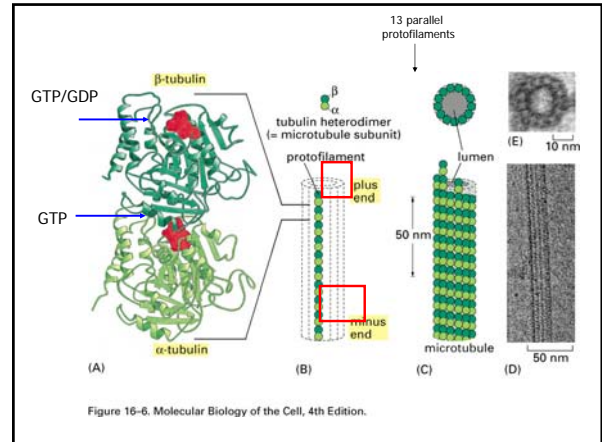


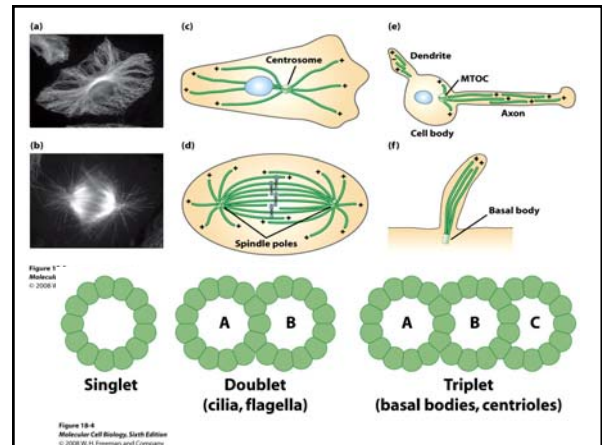
## Chapters 17 and 18

- Introduction: The building blocks of the cytoskeleton
- Actin, actin dynamics, and actin-binding proteins
- Intermediate filaments
- Myosins motor proteins
- Myosins-powered movements
- Actin-directed movement
- Cell migration
- **Microtubules**
- **Kinesins and dyneins; structure and function**
- **Mitosis**

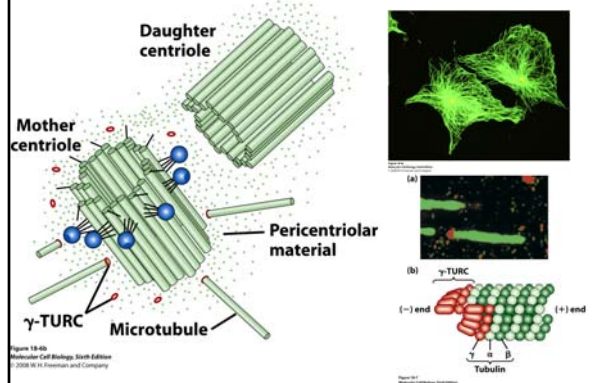


## Tubulin

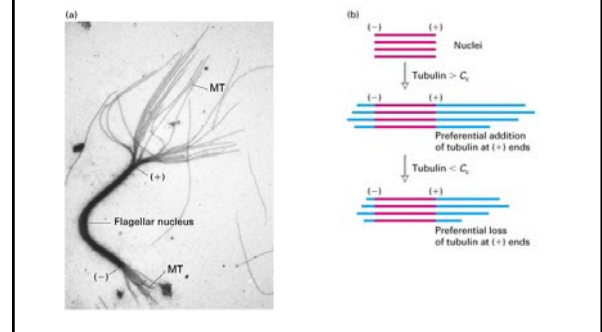
- A dimer of one alpha and one beta subunit, each about 55 kDa in size.
- In mammals at least 6 alpha and 6 beta isoforms have been identified
- The proteins are highly conserved (75% homology between yeast and human)
- Most variability is found in the C-terminal region of the molecules and is likely to affect interactions with accessory proteins
- A tubulin homologue, FtsZ, is expressed in prokaryotes

