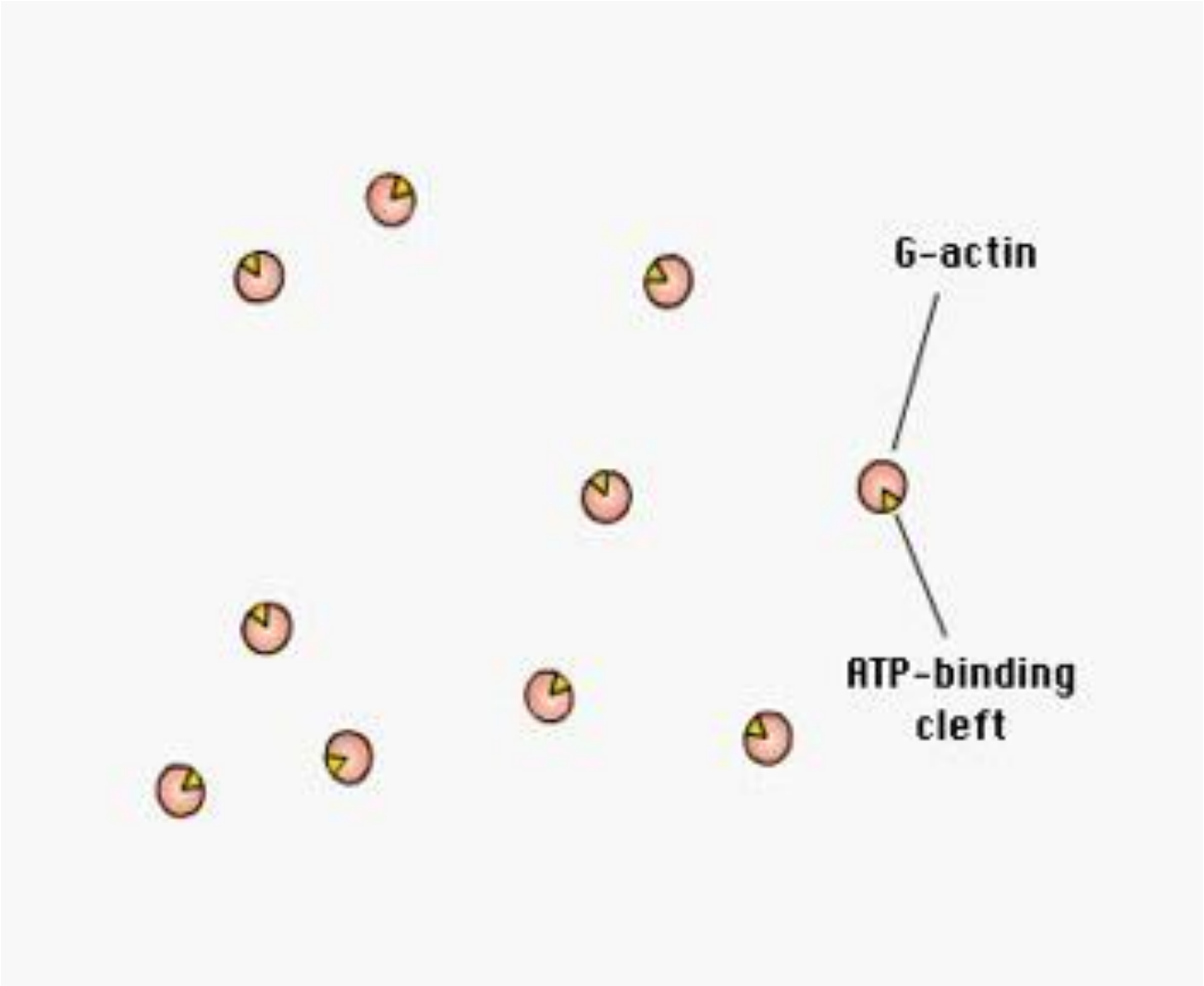
Figure 16-12 *Molecular Biology of the Cell* (© Garland Science 2008)

