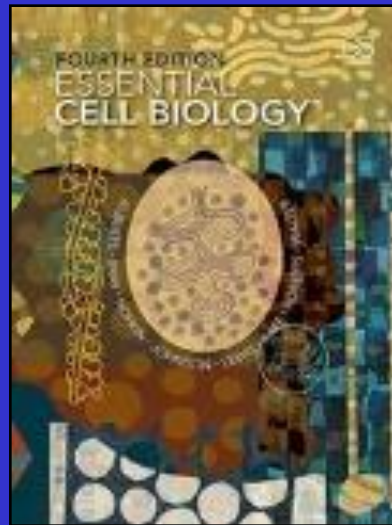
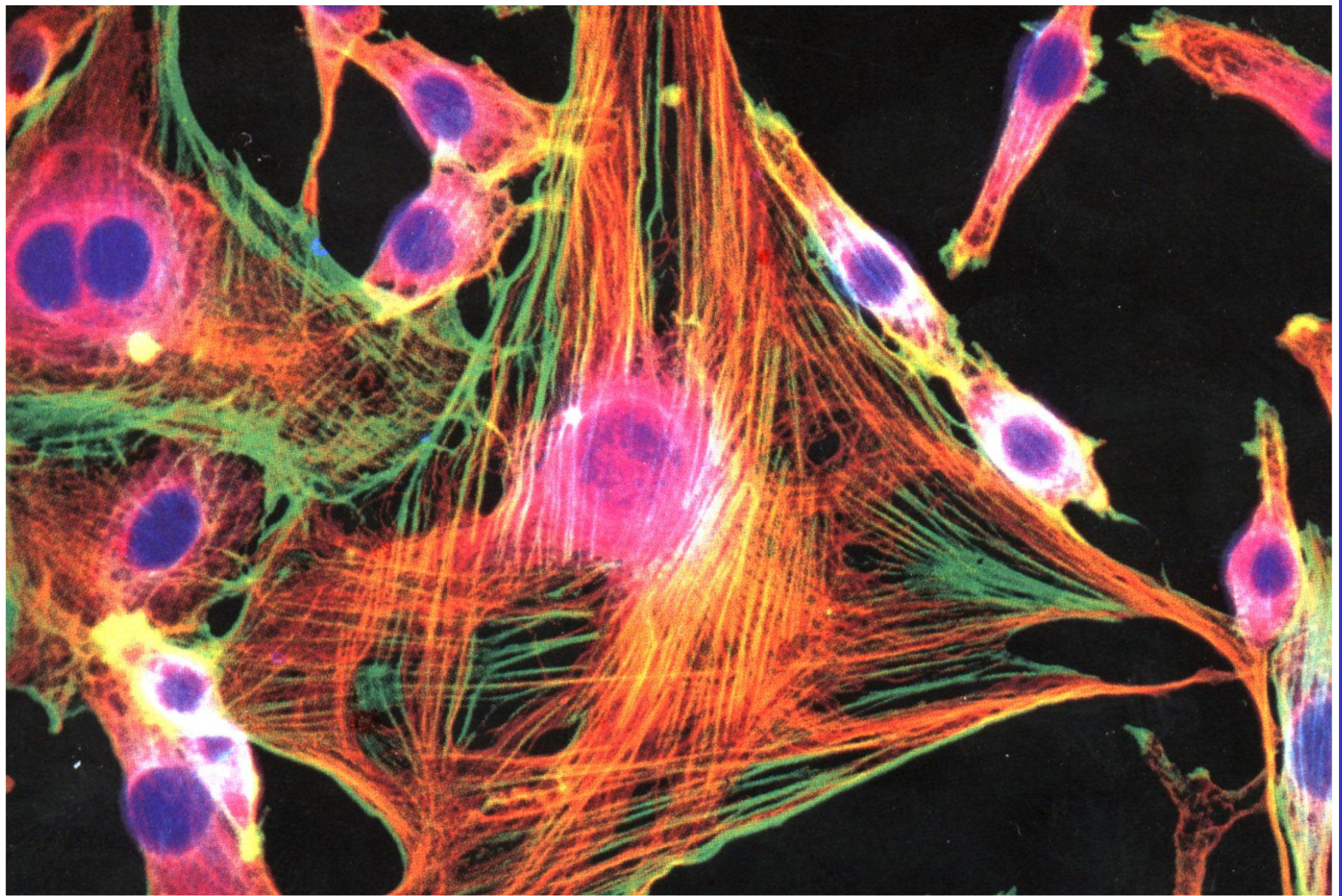


Lecture 20: The Cytoskeleton: Intermediate Filaments and Microtubules



**Essential
Cell Biology**
Fourth Edition
Chapter 17

The Cytoskeleton Includes Dynamic Networks Of Microfilaments And Microfilaments



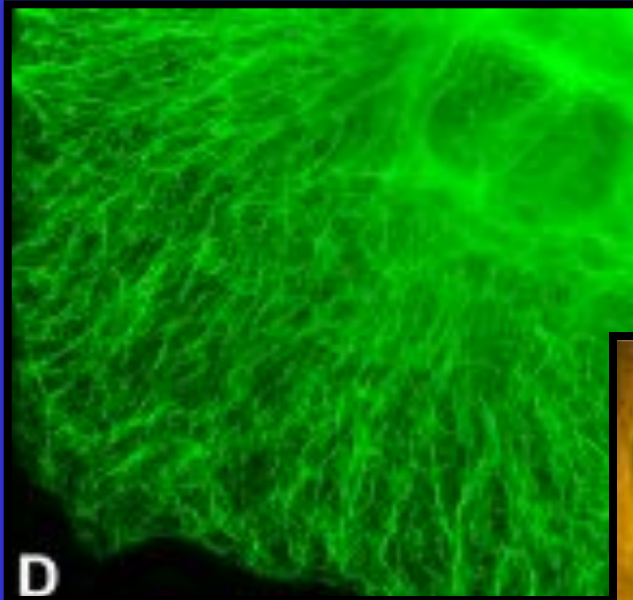
The cytoskeleton consists of three major types of filaments plus many filament-associated proteins including molecular motors

Microfilaments – composed of actin, these filaments form dynamic networks that form the basis for cell shape and movement

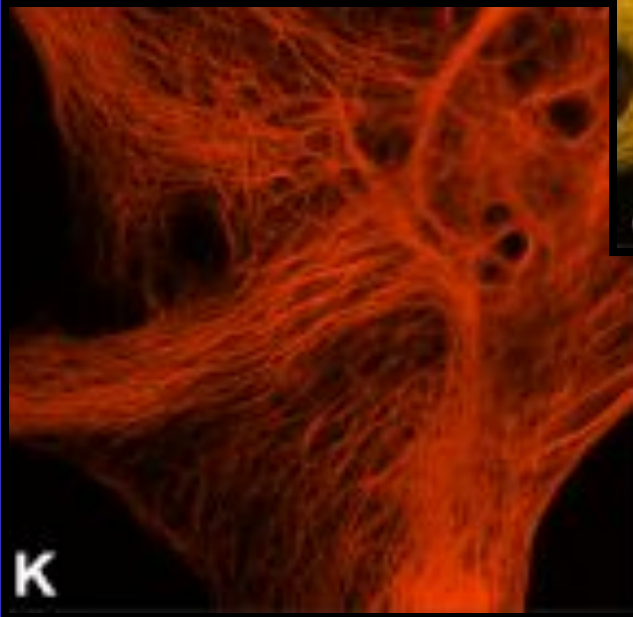
Microtubules – composed of tubulin, these tubules act as tracks on which to move vesicles and organelles. They also form the basis of cilia and flagella. They are dynamic.

Intermediate filaments – composed of proteins that associate to form rope-like structures that are of high mechanical strength. They position organelles and form a strong, long lasting cell superstructure.

KERITAN – INTERMEDIATE FIL.

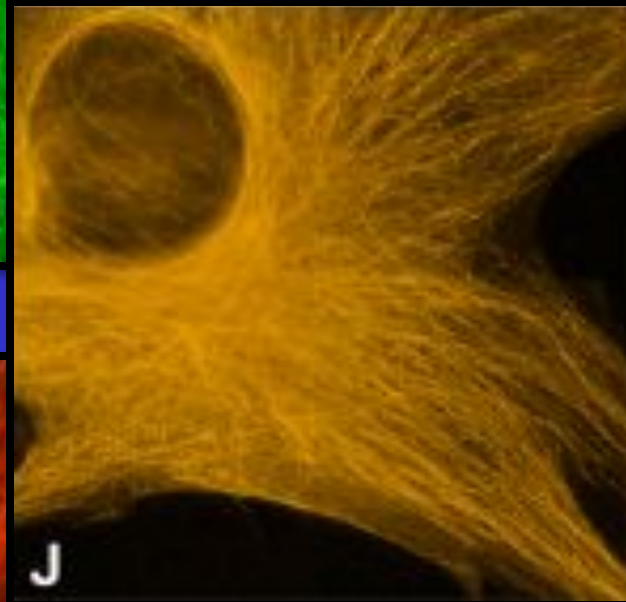


VIMENTIN – INTERMEDIATE

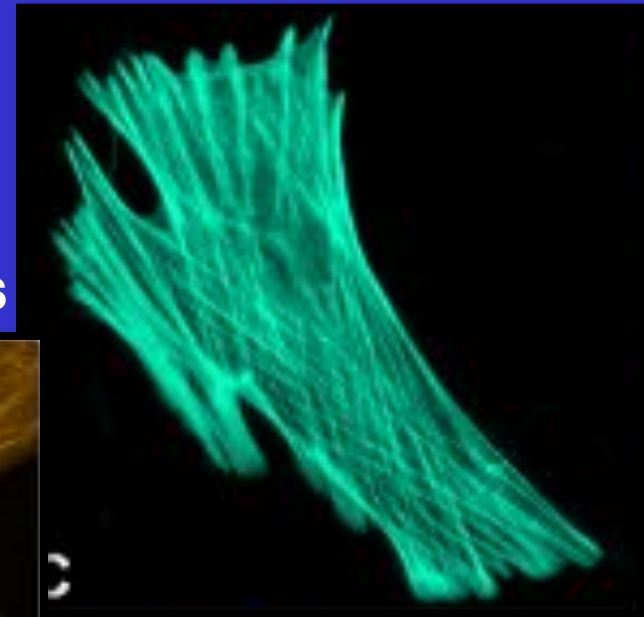


**Cytoskeletal
Networks
Containing
Fluorescent
Proteins**

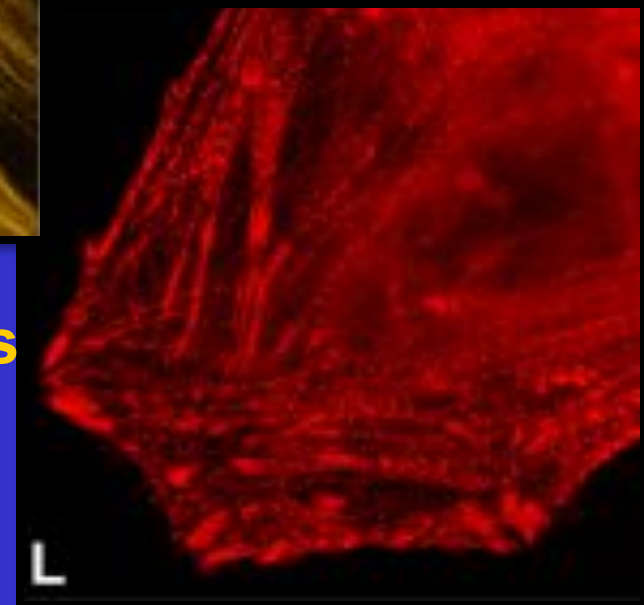
TUBULIN - MICROTUBULES



ACTIN – STRESS FIBERS

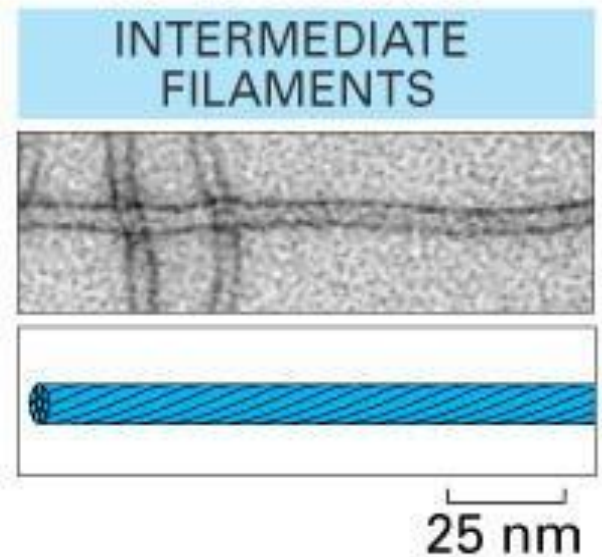
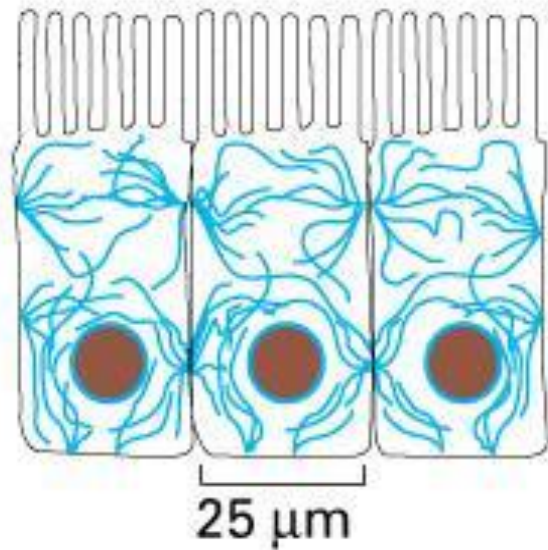