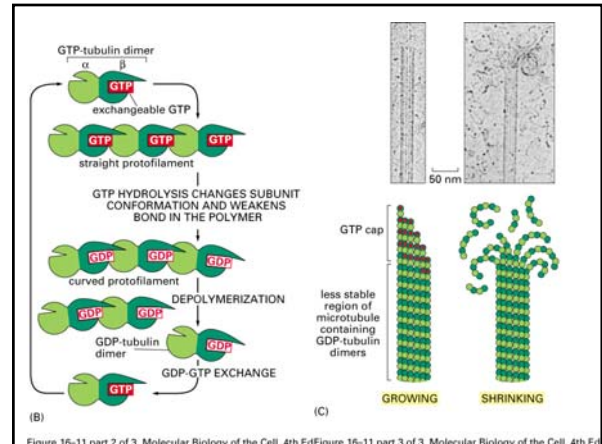
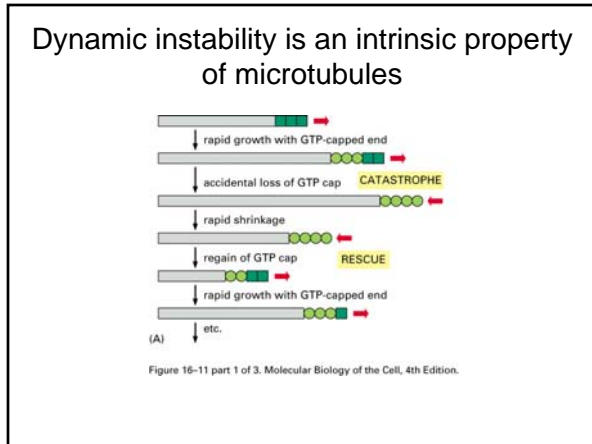
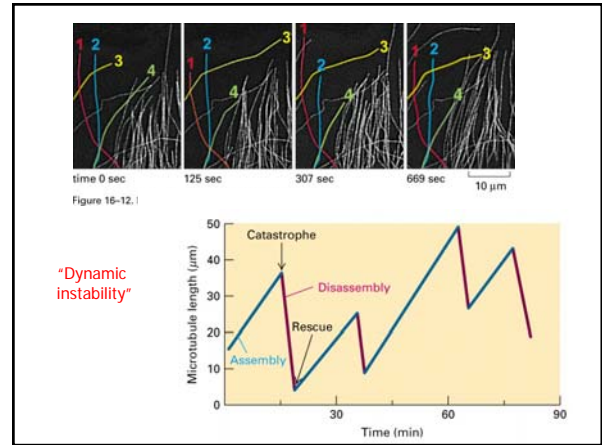
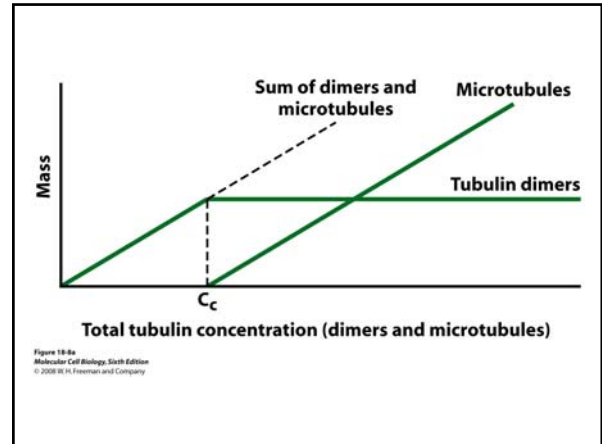
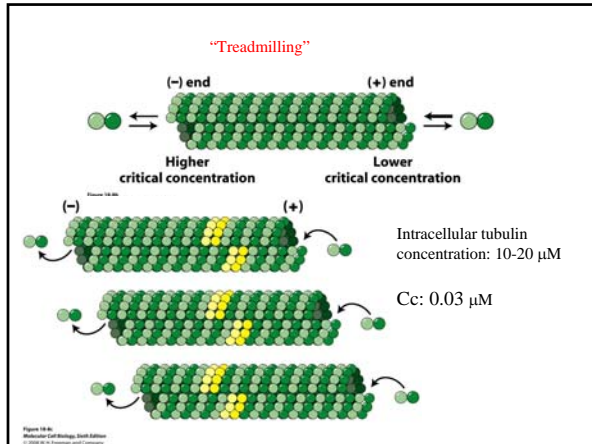