ACTIN FILAMENTS



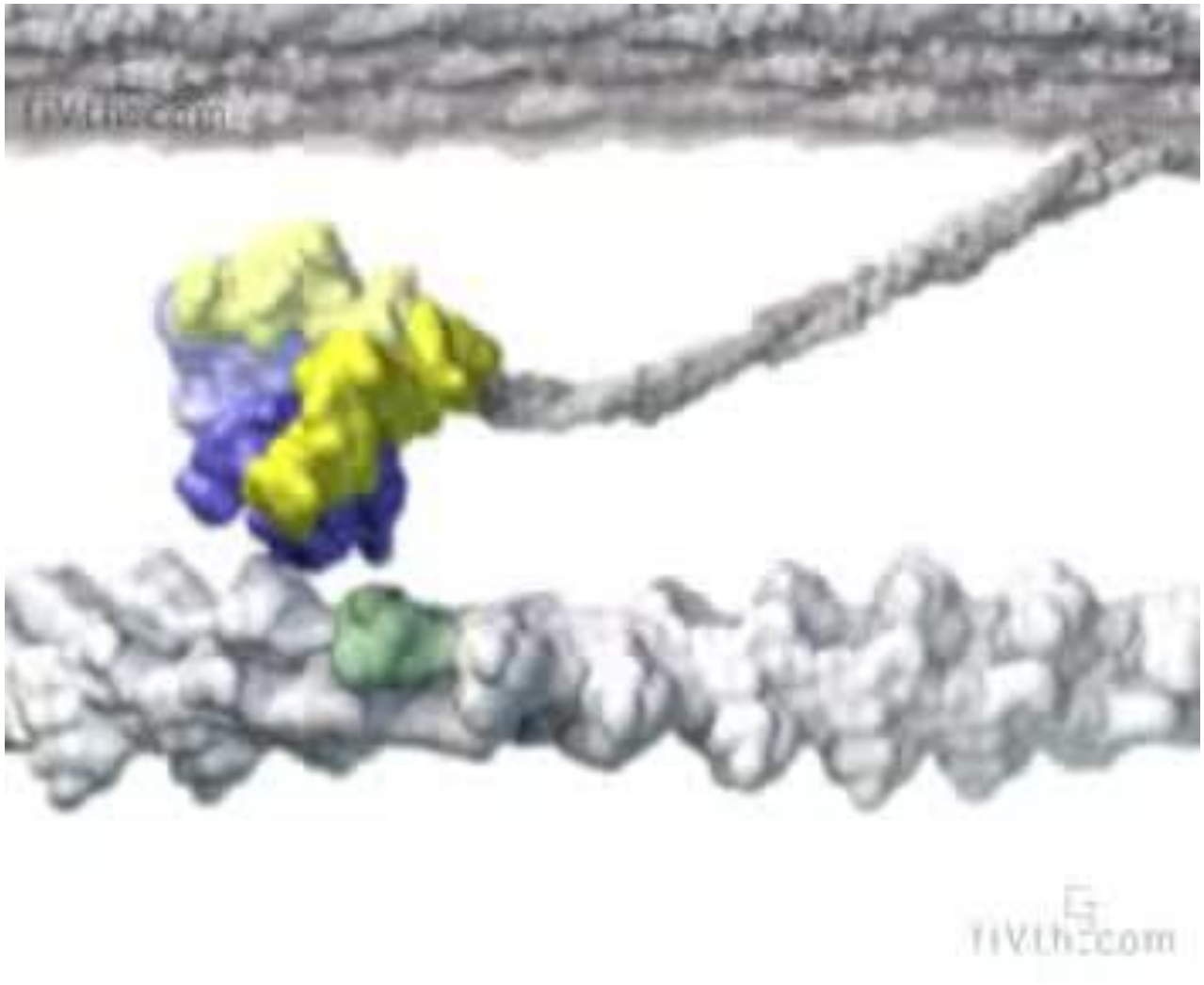
Some of the major accessory proteins of the actin cytoskeleton. Except for the myosin motor proteins, to be discussed in a later section, an example of each major type is shown. Each of these is discussed in the text. However, most cells contain more than a hundred different actin-binding proteins, and it is likely that there are important types of actin-associated proteins that are not yet recognized.