ACTININ – STRESS FIBERS

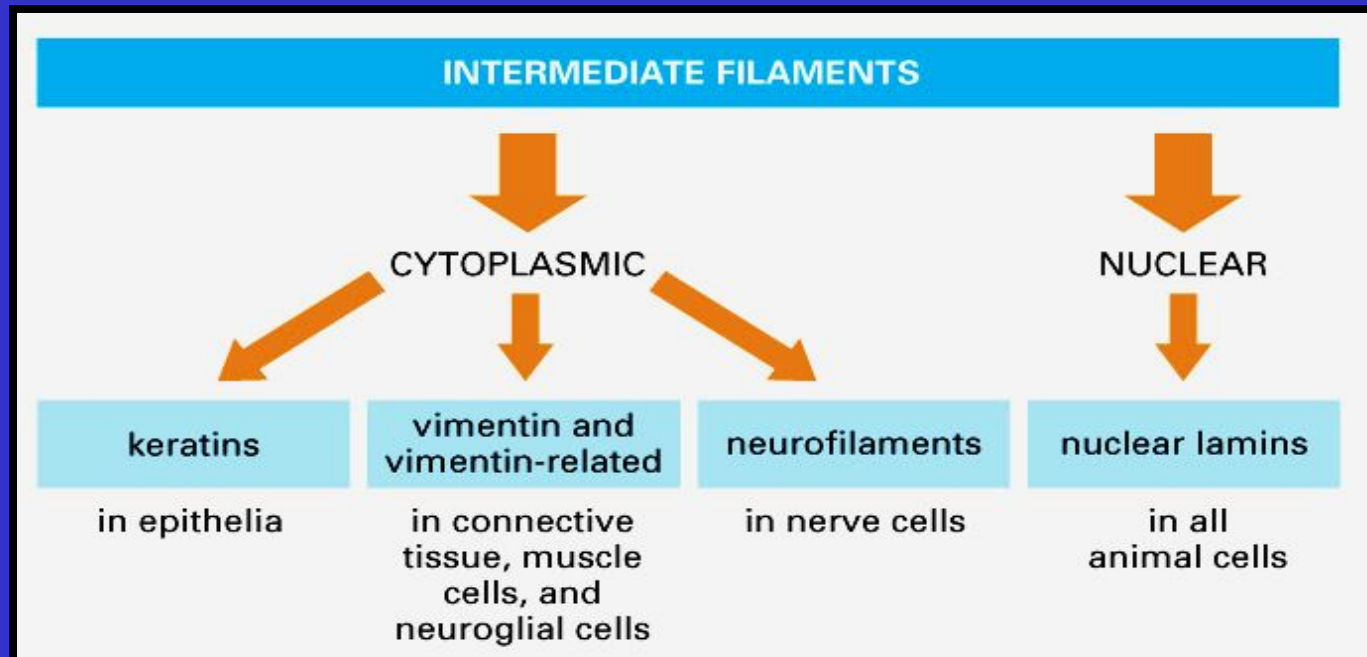


**Fluorescence
Microscopy allows
Visualization
Of cytoskeletal
Networks**

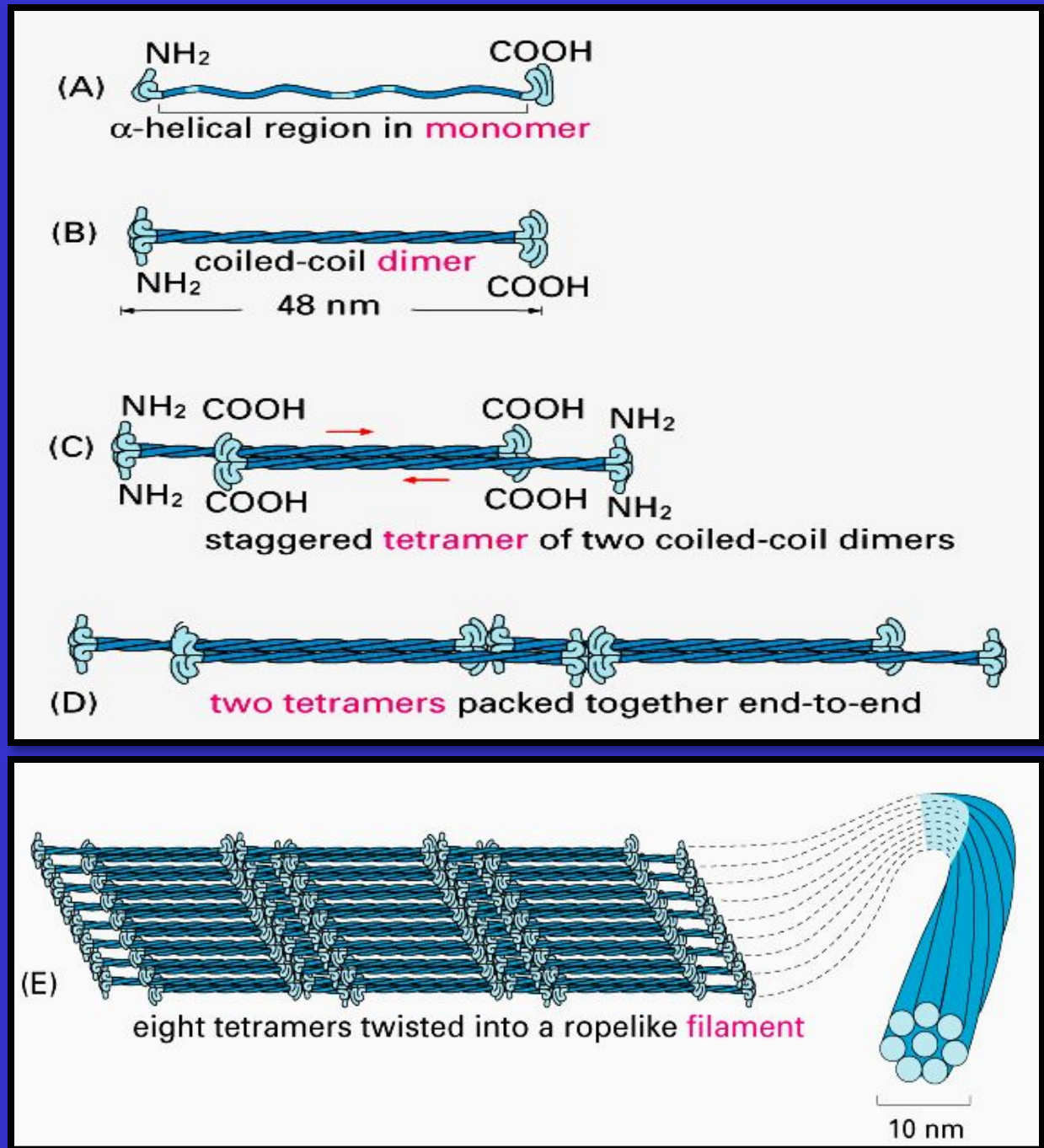
Intermediate Filaments are non-dynamic and structural. They position the nucleus and insert into Desmosomes to hold neighboring cells together.



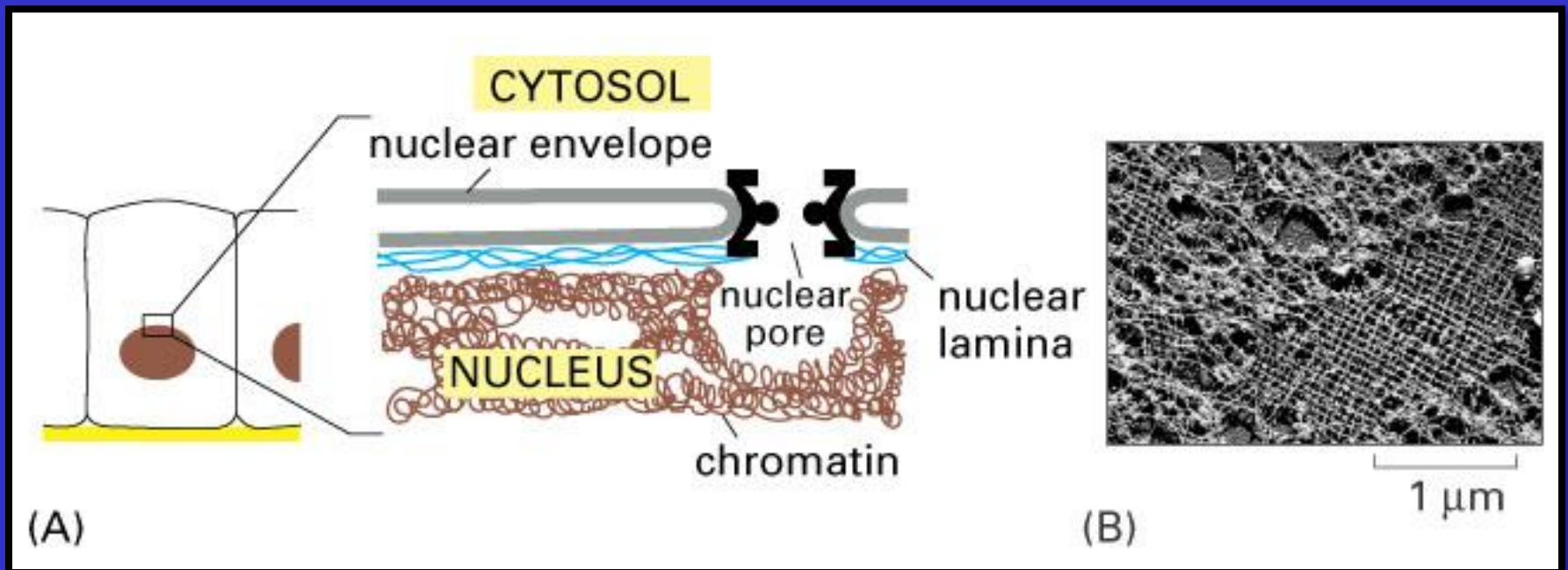
Intermediate filaments are ropelike fibers with a



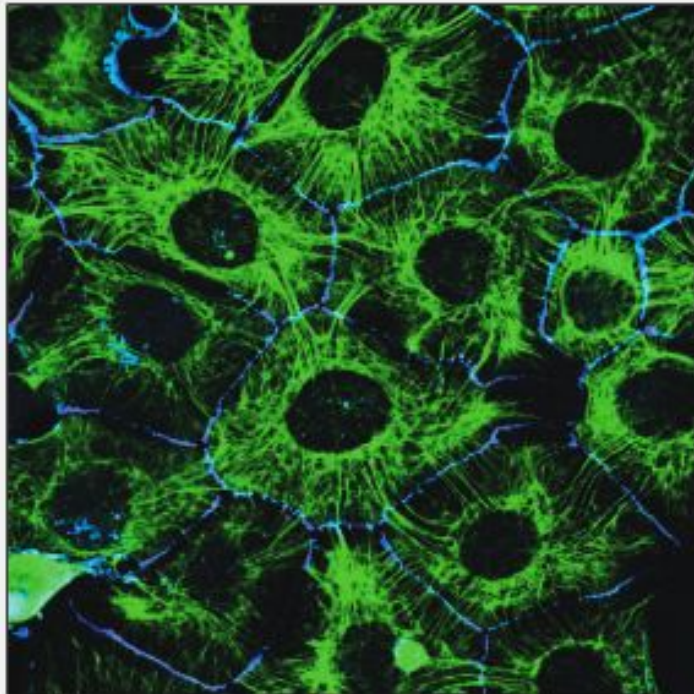
Intermediate
Filaments
polymerize
to form strong
rope-like fibers.
The basic
structural unit
is a coiled-coil
dimer. These
fibers are
symmetric



The inner side of the nuclear envelope is lined by a network of intermediate filaments called **lamins**. They serve as an anchoring site for chromosomes as well as for intermediate filament networks that extend from the nucleus out into the cytoplasm.



Intermediate filament networks flare out from the nucleus and insert into plasma membrane junctions called **desmosomes**. Desmosomes connect the intermediate filaments networks of neighboring cells forming a strong mechanical bond that keeps the cells from being pulled apart.

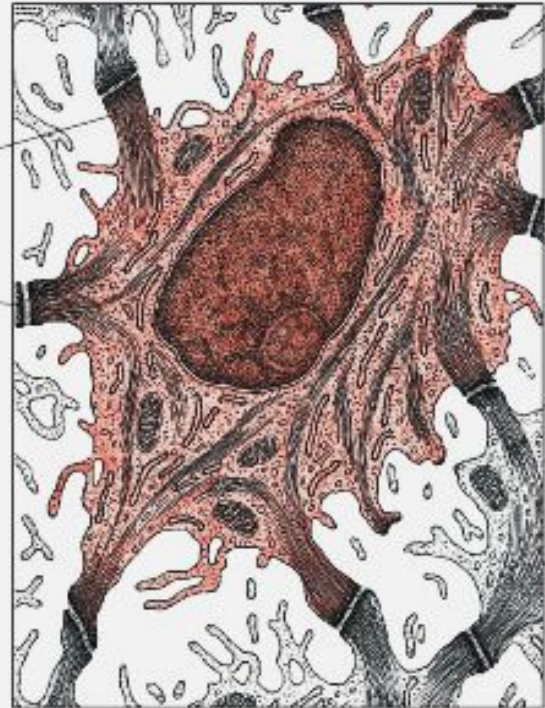


(A)

10 μm

intermediate
filaments

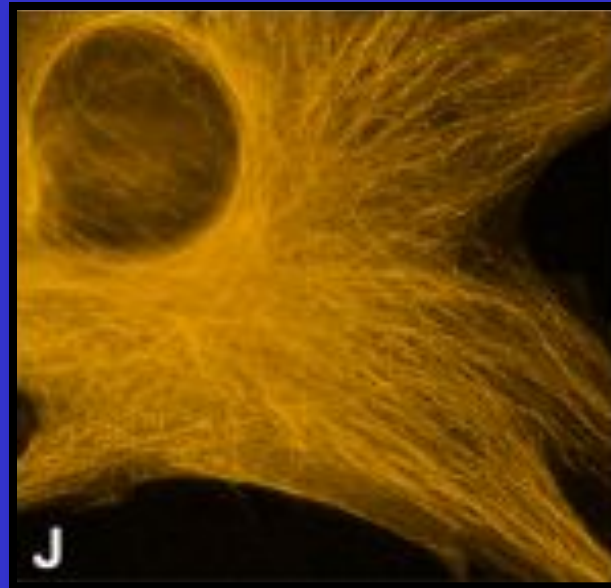
desmosome
connecting
two cells



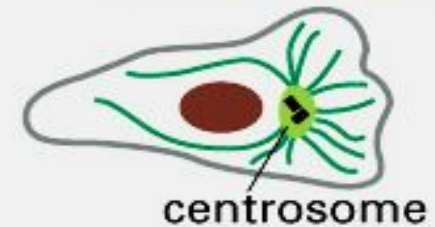
(B)

5 μm

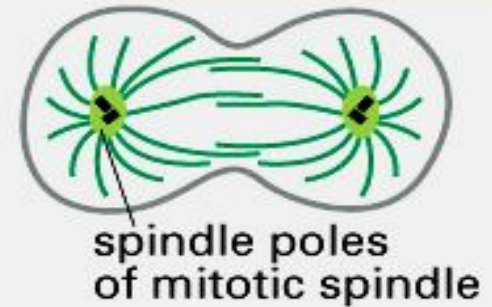
Microtubules Make Up Dynamic Networks



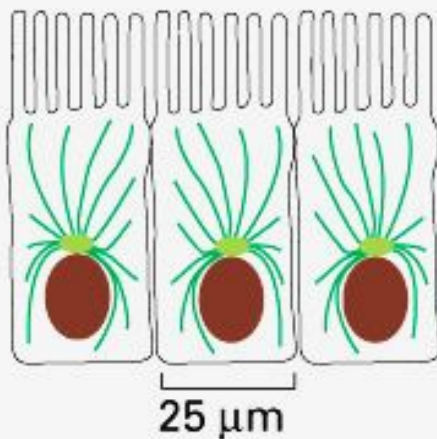
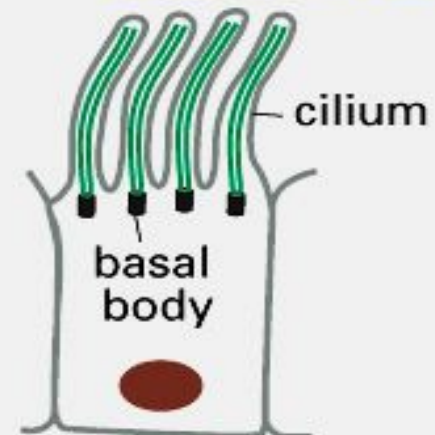
(A) INTERPHASE CELL



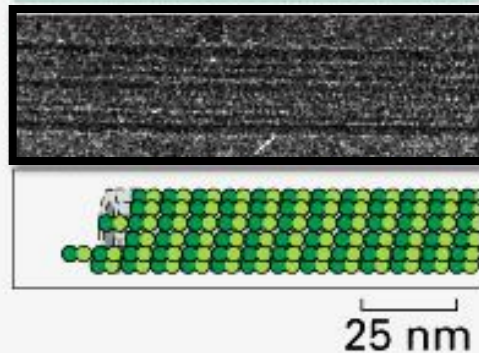
(B) DIVIDING CELL



(C) CILIATED CELL



MICROTUBULES



Microtubules are long, hollow cylinders made of the protein tubulin. With an outer diameter of 25 nm, they are more rigid than actin filaments or intermediate filaments.