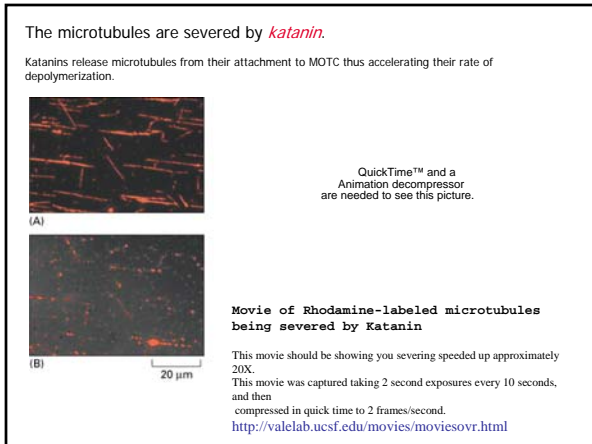
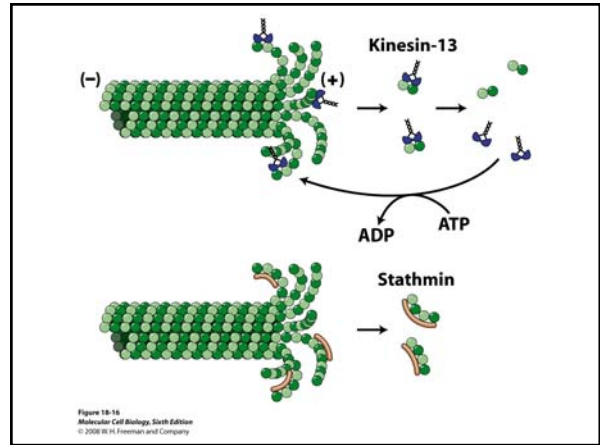
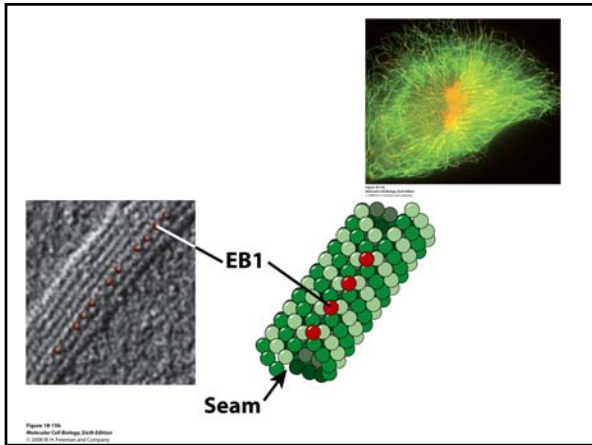
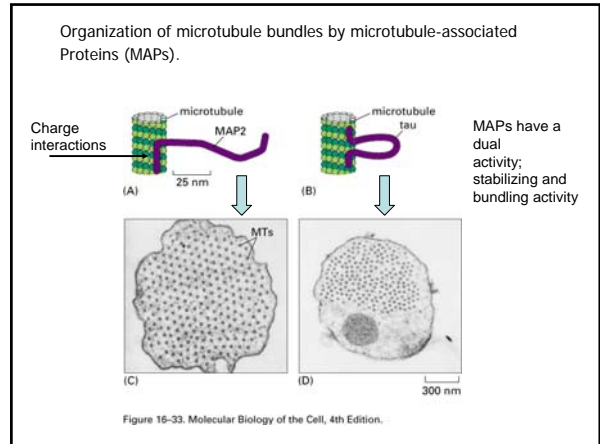
## Centrosomes and the $\gamma$ -tubulin ring complex



## Microtubule assembly and disassembly occur preferentially at the (+) end





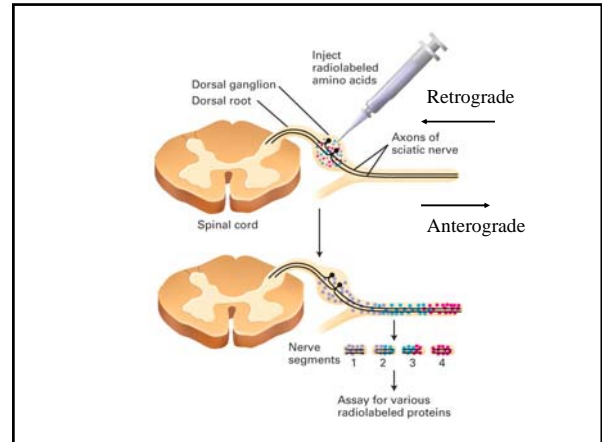


microfilaments regulatory proteins	microtubules regulatory proteins
<ul style="list-style-type: none"> <li><b>G-actin binding proteins</b> Thymosin <math>\beta_4</math> (inhibits polymerization) Profilin (accelerates polymerization)</li> <li><b>Capping proteins</b> Cap Z (+) Tropomodulin (-)</li> <li><b>Severing proteins</b> Gelsolin (severs and caps (+) ends) ADF (actin depolymerizing factor); cofilin</li> </ul>	<ul style="list-style-type: none"> <li><b>Stabilizing proteins</b> MAPs (phosphorylated MAPs do not bind to microtubules) Tip proteins</li> <li><b>Destabilizing proteins</b> kinesin-13 (+) stathmin (+) katanin (-)</li> </ul>
<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <math>PIP_2</math> <math>Ca^{+2}</math> </div>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">phosphorylation</div>

**Motor proteins** are enzymes that couple the hydrolysis of **ATP** to a conformational change

**Myosins**: Motor proteins that 'walk' along actin filaments

**Kinesin** and **dynein**: Motor proteins that 'walk' along microtubules



QuickTime™ and a Sorenson Video 3 decompressor are needed to see this picture.