Polymerization of G-actin proteins generates F-actin filaments



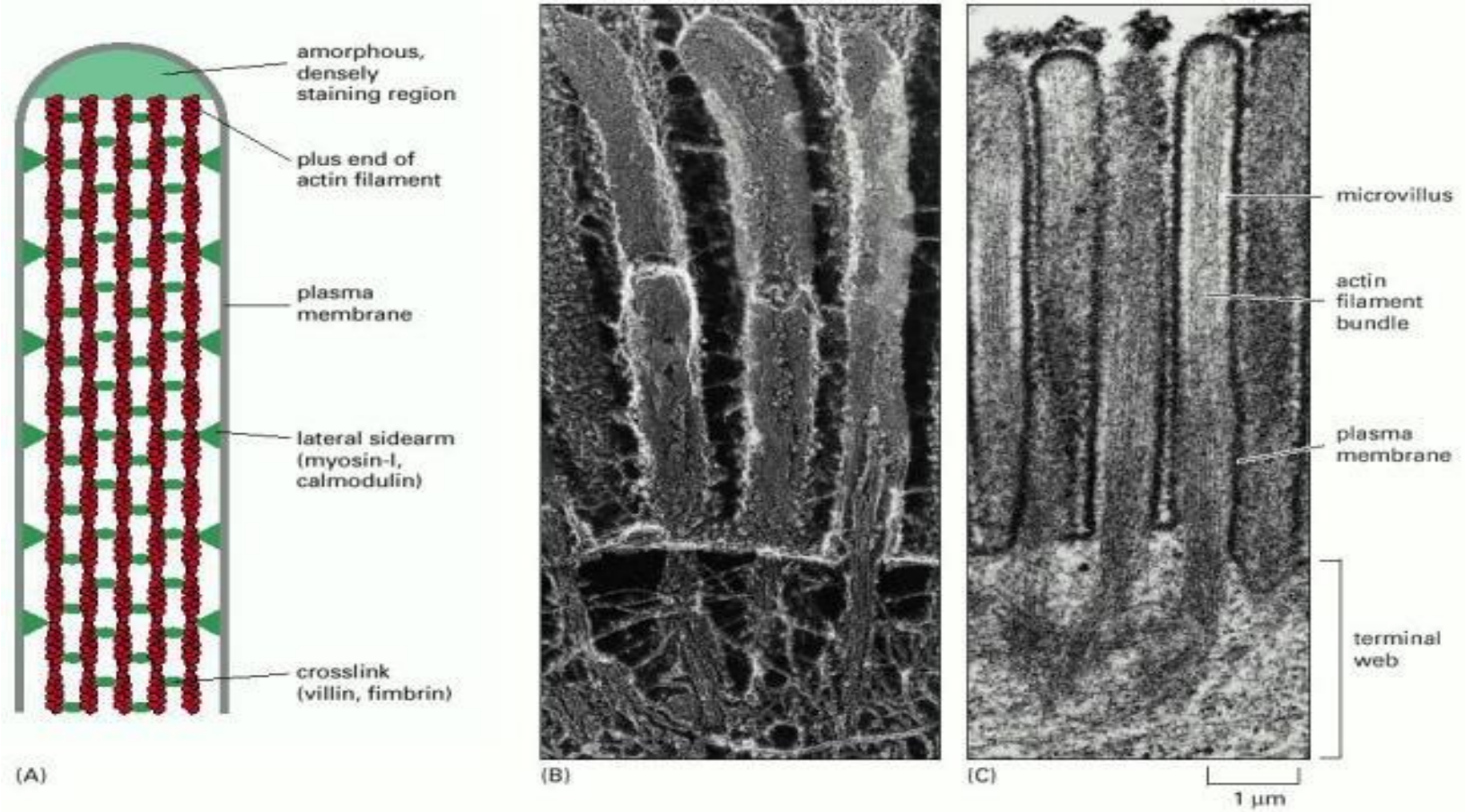
Myosin II – actin fiber interaction

Myosin – accessory (motor protein)