Microtubules serve four functions:

1. To give shape to the cell.

Example: nerve axons contain numerous microtubules along their length. If disrupted the axon shrivels.

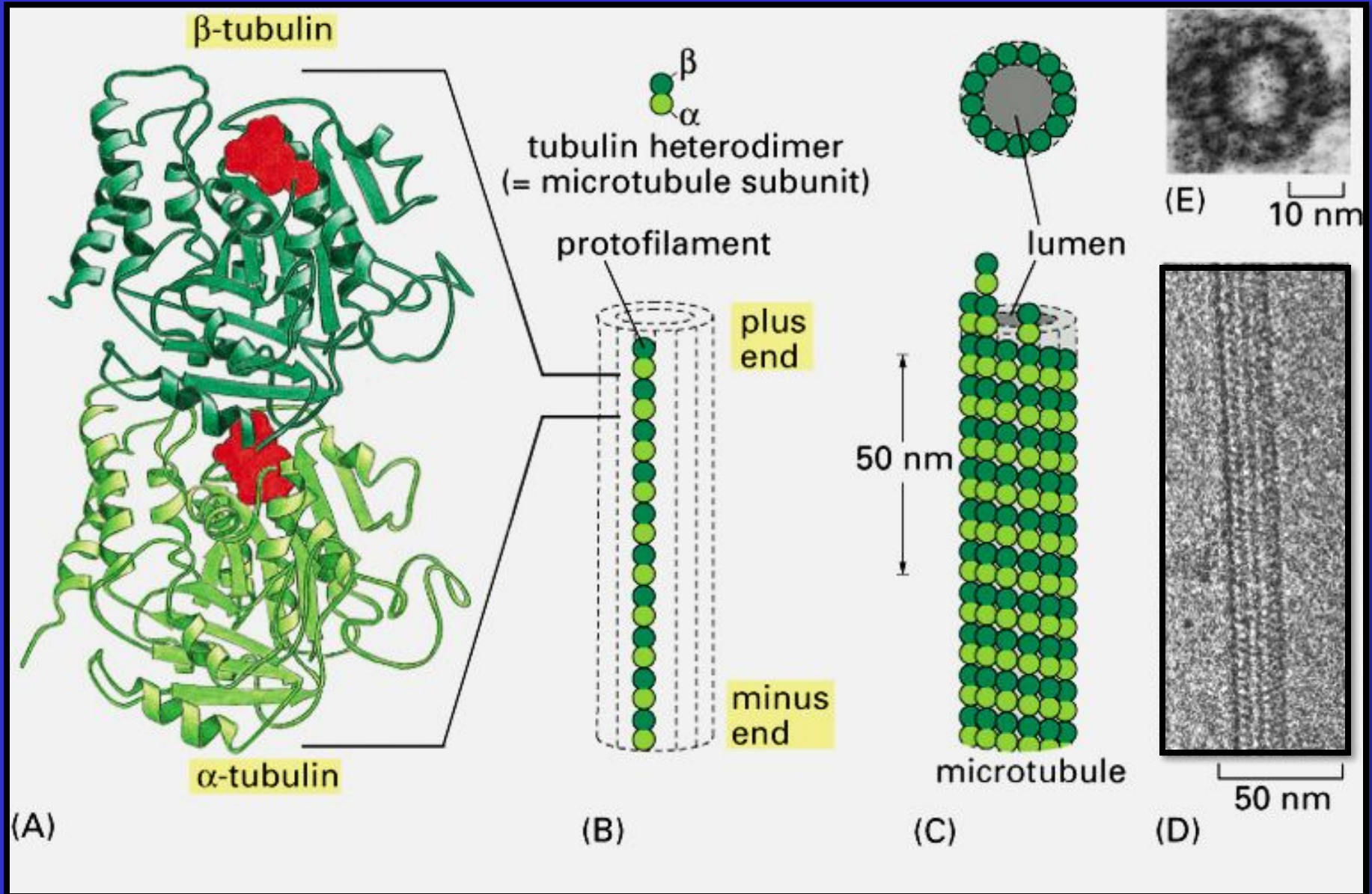
2. To provide “tracks” on which to move vesicles carrying cargo.

Example: pigment granules move outward and inward from cell center using microtubules.

3. To form the mitotic spindle which separates chromosomes during mitosis and meiosis.

4. To form flagella and cilia – whip like structures that propel cells.

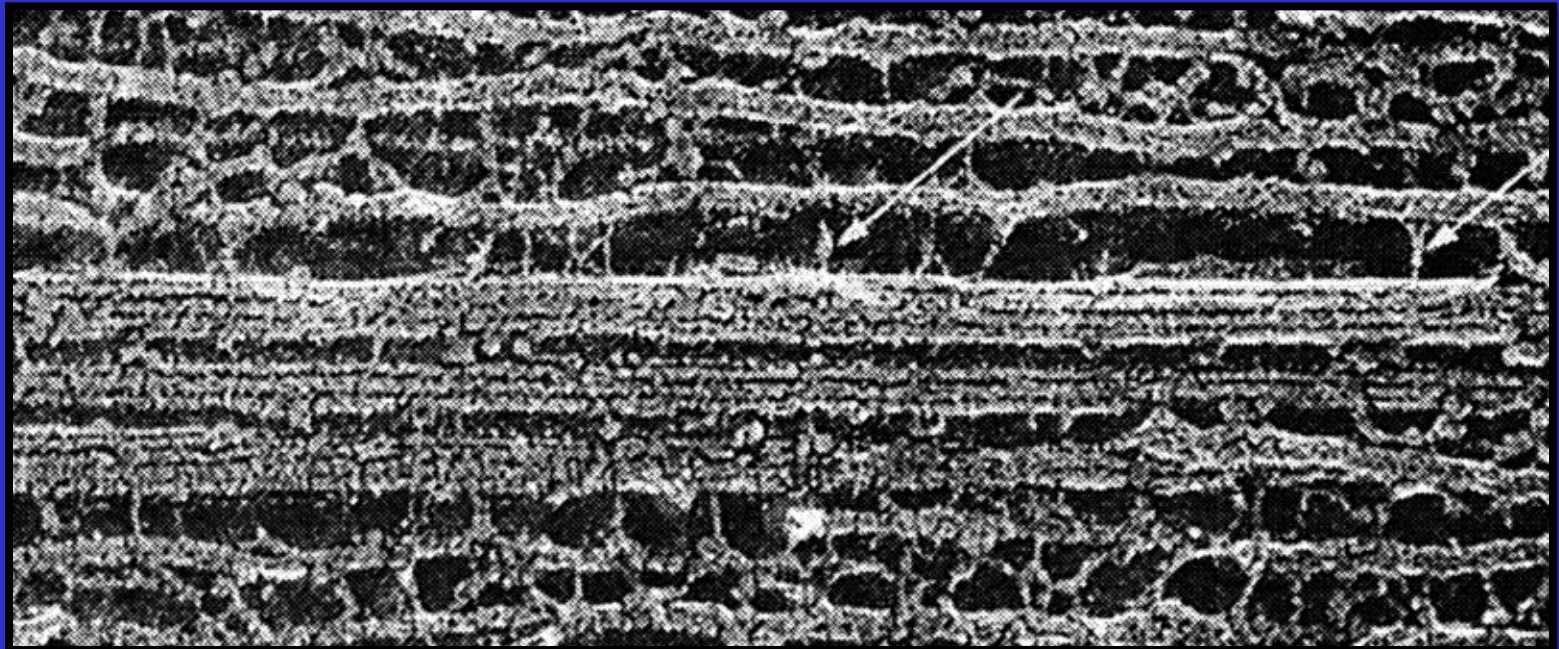
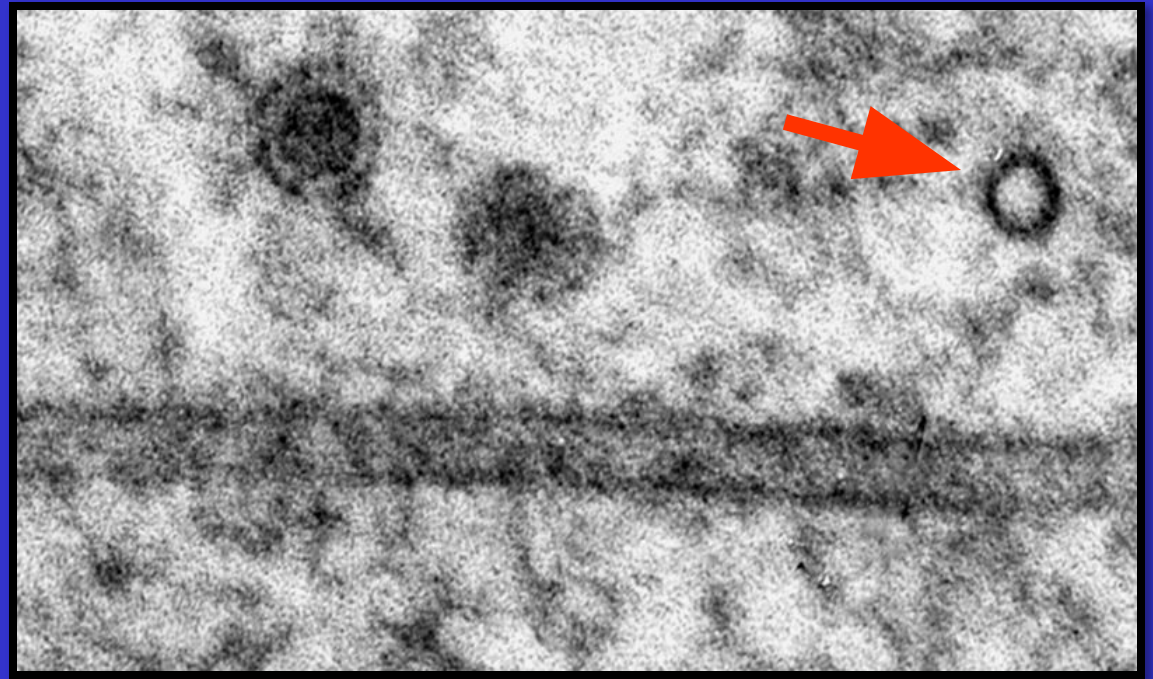
Microtubules Are Made Of Tubulin Protofilaments



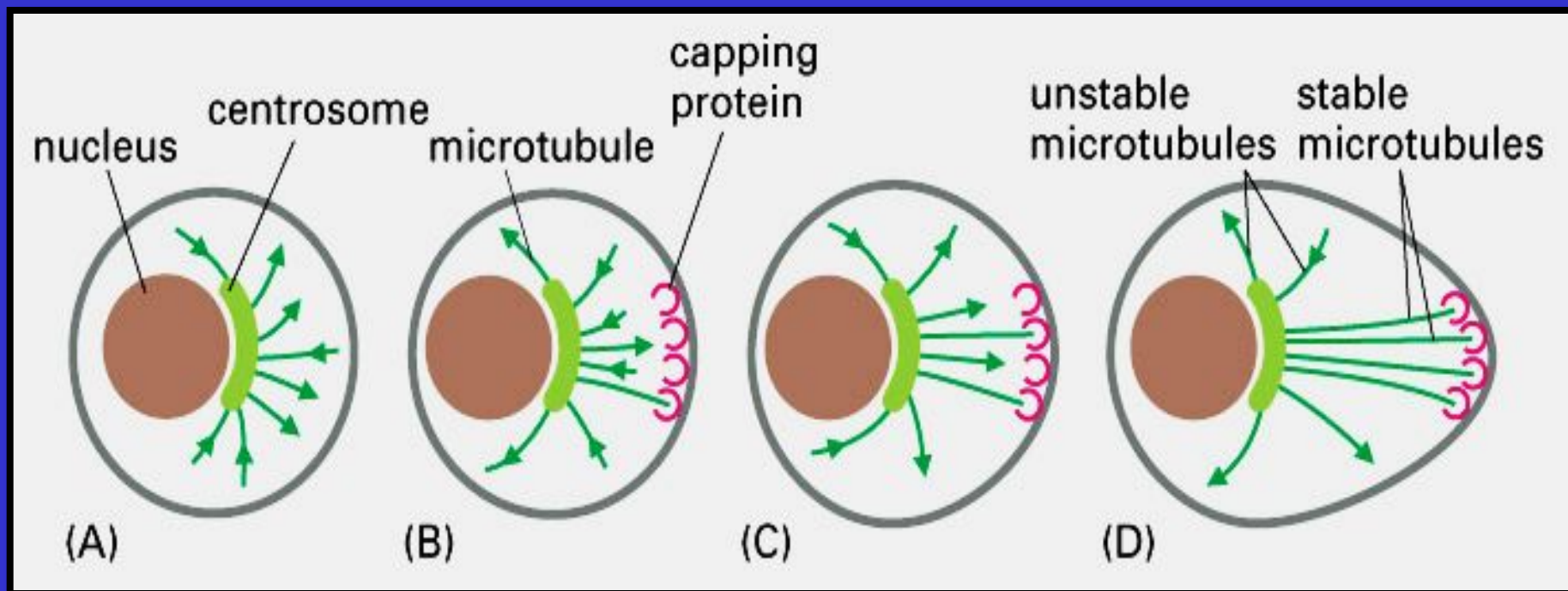
Microtubules as seen by Electron Microscopy

