Hyaloplasm

1. Definition

It is the fundamental substance of the cell in which the organelles are bathed. It accounts for 50 to 60% of cell volume.

The hyaloplasm with the organelles (without the nucleus) make up the cytoplasm. It consists of two parts:

- A complex aqueous solution (cytosol).

- Un réseau de filaments protéiques: le cytosquelette

2. Chemical Composition of Cytosol

Water: 70%

Protein: 15-20%

ARNm et ARNt

Various solutes: soluble sugars, amino acids, nucleotides, organic compounds, ions...

pH 7 (animal cell), pH 5.5 to 6 (plant cell)

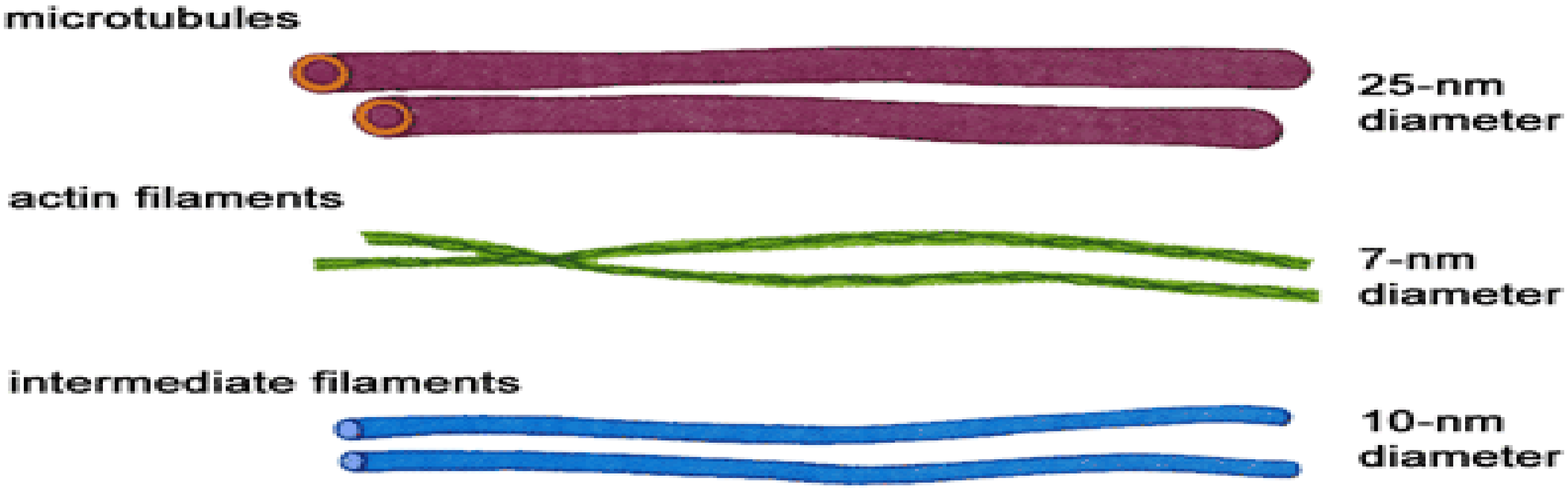
Hyaloplasm can be solid (in gel form) or fluid

In the hyaloplasm of some cells, there are reserves such as glycogen inclusions (hepathocytes) or lipid inclusions (adipose tissue, oilseeds).