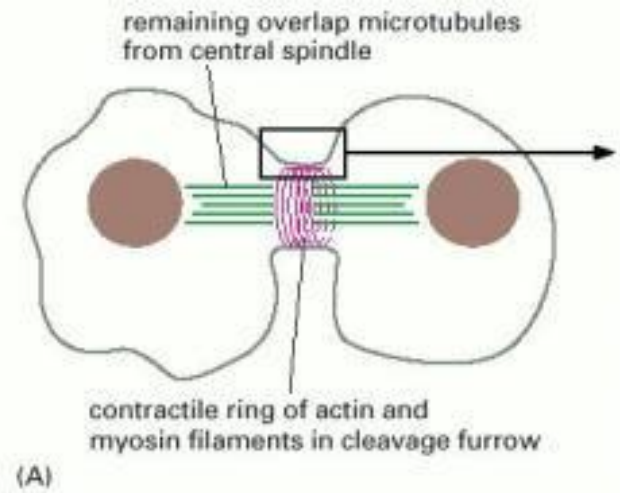
Microvilli and Actin Filaments

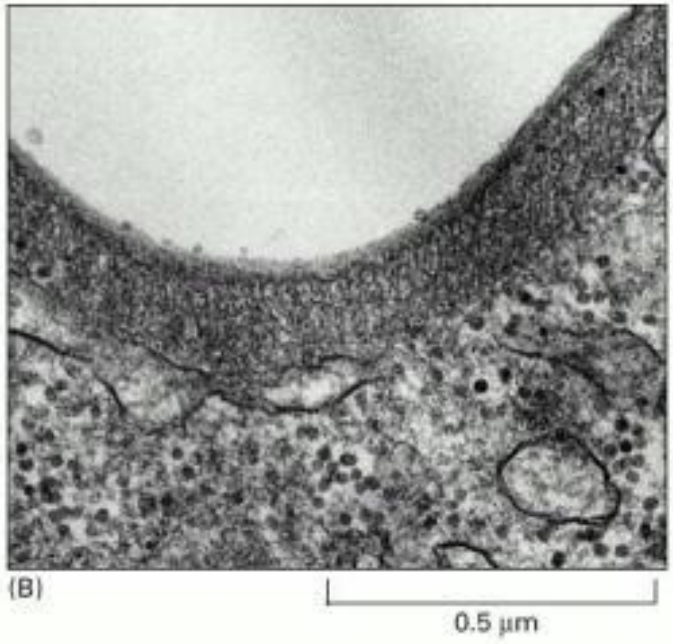
The dense bundle of cross-linked actin filaments - structural core