1) thin section

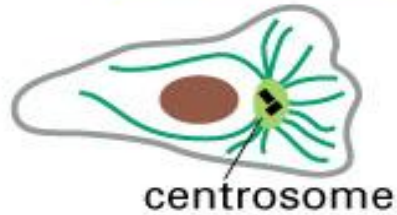
2) freeze dried
And platinum
Shadowed



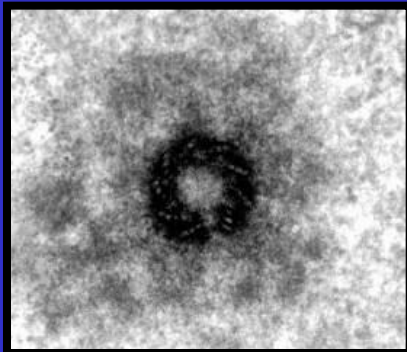
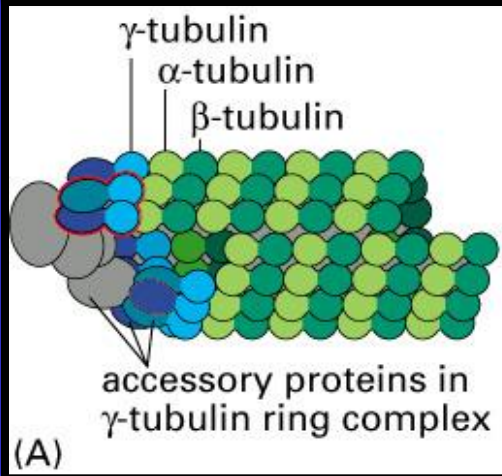
Microtubules are stabilized by capping at their Plus and minus ends. Centrosomes and Microtubule organizing centers (MTOCs) cap the minus end; special membrane-associated proteins cap the plus end.



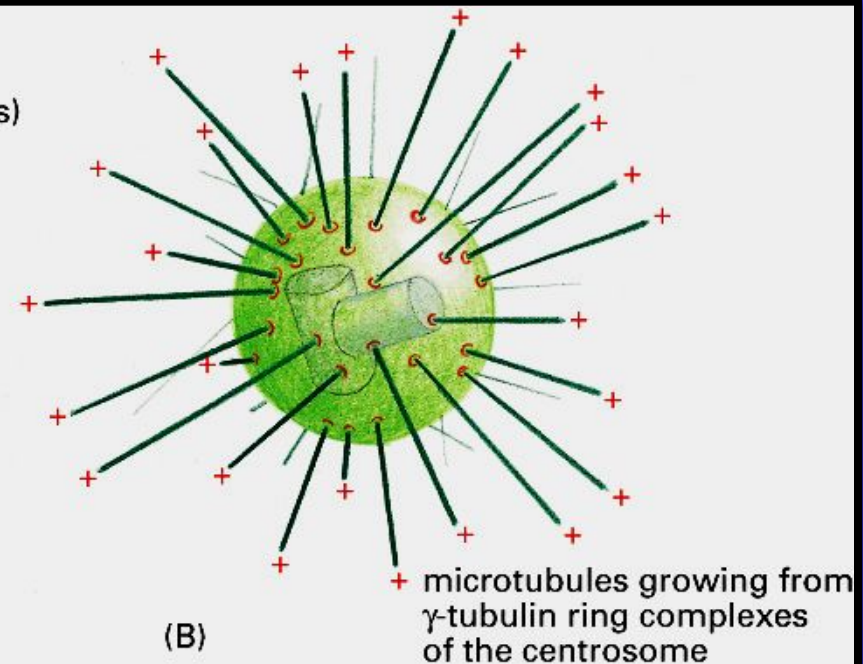
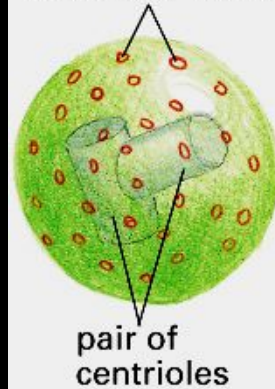
(A) INTERPHASE CELL



The centrosome consists of centrioles surrounded by a “protein cloud”. Minus ends of microtubules are capped by gamma tubulin rings and the centrosome serves as a microtubule organizing center (MTOC).

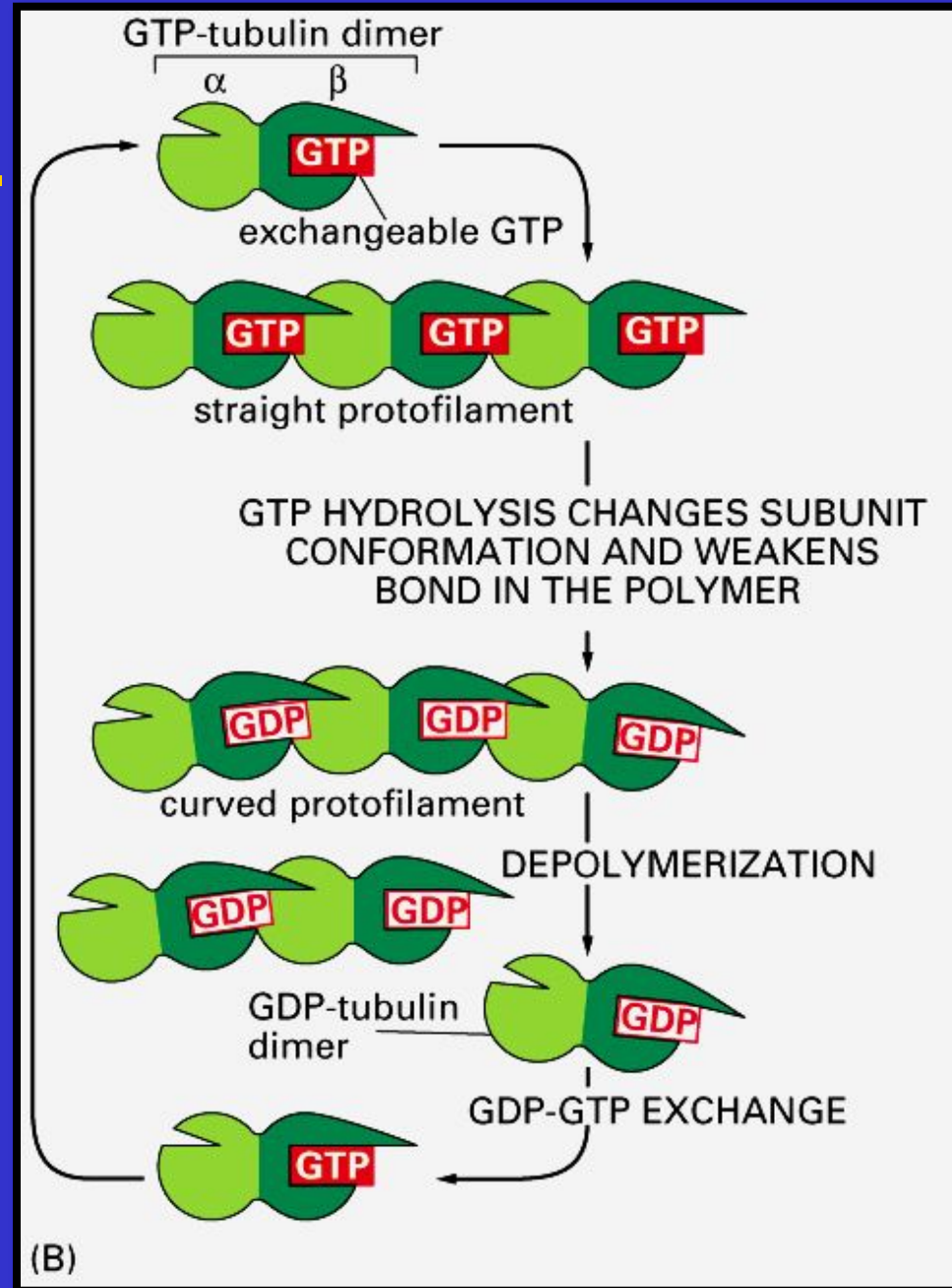
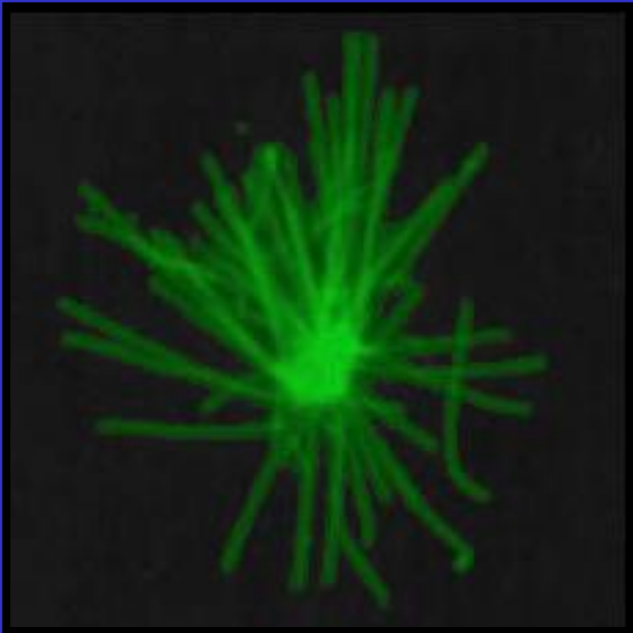


nucleating sites
(γ -tubulin ring complexes)

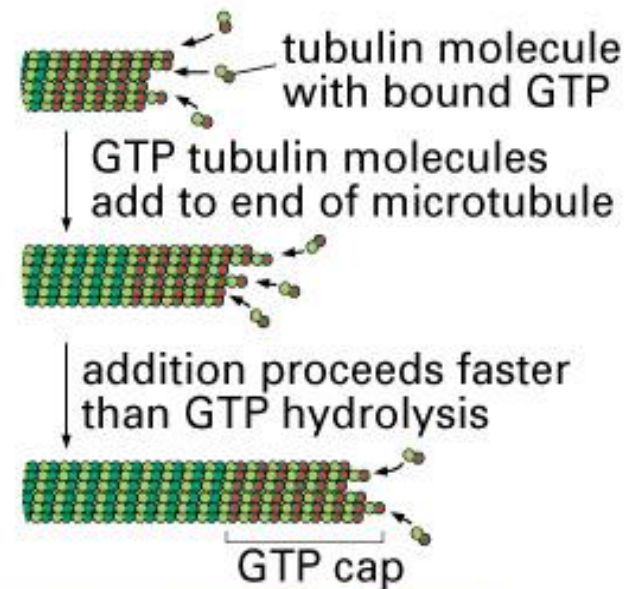
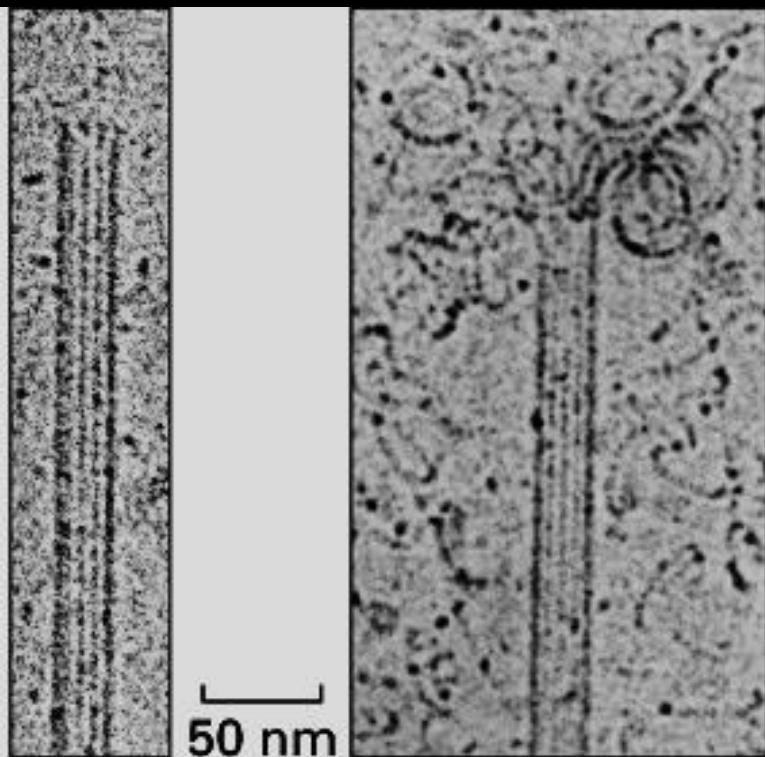


Microtubule assembly at plus end is governed by GTP hydrolysis; GTP-tubulin is required for polymerization;

But after hydrolysis, GDP-tubulin favors depolymerization



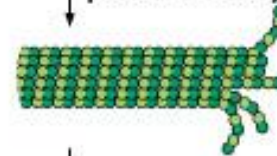
Catastrophic Disassembly can occur if growth at the plus end stops or is slow; but the microtubule starts to grow at this end again.