3. Cytoskeleton

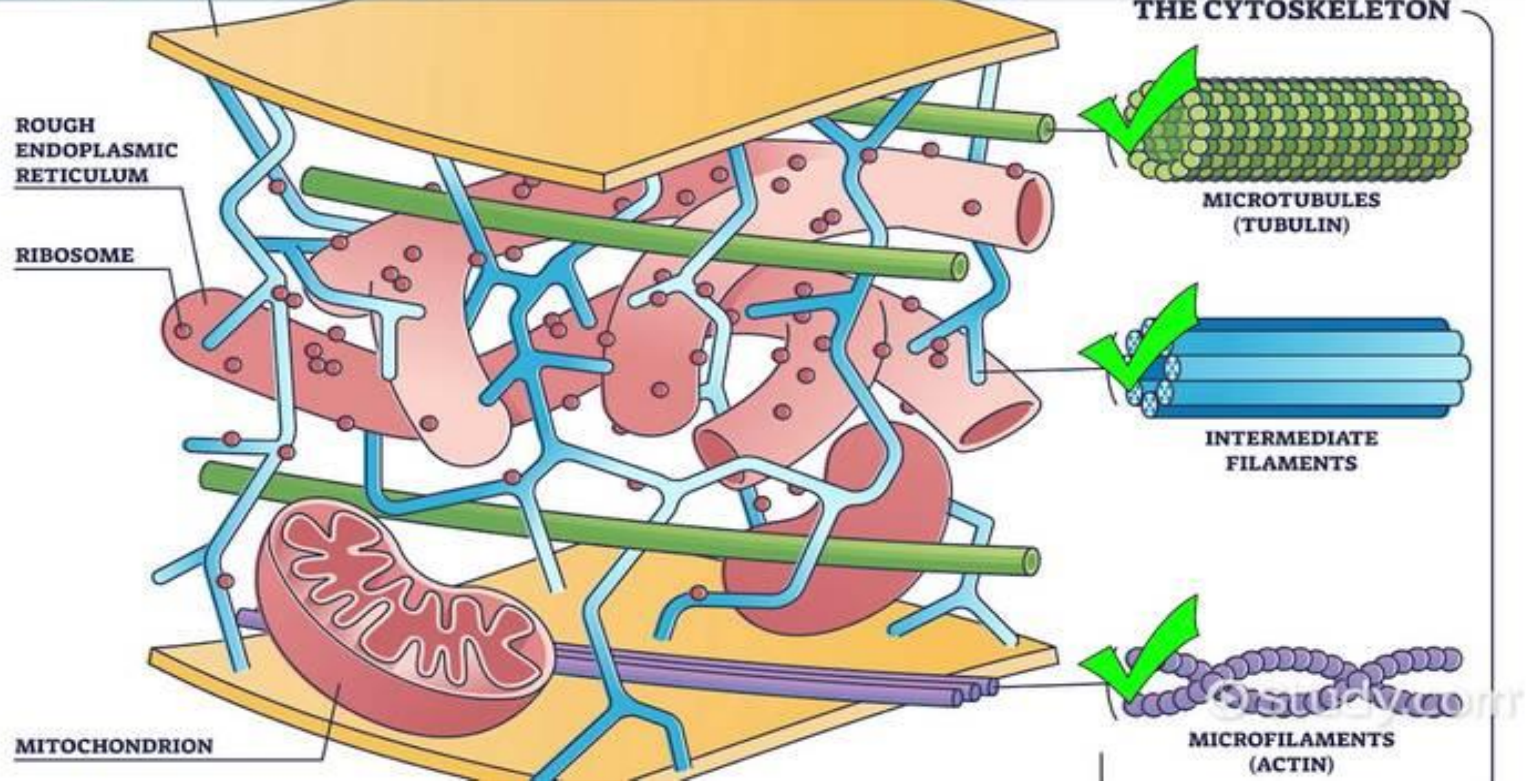
All eukaryotic cells have several types of fibrous or tubular structures that participate in both its architecture and its dynamics: the cytoskeleton.

They are classified into three networks in animal cells:



Plant cells lack intermediate filaments.

WHAT IS CYTOSKELETON?



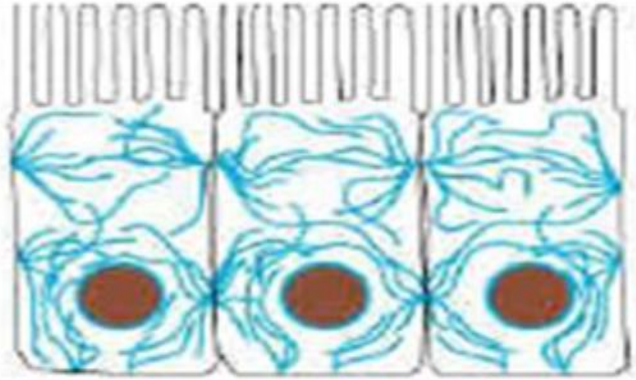
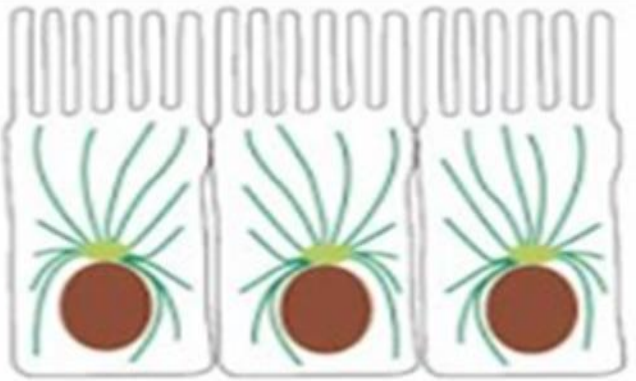
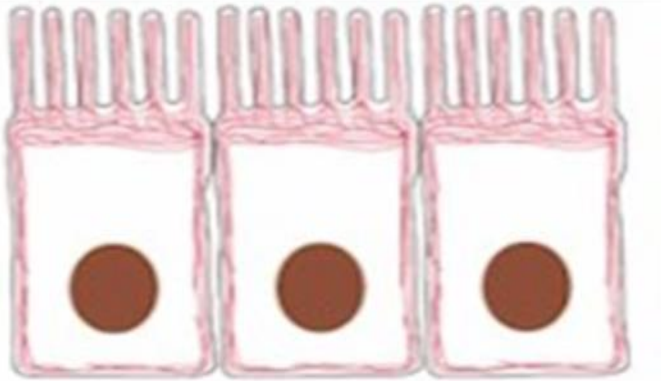
Cytoskeletal Location:

The cytoskeleton is located in:

- Cellular Periphery
- in the cytoplasm
- in the nucleoplasm

- The cytoskeleton is a dynamic system that is constantly assembling and disassembling and requires energy (GTP and ATP),

3 types of fibers make up the cytoskeleton

		
Intermediate Filaments	**Microtubules**	**Actin Microfilaments**

- Microtubules interact with motor systems: **dyneins** and **kinesins**
- Microfilaments interact with **myosins**
- Intermediate filaments **do not** interact with motor proteins

1* Intermediate filaments

- Intermediate filaments have diameters between 8 and 11 nm, which is intermediate between the diameters of the two other principal elements of the cytoskeleton, actin filaments (about 7 nm) and microtubules (about 25 nm).