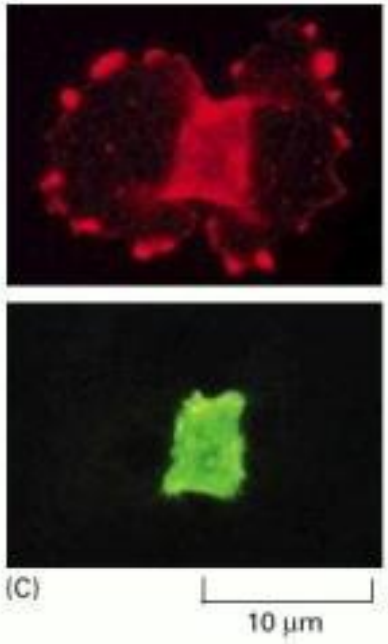


The role of Actin Filaments in Cytokinesis

- the cytokinetic contractile ring -

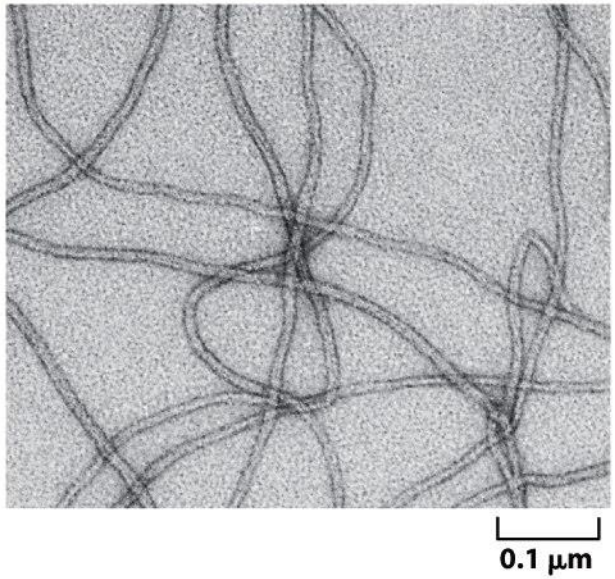


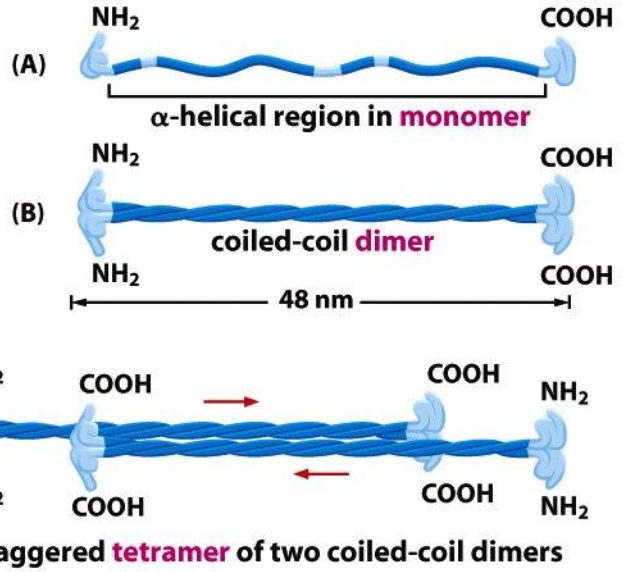




INTERMEDIATE FILAMENTS

INTERMEDIATE FILAMENTS





NO GTP/ATP binding site!!!