GROWING MICROTUBULE



protofilaments containing GDP tubulin peel away from the microtubule wall



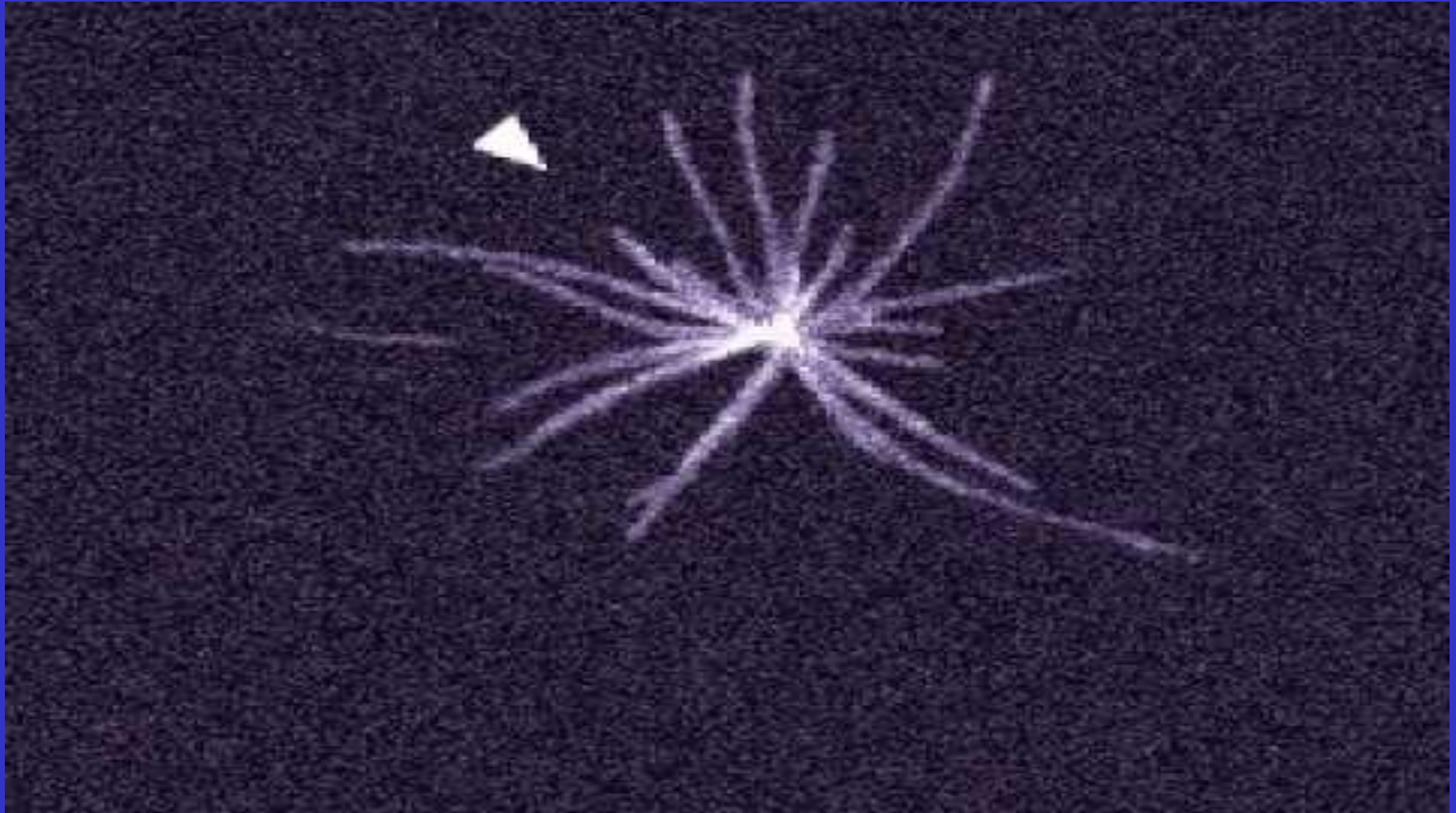
GDP tubulin is released to the cytosol



tubulin molecule with bound GDP

SHRINKING MICROTUBULE

DYNAMIC INSTABILITY IN A MICROTUBULE ASTER



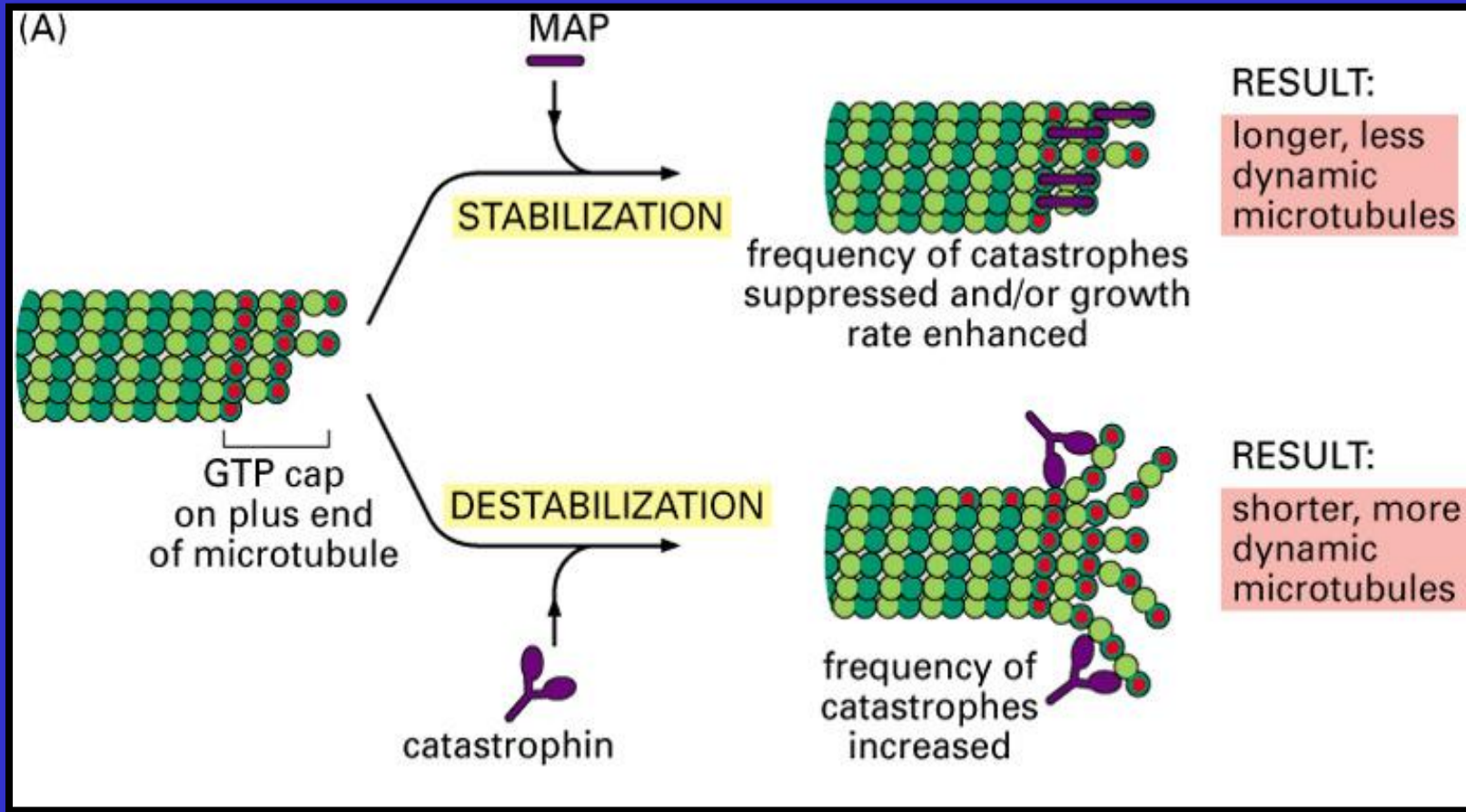
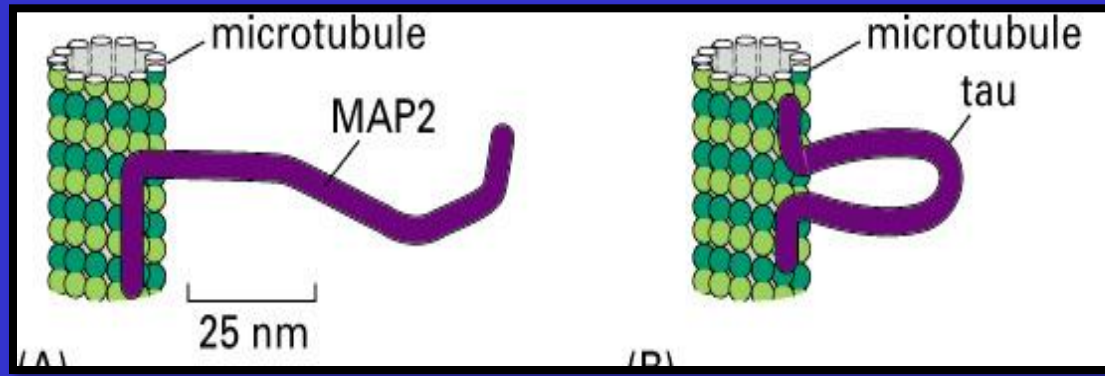
MICROTUBULE DYNAMICS SEEN WITH FLUORESCENT PLUS END PROTEINS



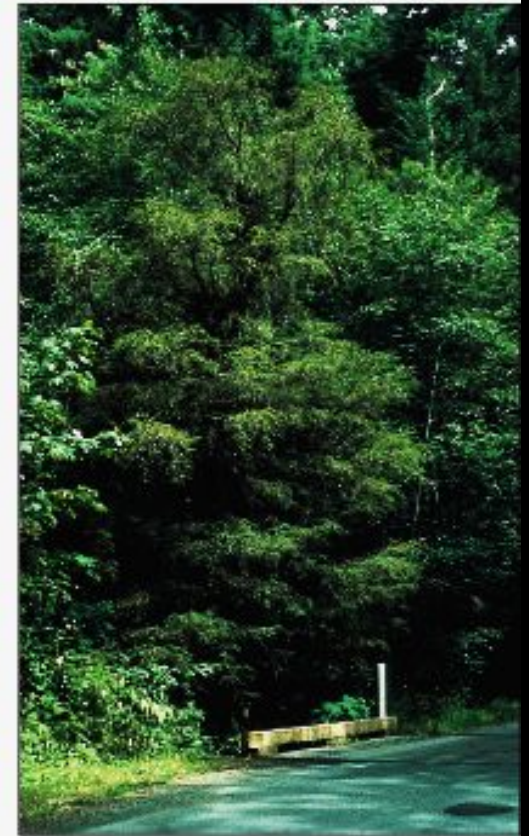
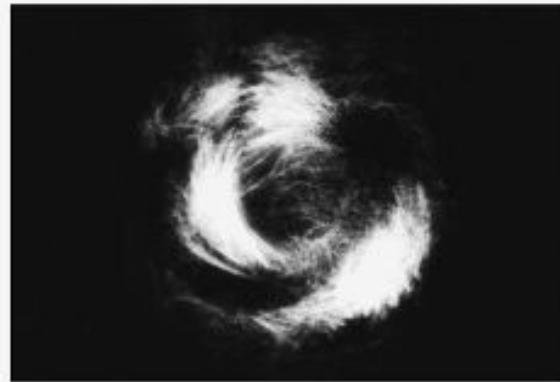
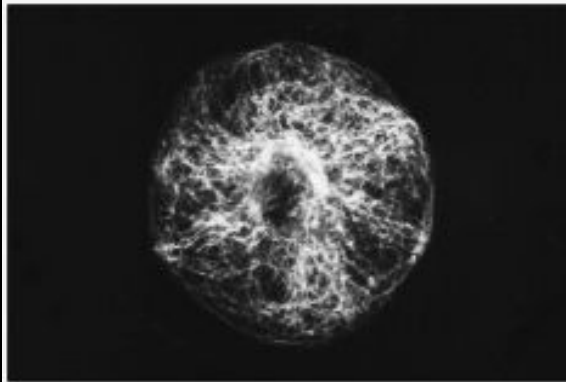
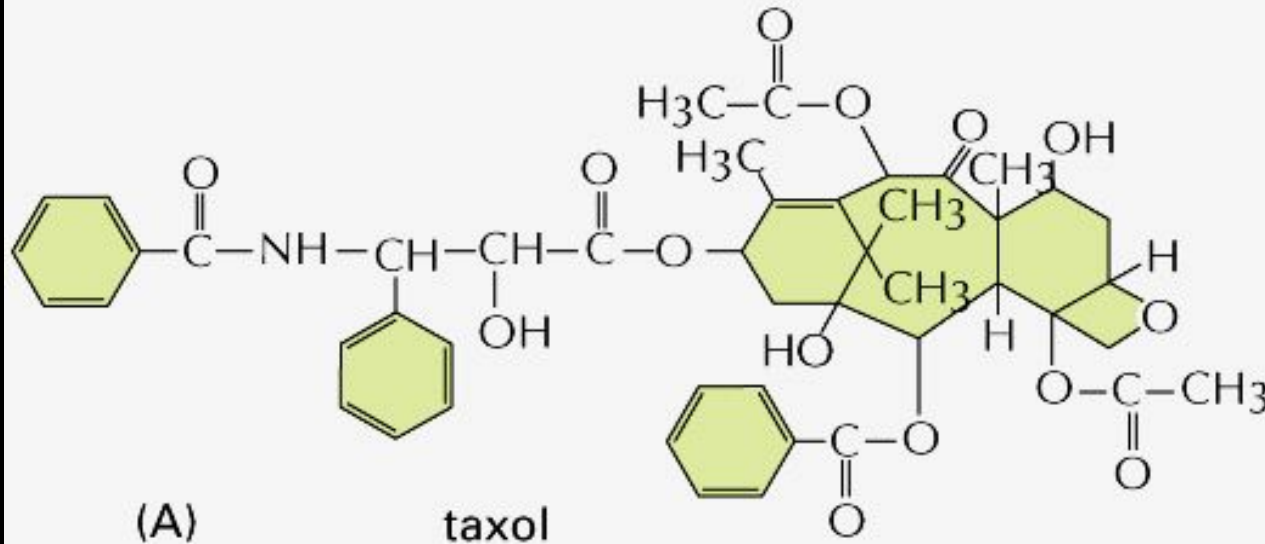
MICROTUBULE DYNAMICS SEEN WITH FLUORESCENT PLUS END PROTEINS