Cell extract is added to a preparation of microtubules. Motor proteins are bound to vesicles, and upon addition of ATP, bind to the microtubules. Vesicles are bound to kinesin, dynein, or both, which explains the ability of a single vesicle to move in both directions.

### The structure of kinesin-1 microtubule motor protein

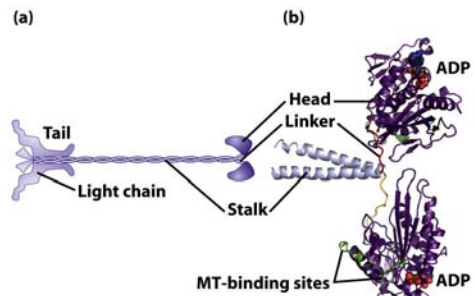


Figure 18-18 Molecular Cell Biology, Sixth Edition

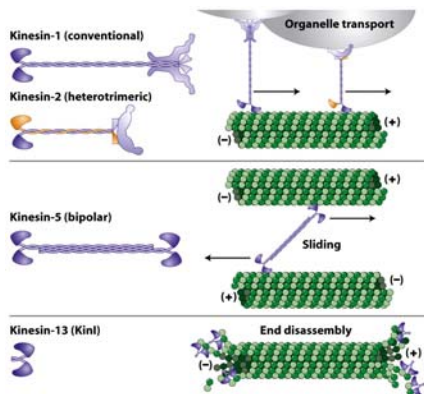
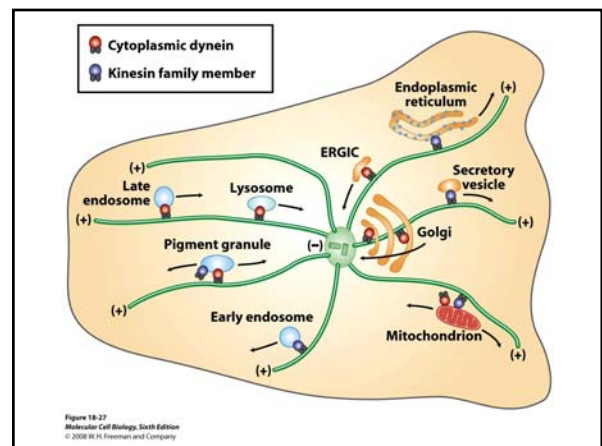
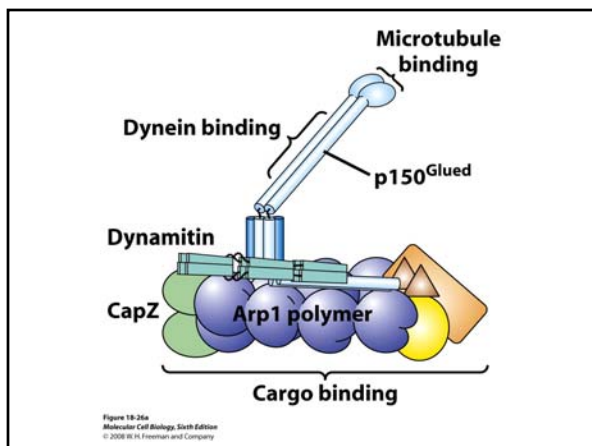
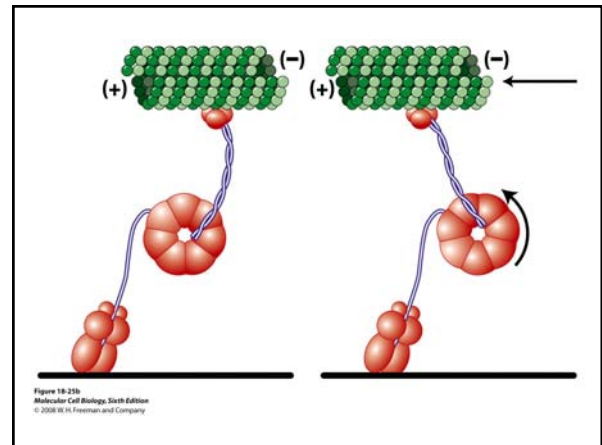
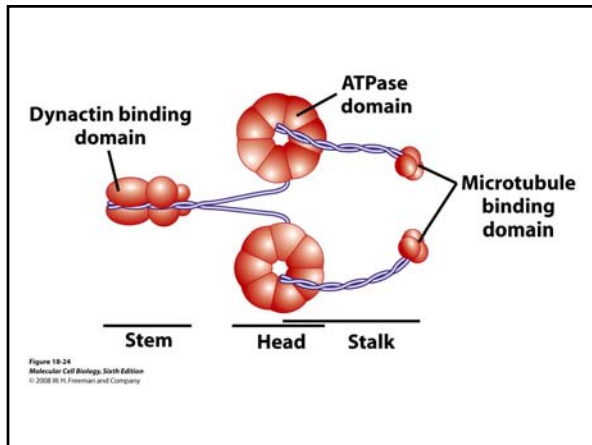