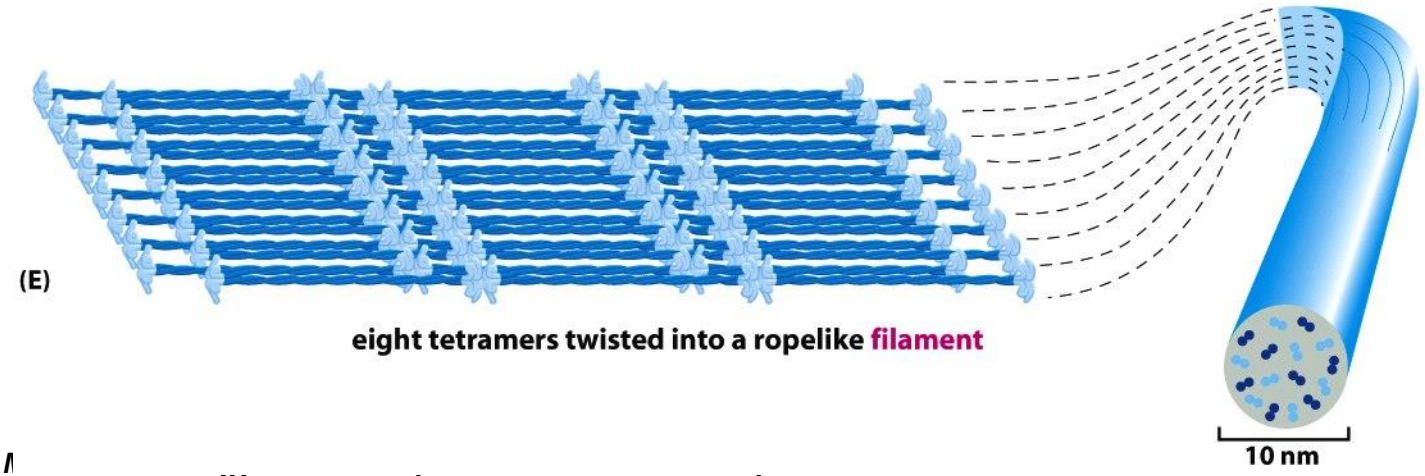


Figure 16-19 M

INTERMEDIATE FILAMENTS

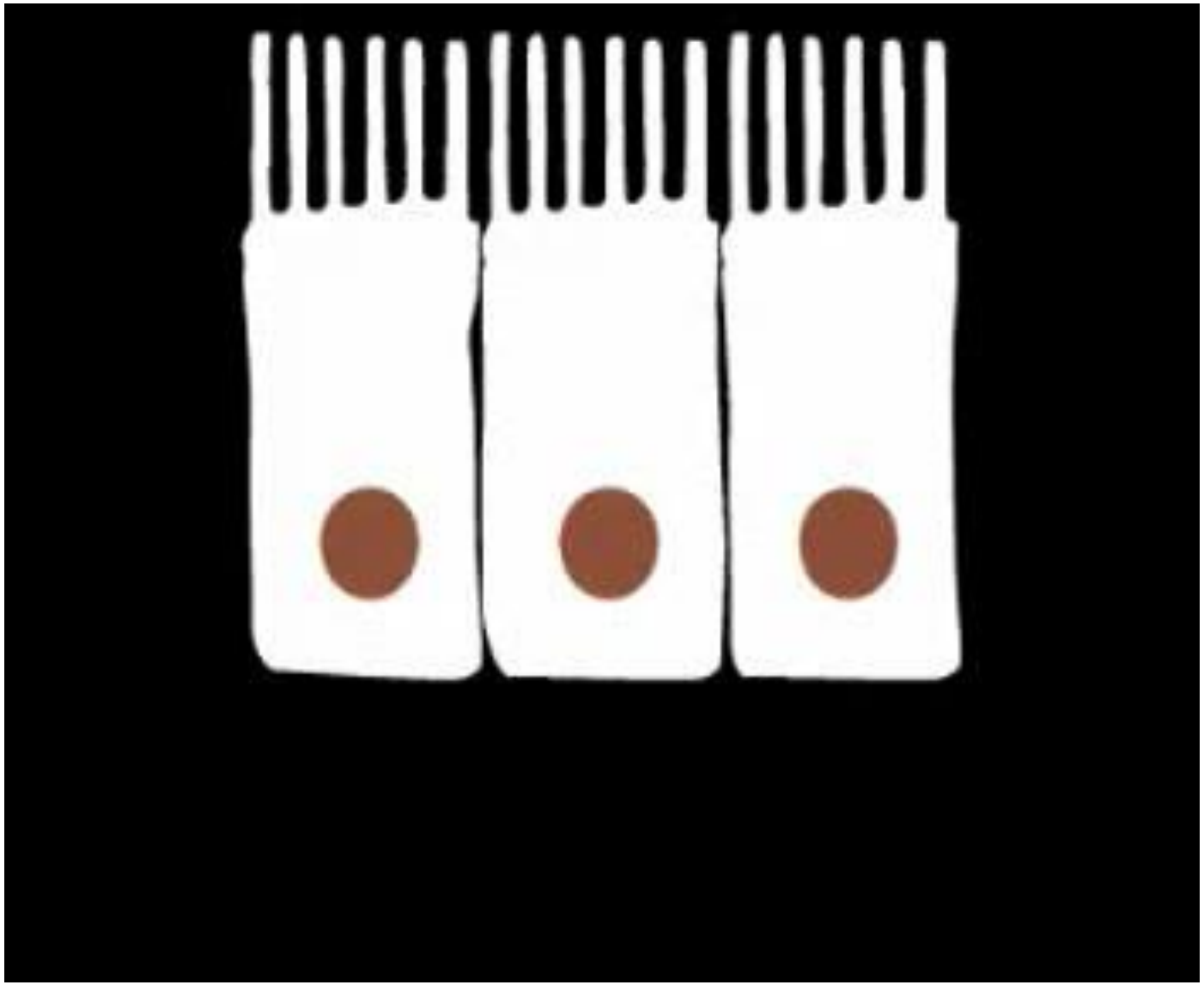