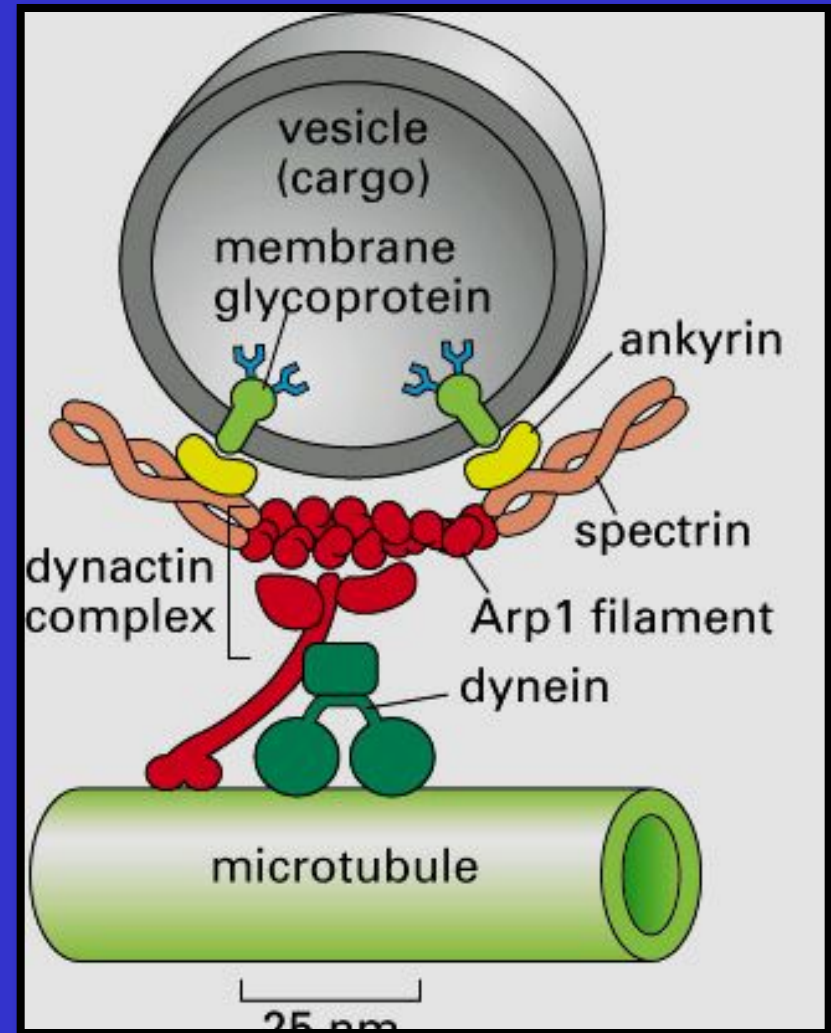
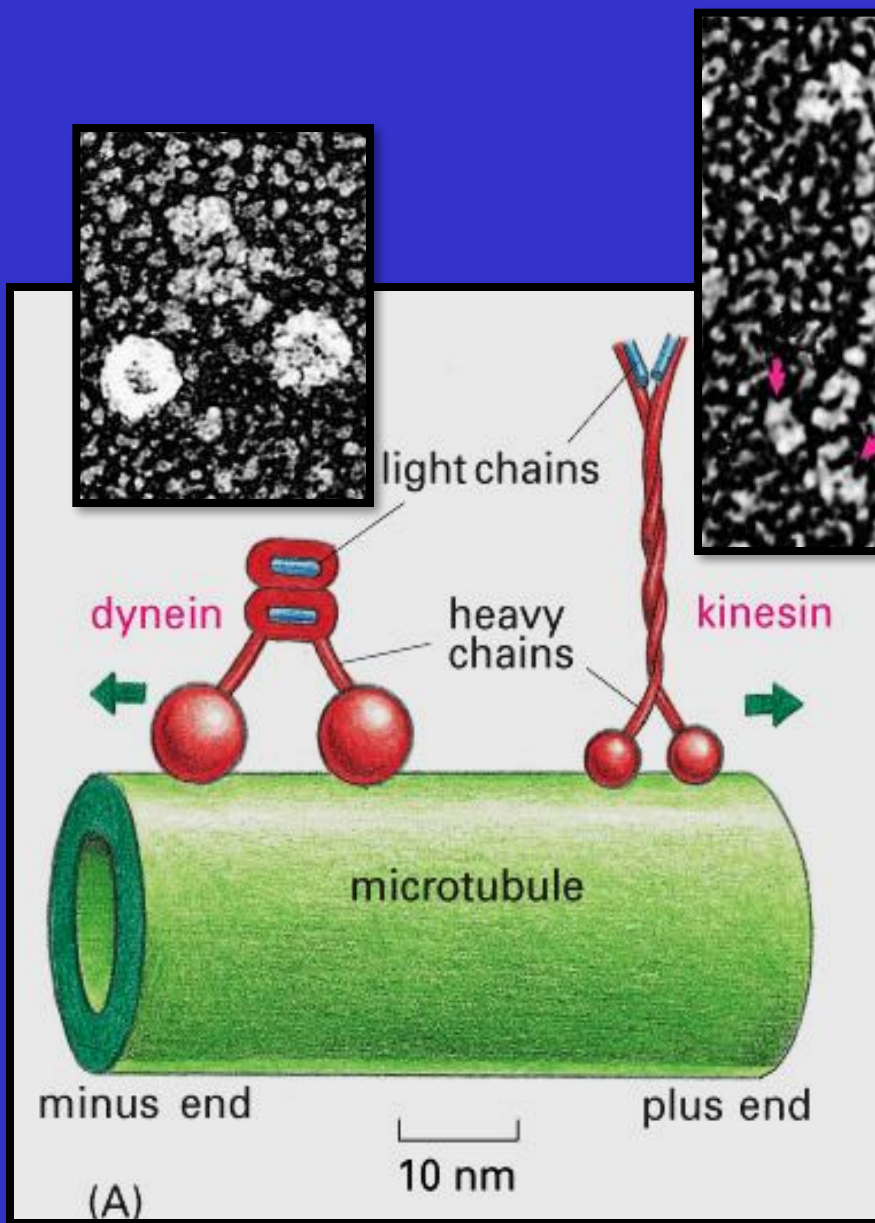
Microtubule associated proteins also stabilize microtubules. Acetylation and tyrosylation do too.



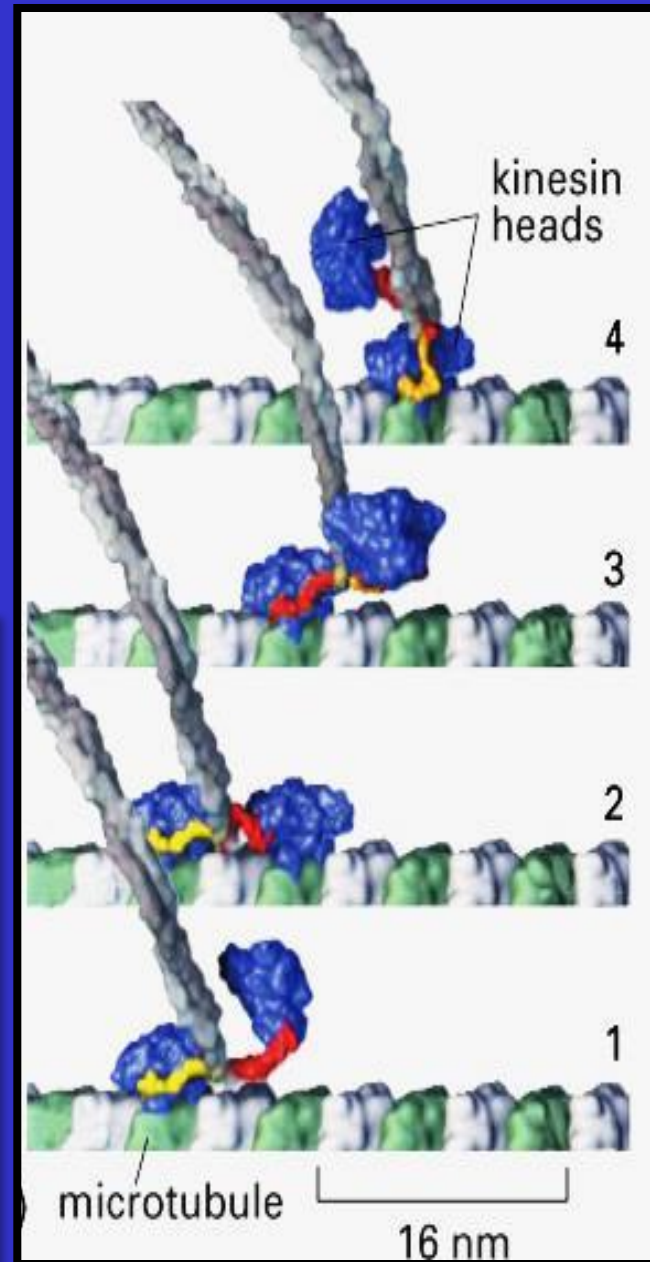
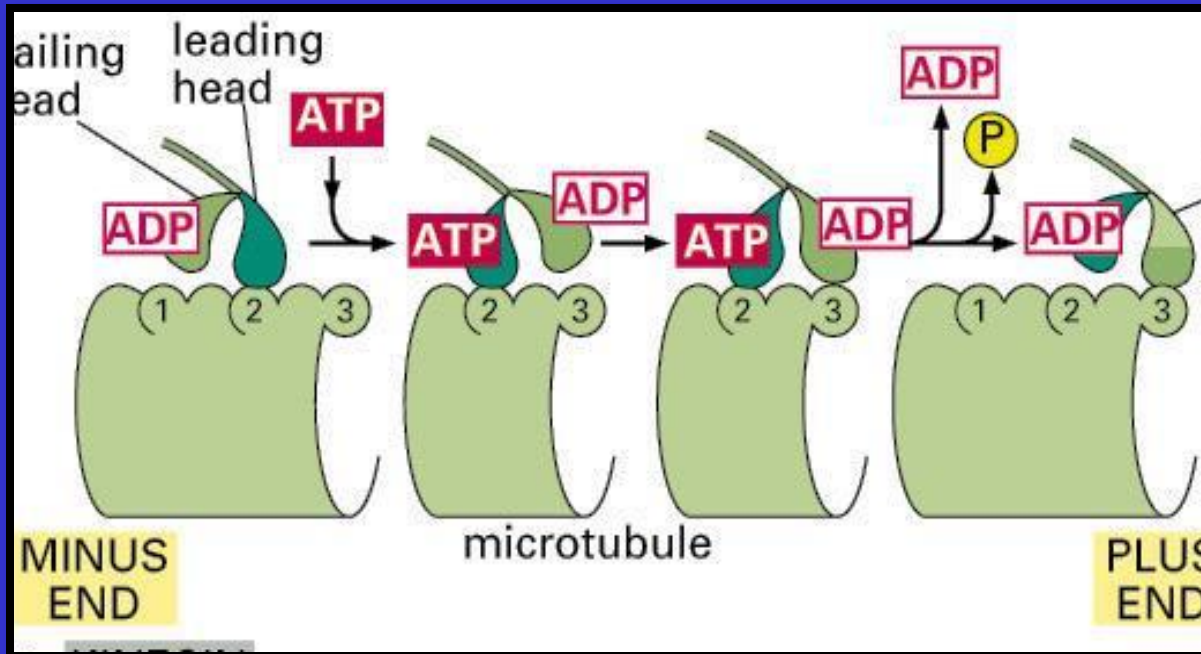
**Drugs can stabilize or destabilize microtubules;
Taxol stabilizes existing mts; colchicine
destabilizes microtubules by monomer binding**



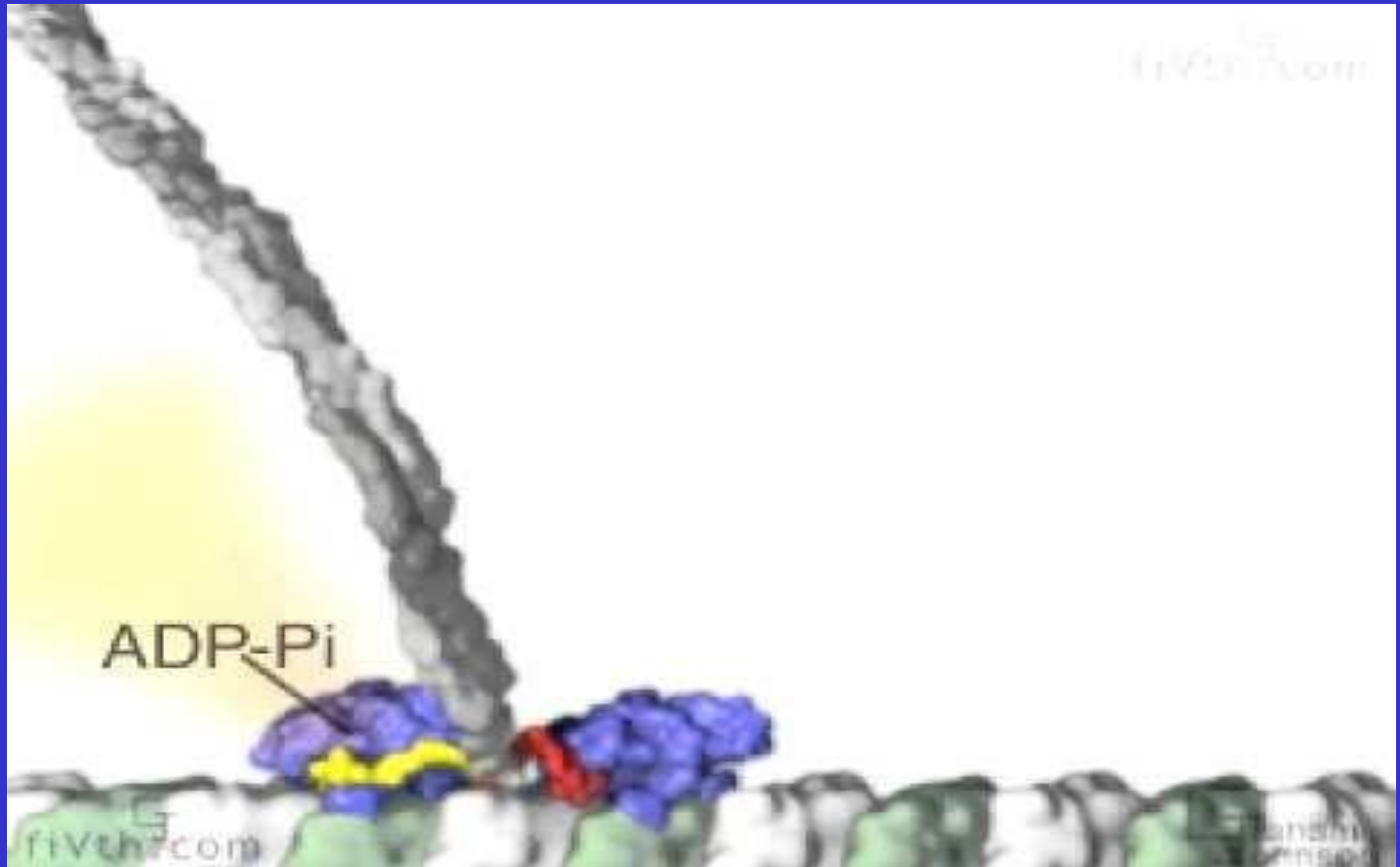
Motor proteins “walk” on microtubules and microfilaments via their heads acting as “motors”