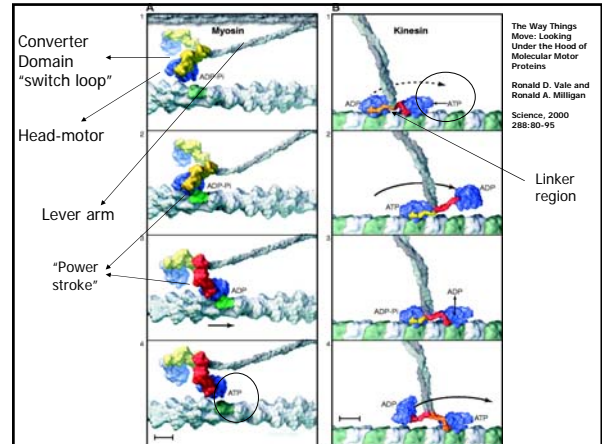
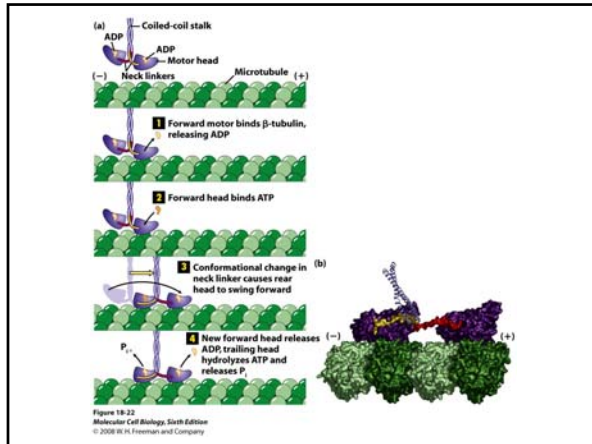
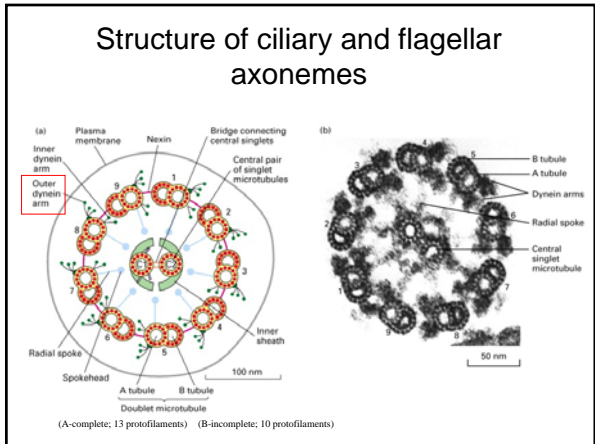
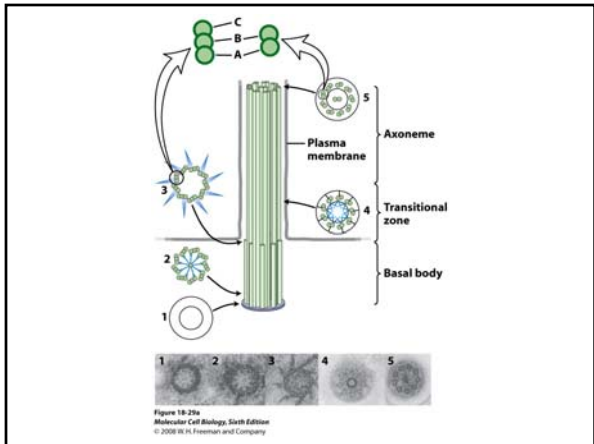
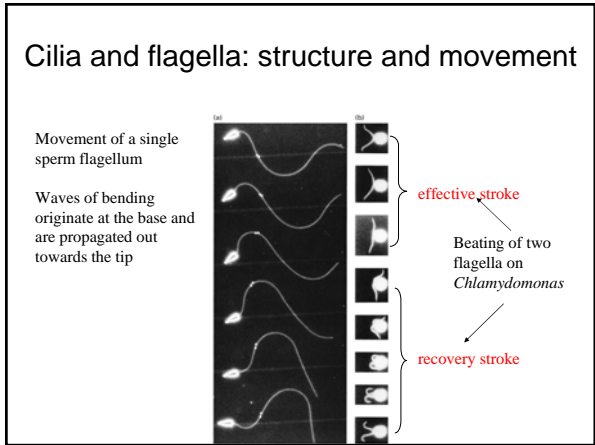
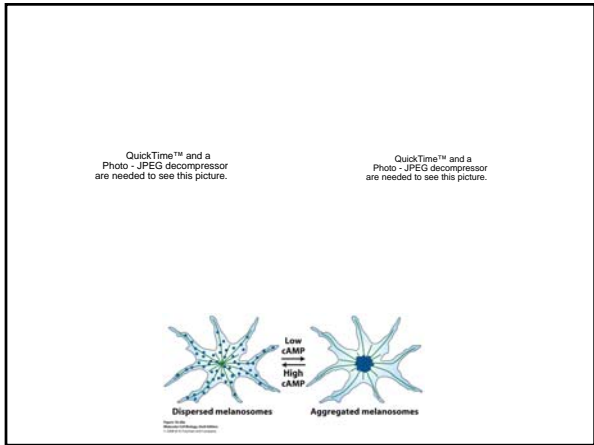
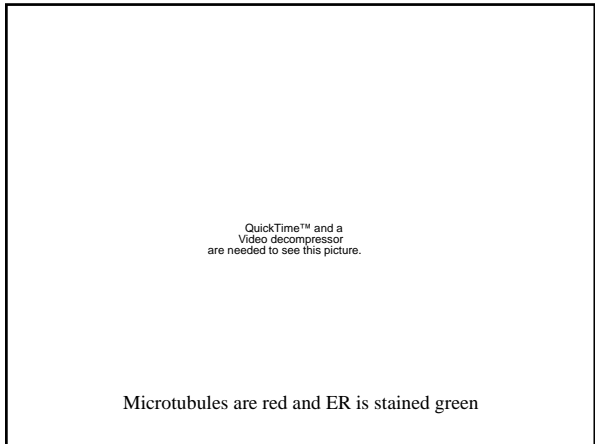
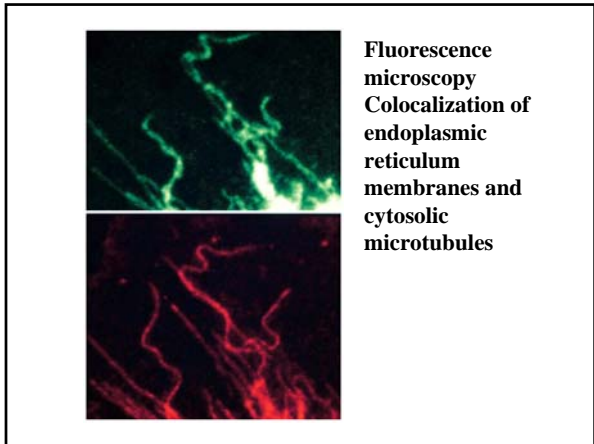