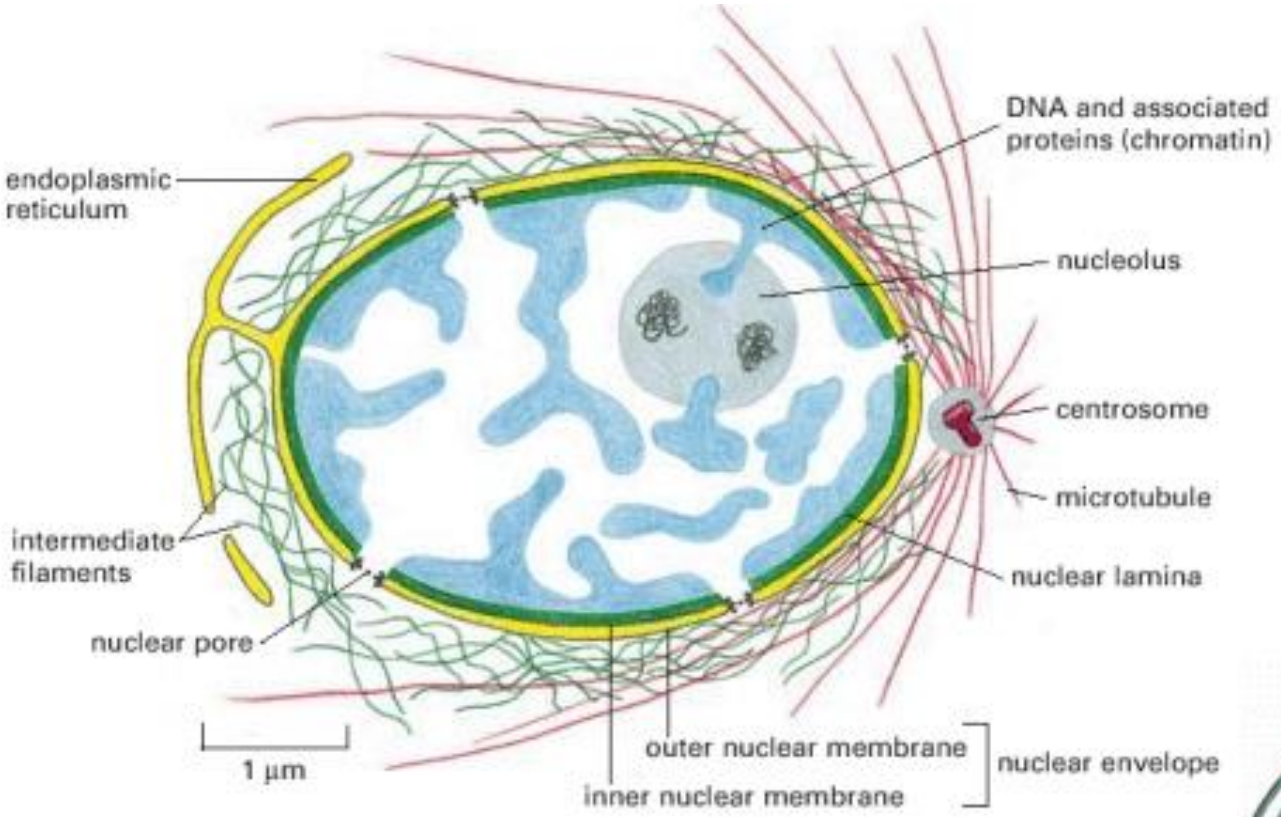
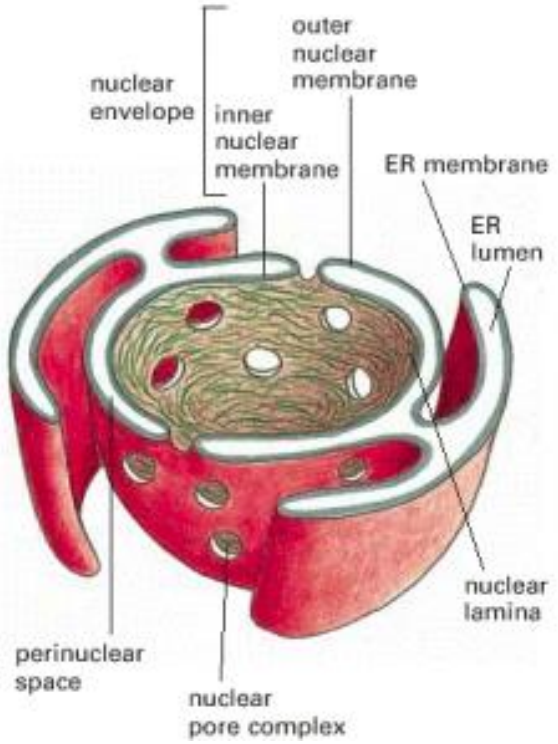