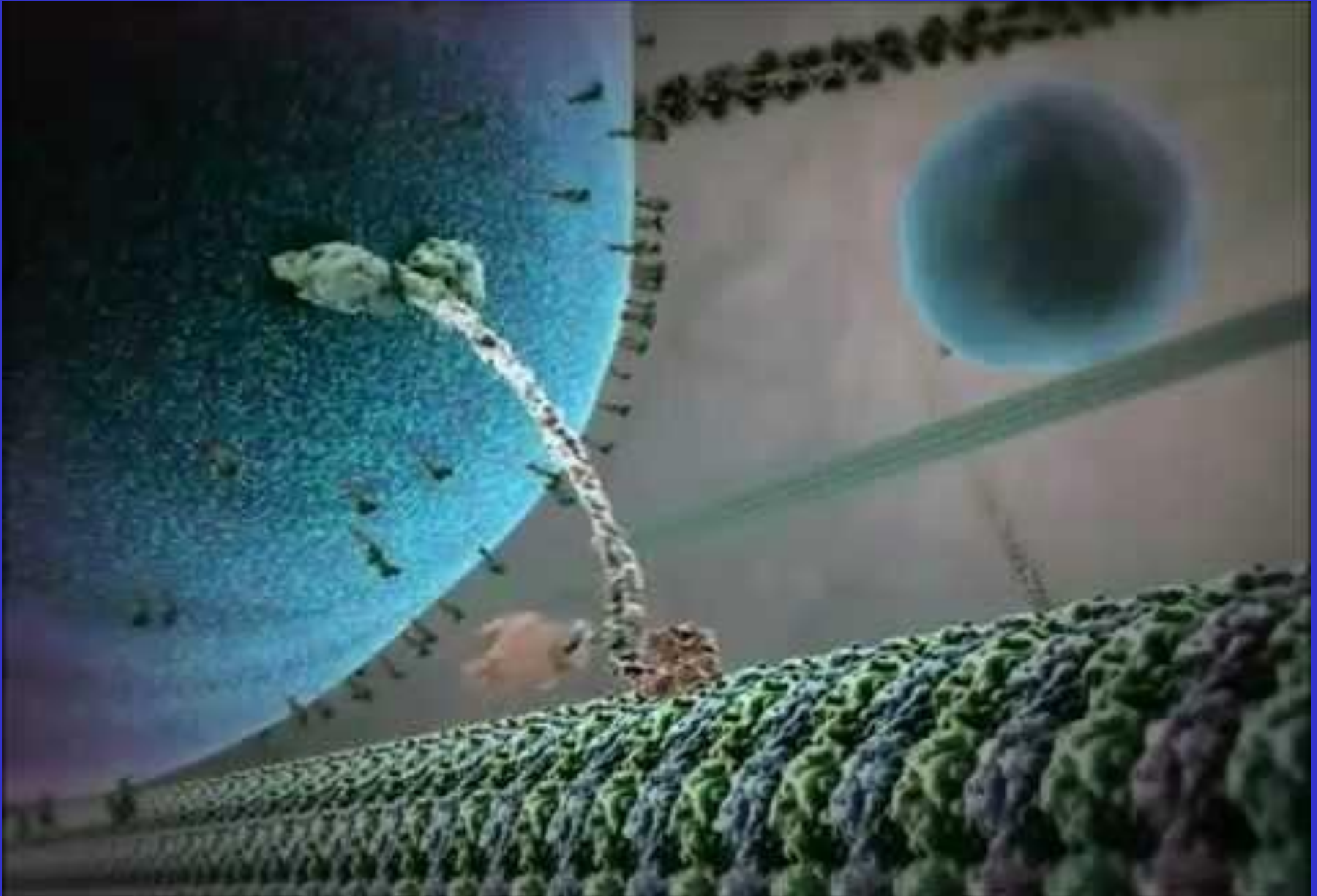
Kinesin, like myosin, hydrolyzes ATP as it walks. During this process chemical energy is transformed into mechanical energy, hence the name motor protein.



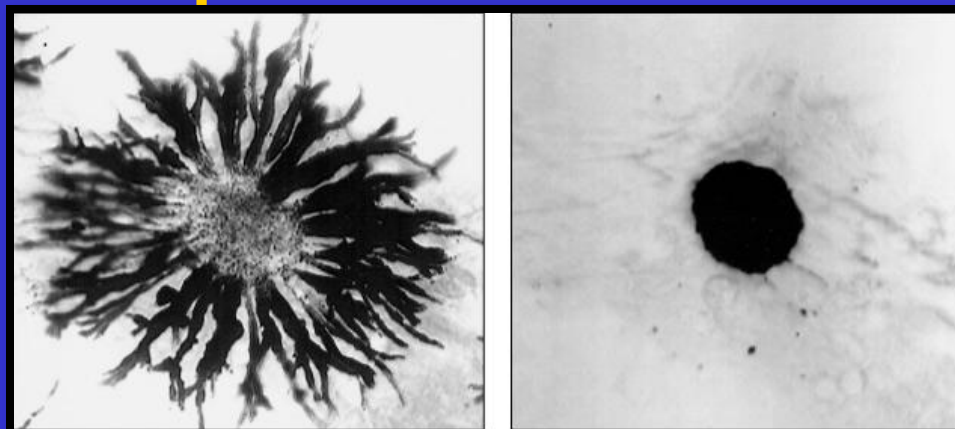
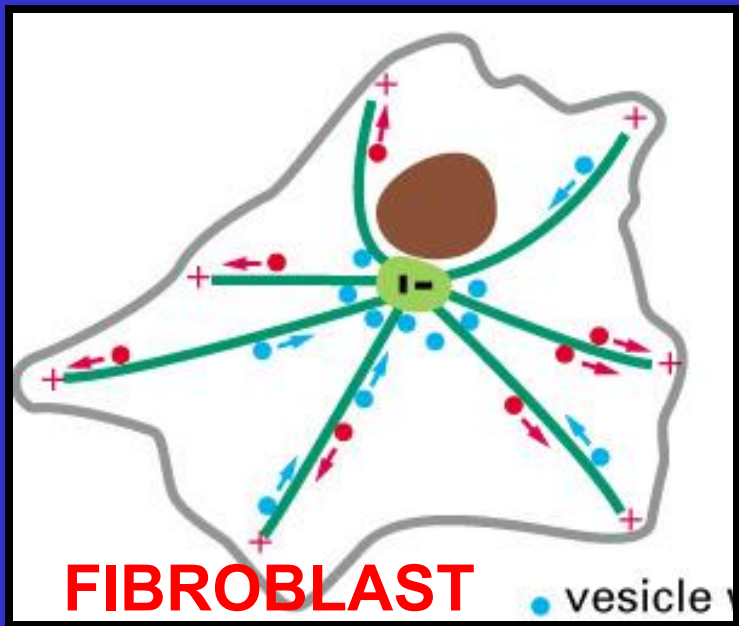
MOTOR PROTEINS MOVE VESICLES ON MICROTUBULE TRACKS – A CONFORMATIONAL CYCLE THAT HYDROLYZES ATP



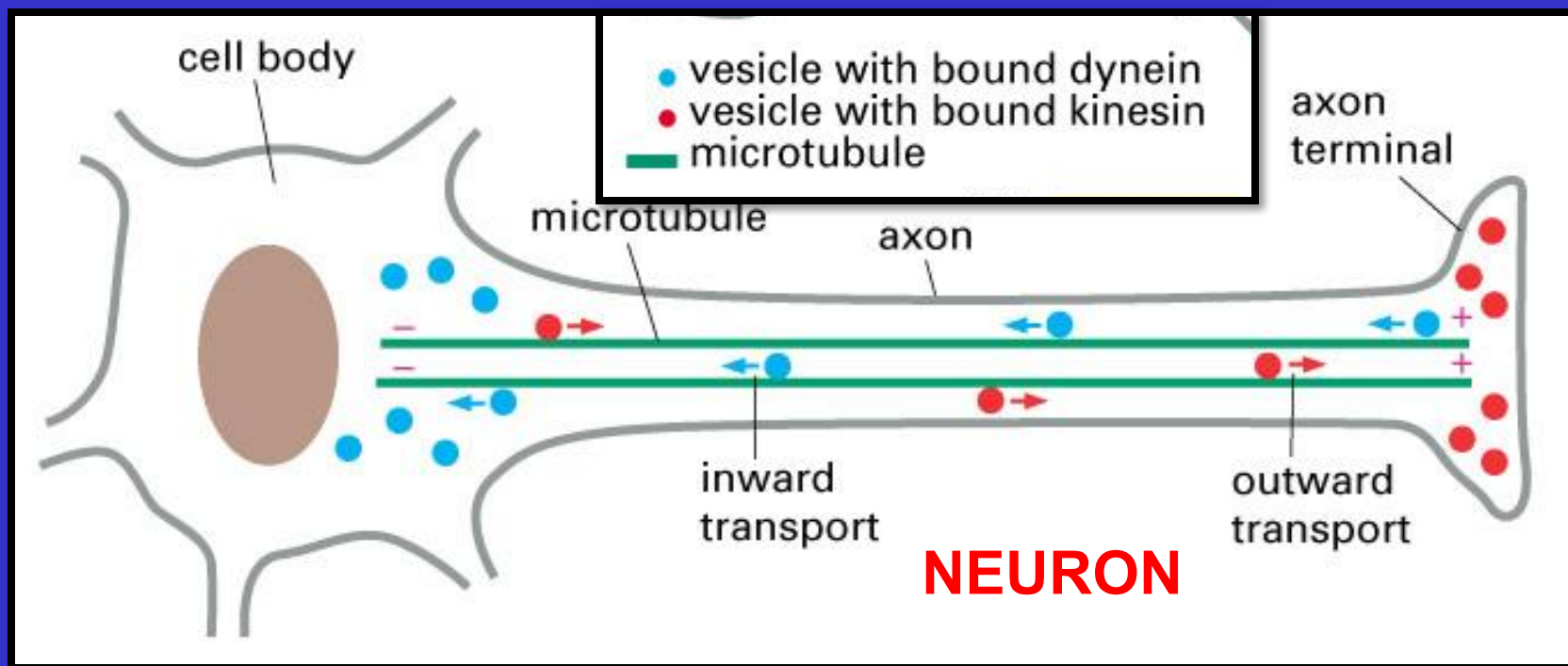
MOTOR PROTEINS MOVE VESICLES ON MICROTUBULE TRACKS



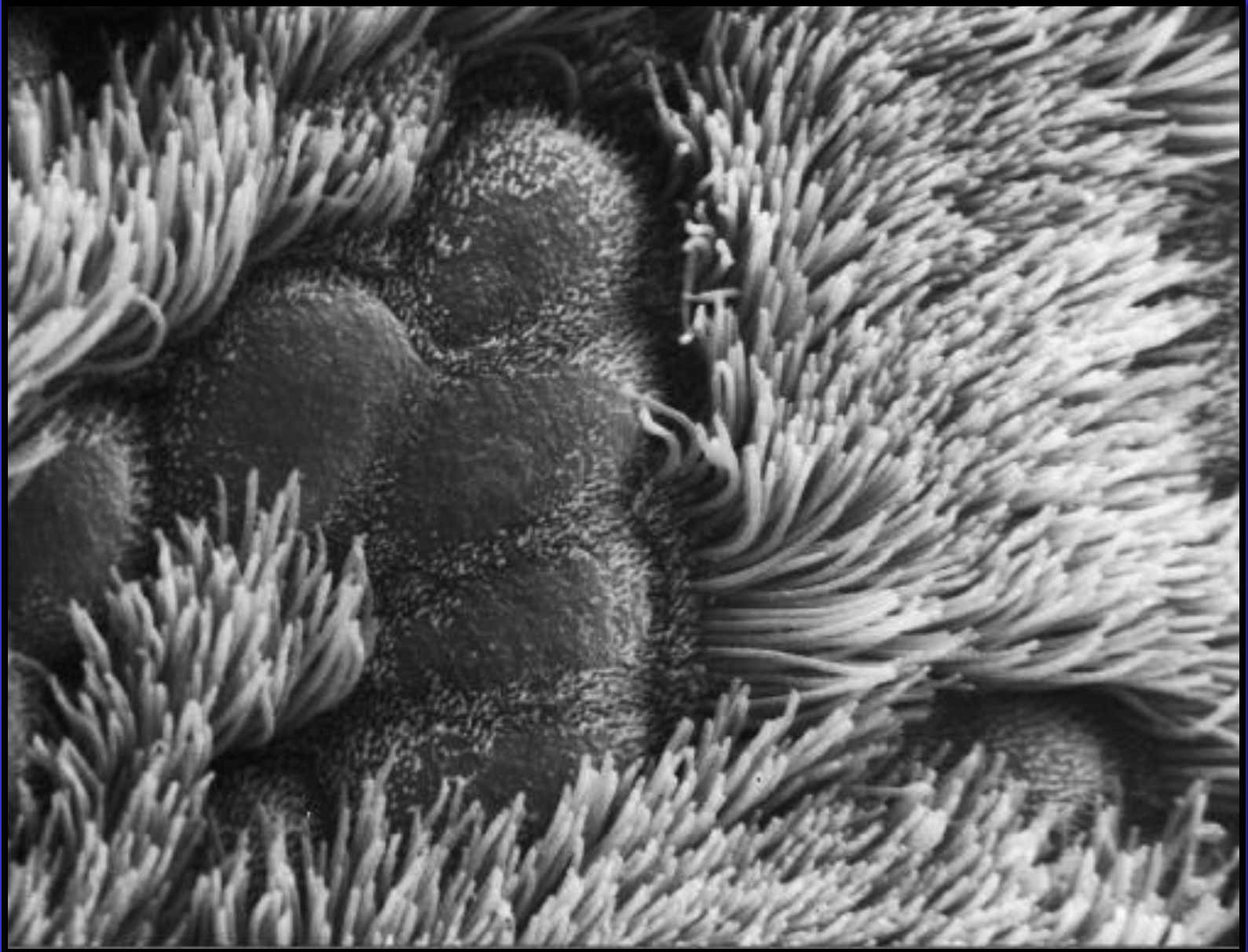
Direction of vesicle Transport on microtubules