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### The movement of kinesin along microtubules

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Axonemal dyneins are multiheaded motor proteins

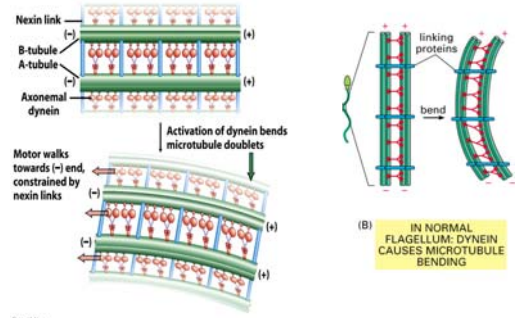
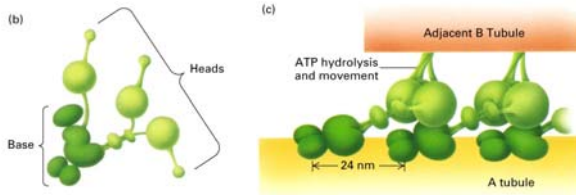


Figure 19-21c  
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Nexin links removed by protease

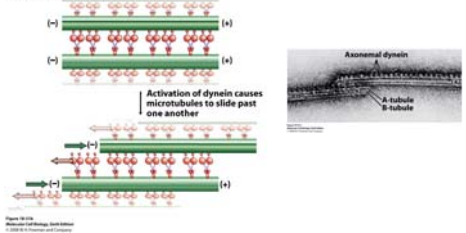


Figure 19-21d  
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Microtubule dynamics and motor proteins in mitosis

19.5 The stages of mitosis and cytokinesis in an animal cell

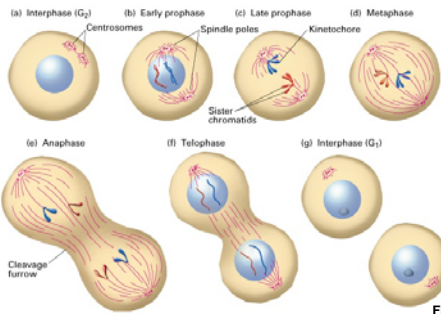


Figure 19-34

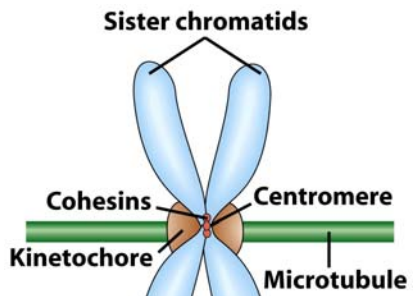
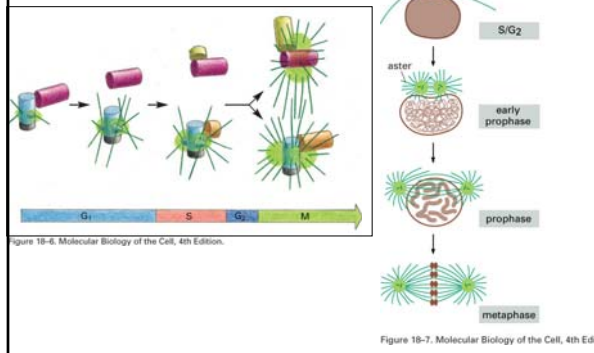
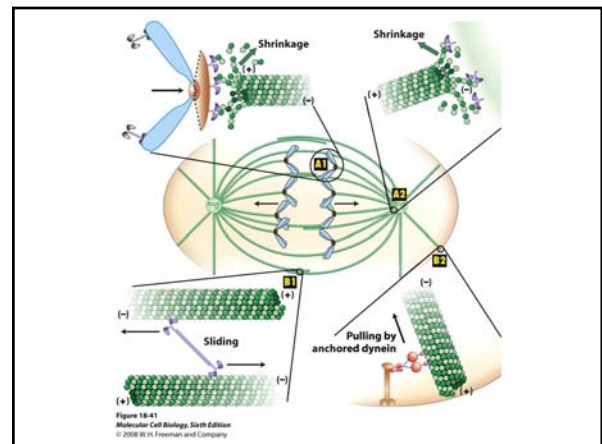
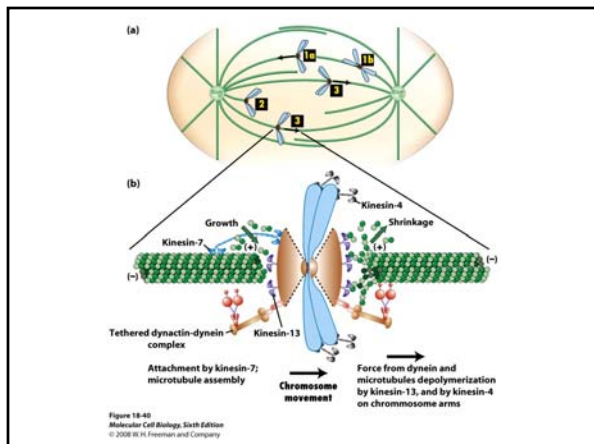
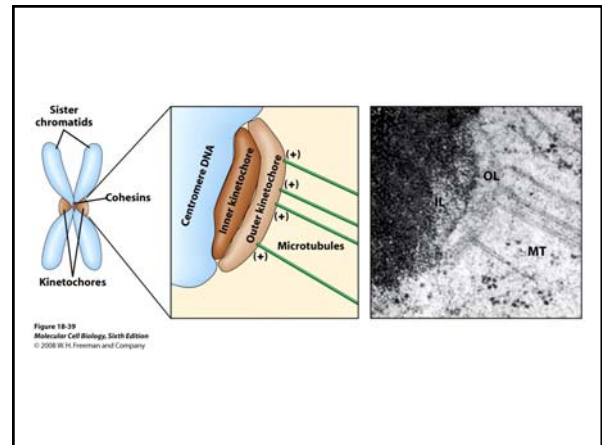
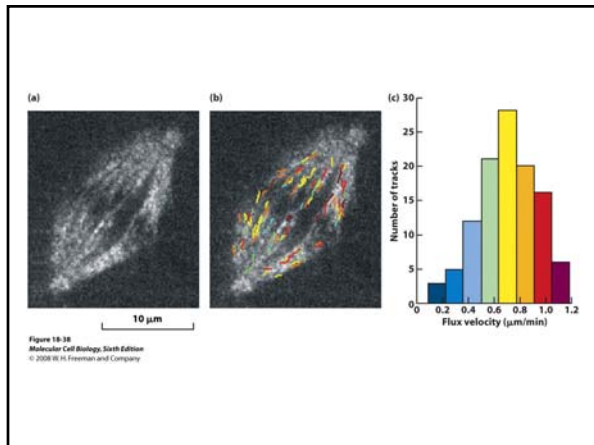
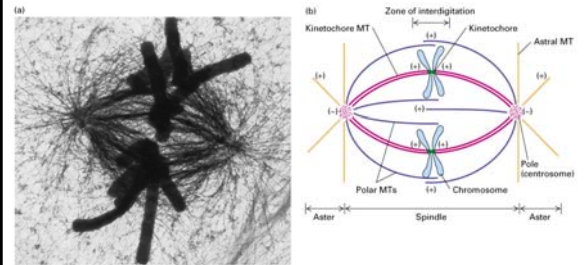