Table 16–1 Major Types of Intermediate Filament Proteins in Vertebrate Cells

TYPES OF IF	COMPONENT POLYPEPTIDES	LOCATION
Nuclear	lamins A, B, and C	nuclear lamina (inner lining of nuclear envelope)
Vimentin-like	vimentin	many cells of mesenchymal origin
	desmin	muscle
	glial fibrillary acidic protein	glial cells (astrocytes and some Schwann cells)
	peripherin	some neurons
Epithelial	type I keratins (acidic)	epithelial cells and their derivatives (e.g., hair and nails)
	type II keratins (basic)	
Axonal	neurofilament proteins (NF-L, NF-M, and NF-H)	neurons

NUCLEAR LAMINA





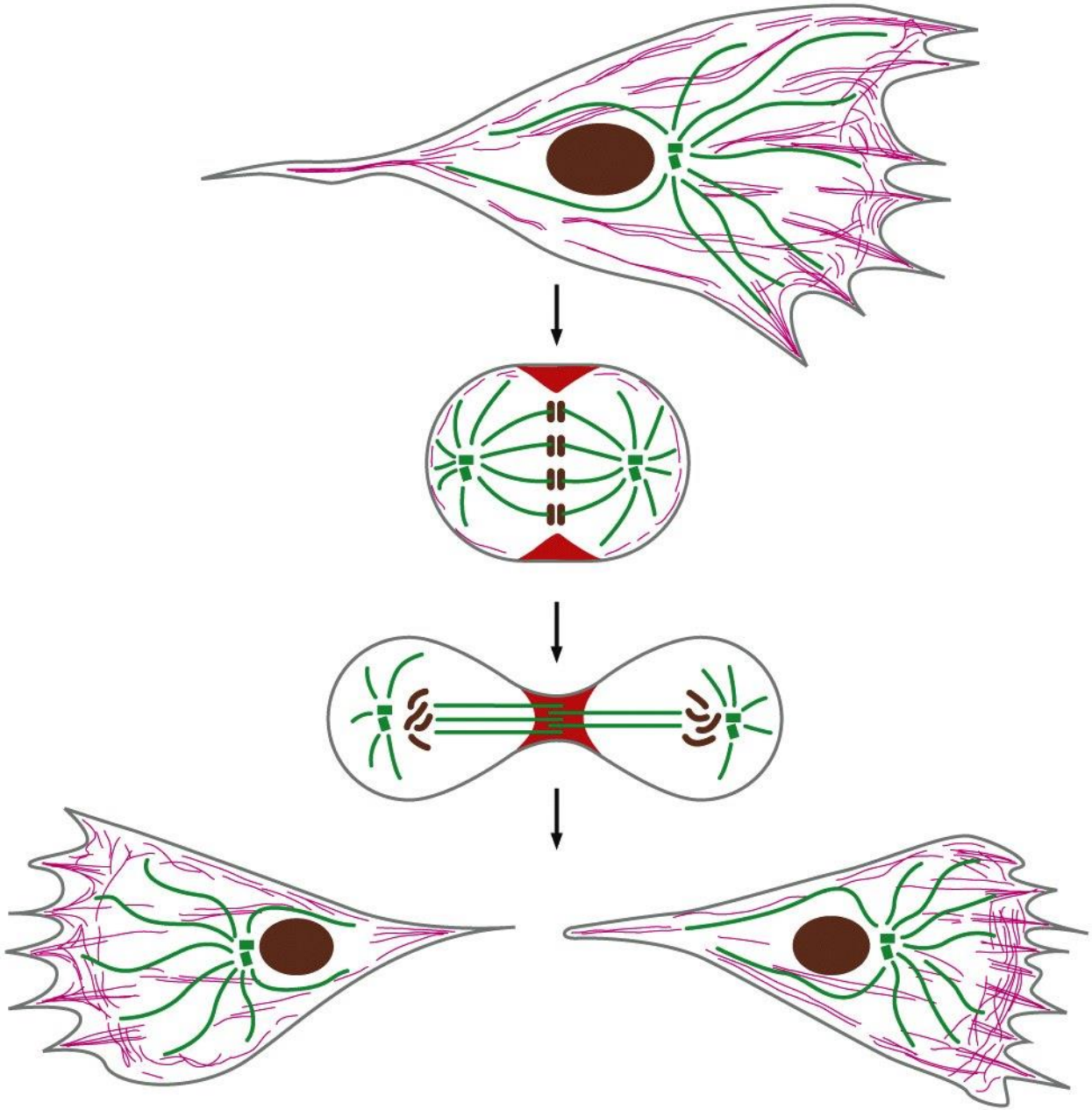


Figure 16-2 *Molecular Biology of the Cell* (© Garland Science 2008)

NUCLEAR LAMINA

- structural scaffold of the nuclear envelope;
- well known for its central role in nuclear organization and maintaining nuclear stability and shape..