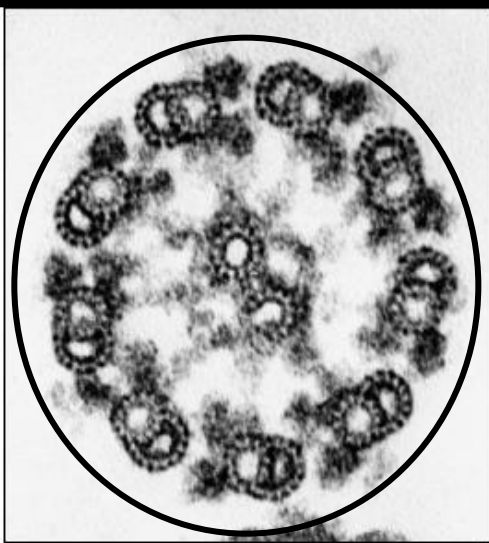


Movement of pigment granules on MTs

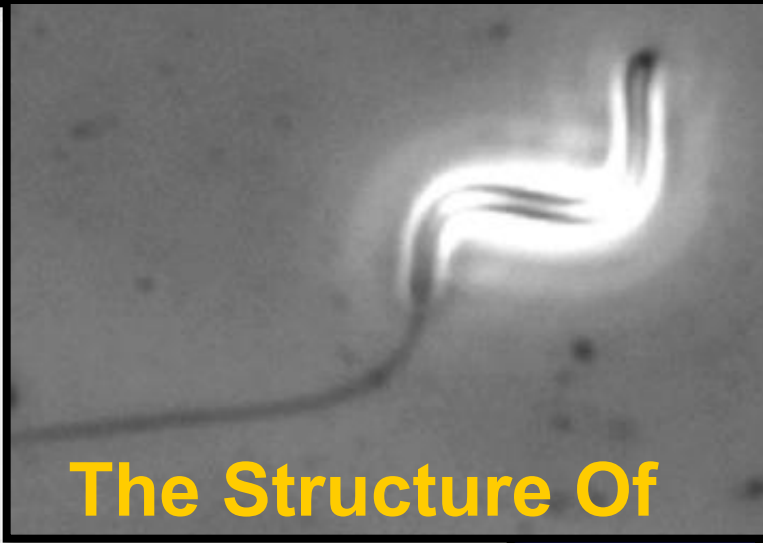


Cilia And Flagella: A Different Form Of Motility

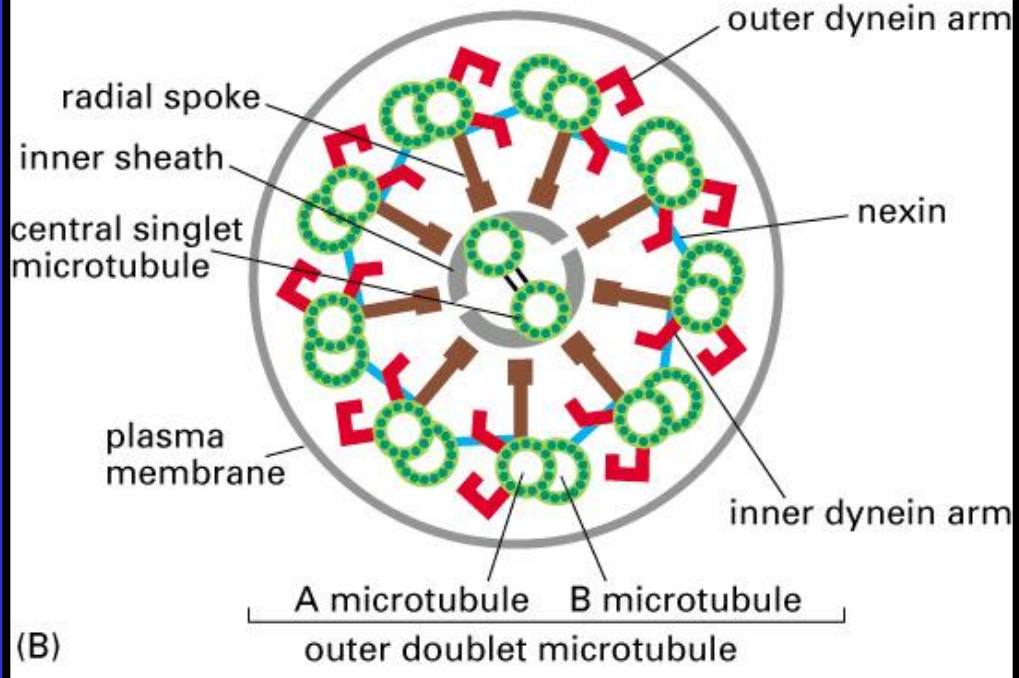




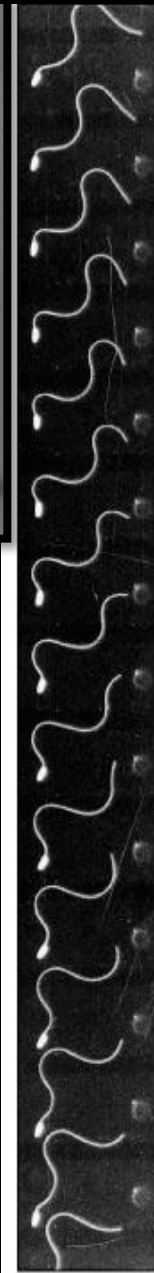
(A) 100 nm



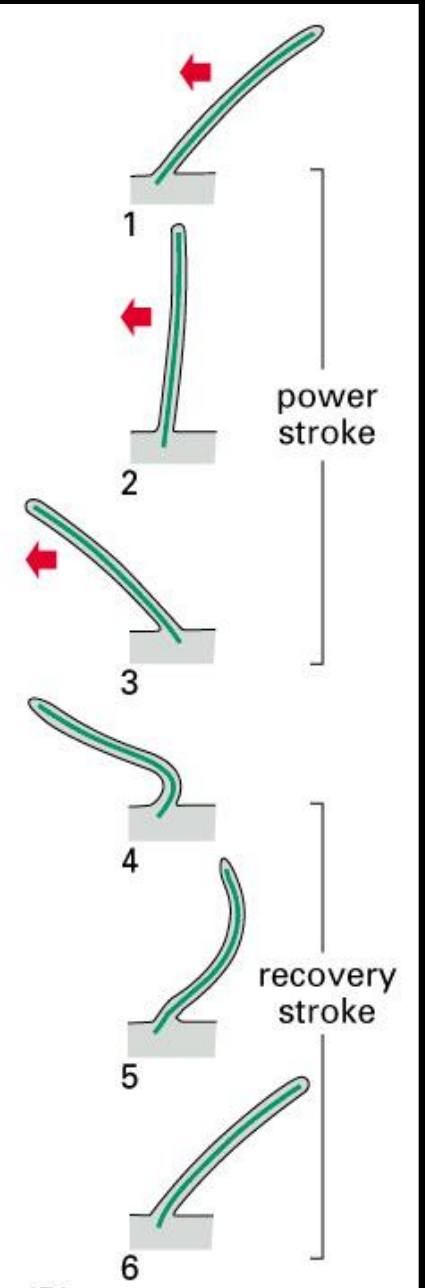
The Structure Of Flagella And Cilia



(B)



(A)



(B)

Dynein provides Motive force to move one MT doublet relative to a neighboring MT doublet

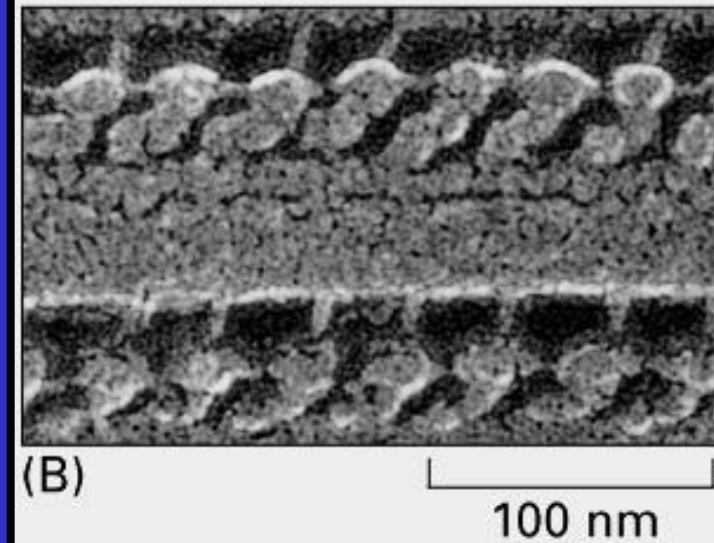
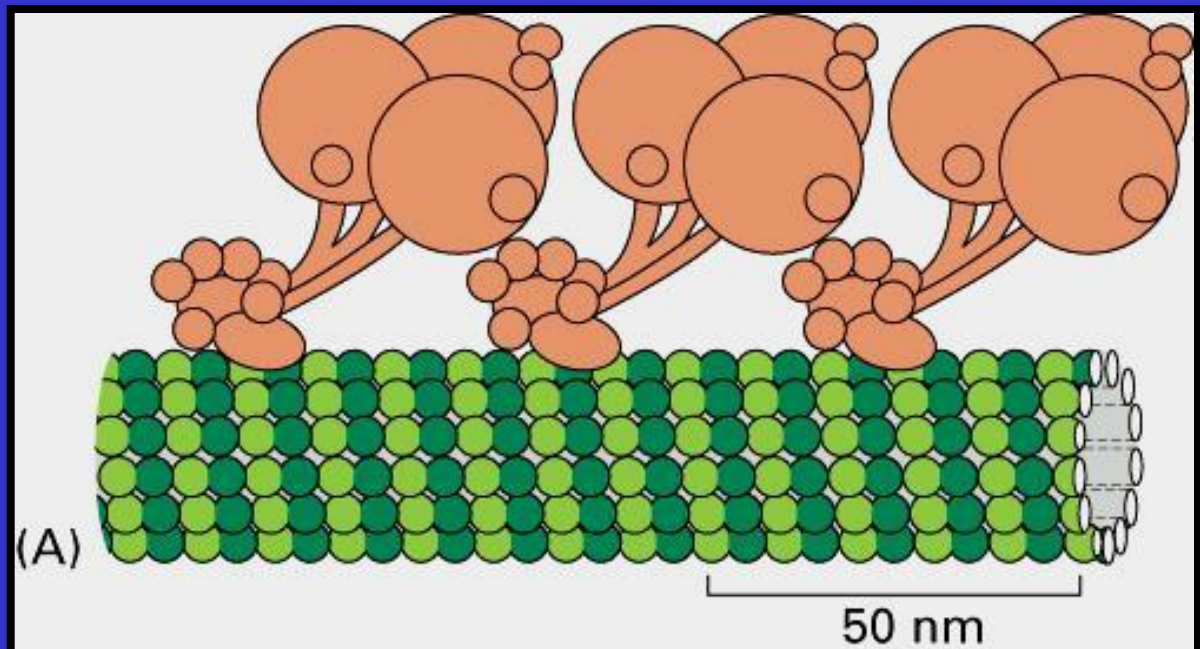
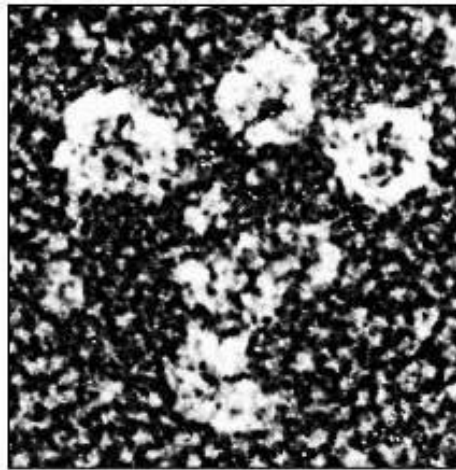


Figure 16-78. Molecular Biology of the Cell, 4th Edition.

ciliary dynein



25 nm

Dynein Motors cause microtubule sliding in vitro; these motors cause bending in an intact flagellum

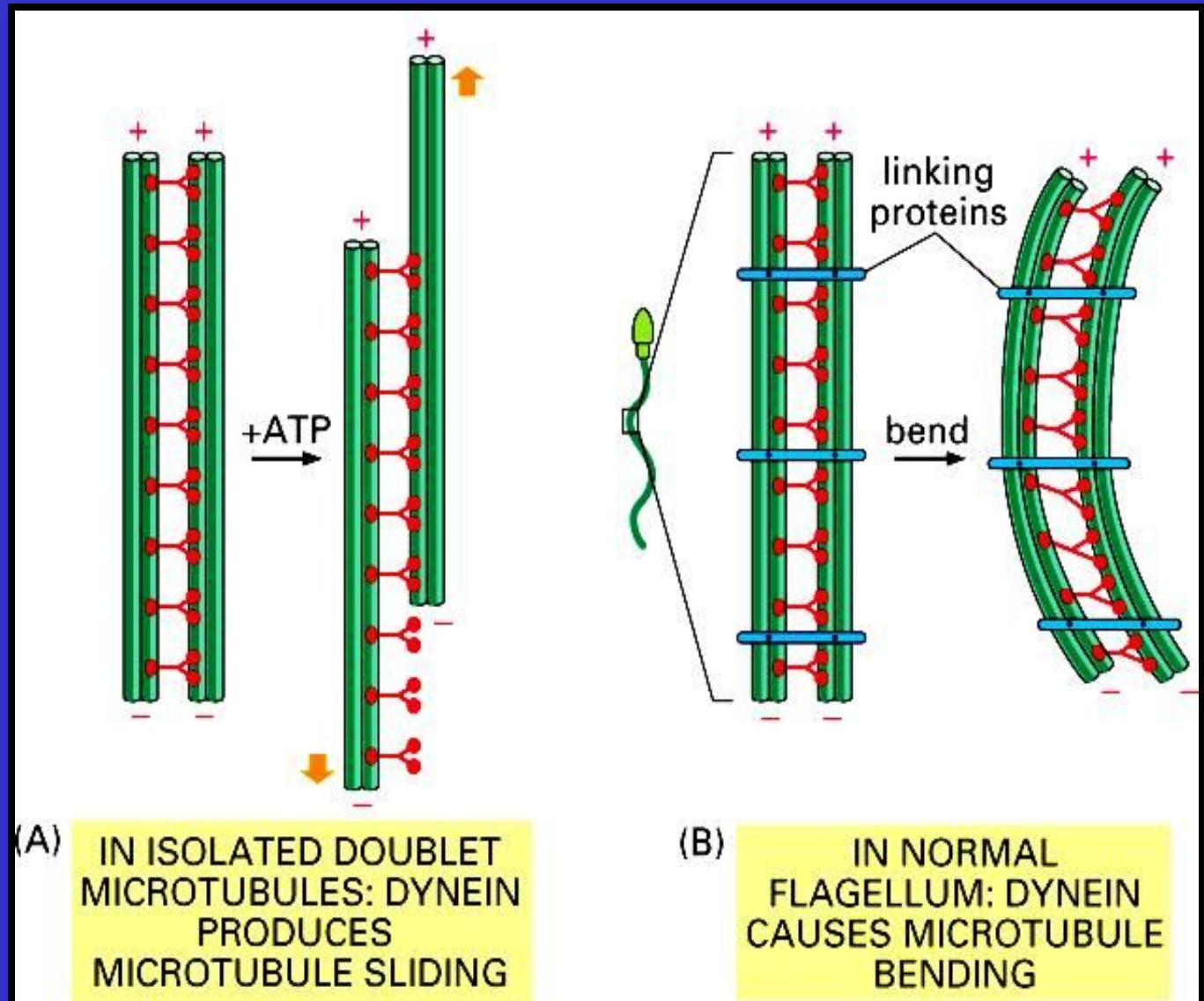


Figure 16-79. Molecular Biology of the Cell, 4th Edition.