Figure 19-34b  
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## 19.5 Centrosome duplication is required for mitosis



## The mitotic apparatus in a metaphase mammalian cell



## Drugs that affect the microtubules dynamics

- Colchicine: Binds to tubulin dimers. Causes microtubules depolymerization. At a low concentration colchicine binds to the growing end of microtubules and prevents mitotic spindle formation.
- Taxol and vinblastine: bind to microtubules and prevents their depolymerization. Cells remain arrested at metaphase.

QuickTime™ and a Microsoft Video 1 decompressor are needed to see this picture.

**Induction of Cytokinesis Is Independent of Precisely Regulated Microtubule Dynamics**  
Mol. Biol. Cell Strickland et al. 16: 4485 October 2005)

• **Supplemental Movie 01** - Confocal time-lapse of an egg microinjected with GFP-EB1 and imaged through mitosis and cytokinesis. The structure and dynamics of the spindle and asters are visible. At anaphase onset, the asters abruptly undergo elongation in all directions. The movie represents 35 minutes of time-lapse acquisition with frames captured every 30 seconds and presented at a rate of 10 frames per second.

QuickTime™ and a Microsoft Video 1 decompressor are needed to see this picture.

**Supplemental Movie 02** - Confocal time-lapse of GFP-EB1 in a taxol-treated egg. The mitotic apparatus is very dense with microtubules. Multiple cyasters appear to polymerize in the equatorial cortex, and some become incorporated into the mitotic apparatus. While the spindle elongates during anaphase, no cleavage furrow is formed. Some contractility is observed at sites of cortical microtubule polymerization. Telophase occurs and the cell becomes binucleate due to failure of cytokinesis. The movie represents 25 minutes of time-lapse acquisition with frames captured every 30 seconds and presented at a rate of 10 frames per second.

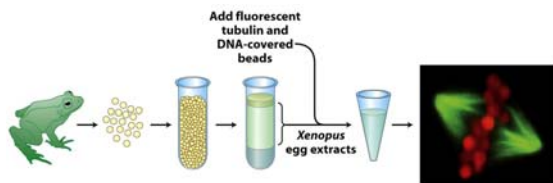


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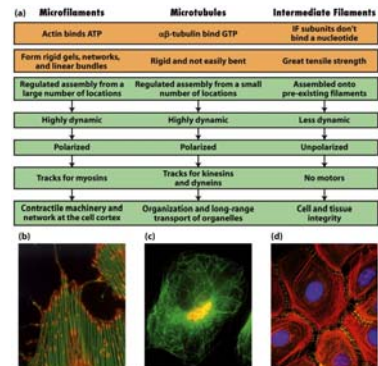


Figure 18-1  
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