- Intermediate filaments are strong, flexible rope like fibers that provide mechanical strength to cells.

- IFs are a chemically **heterogeneous group** of structures that, in humans, are encoded by approximately 70 different genes.

* They reinforce cell shape and fix nucleus and organelle location.

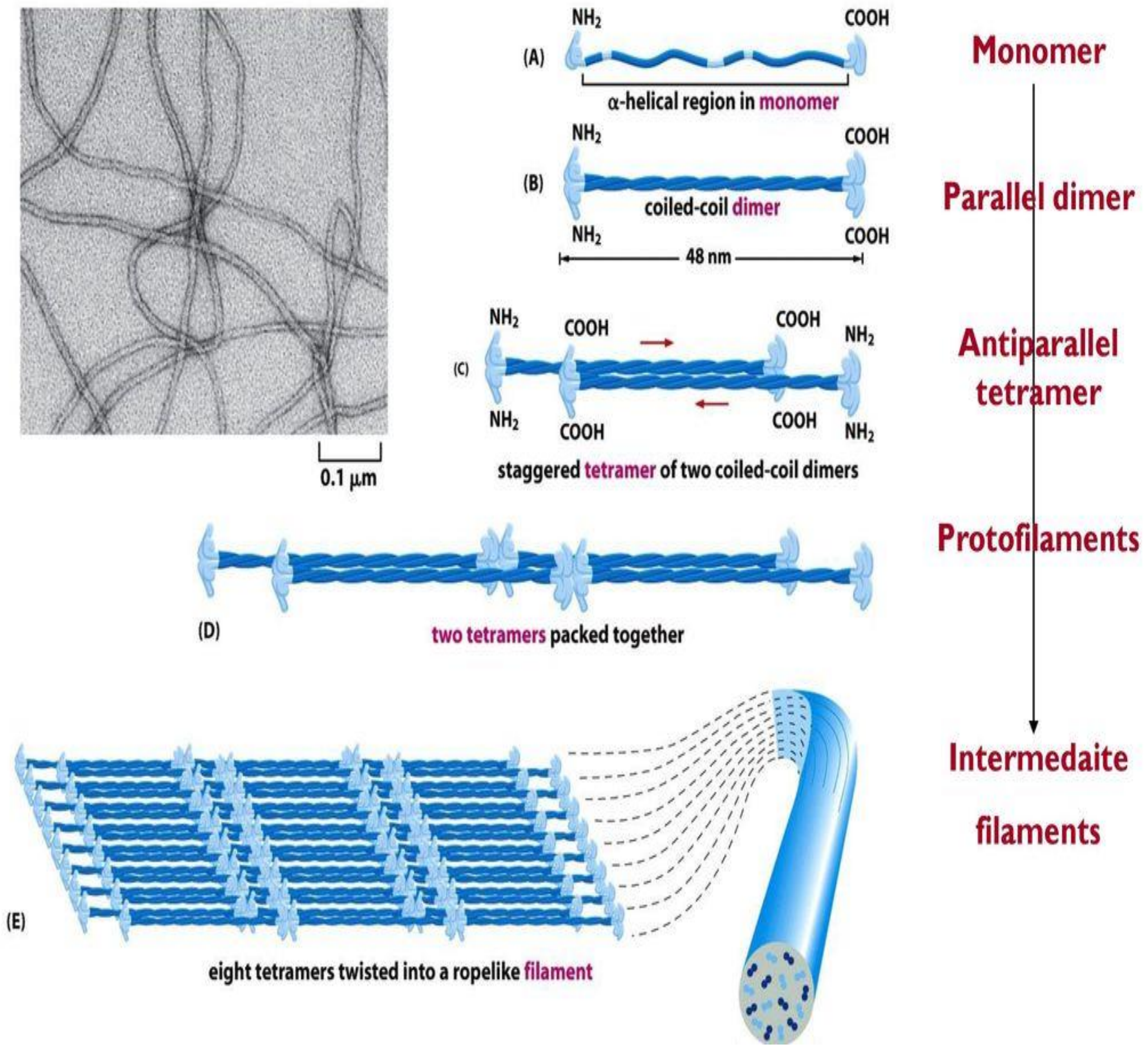
- The Intermediate filaments:
- Are made up of the assembly of monomers of filamentous proteins; these monomers will have a terminal N and C end; the monomers will assemble to form parallel dimers; the terminal N and C ends will match.

- -The dimers will assemble into tetramers in an antiparallel manner

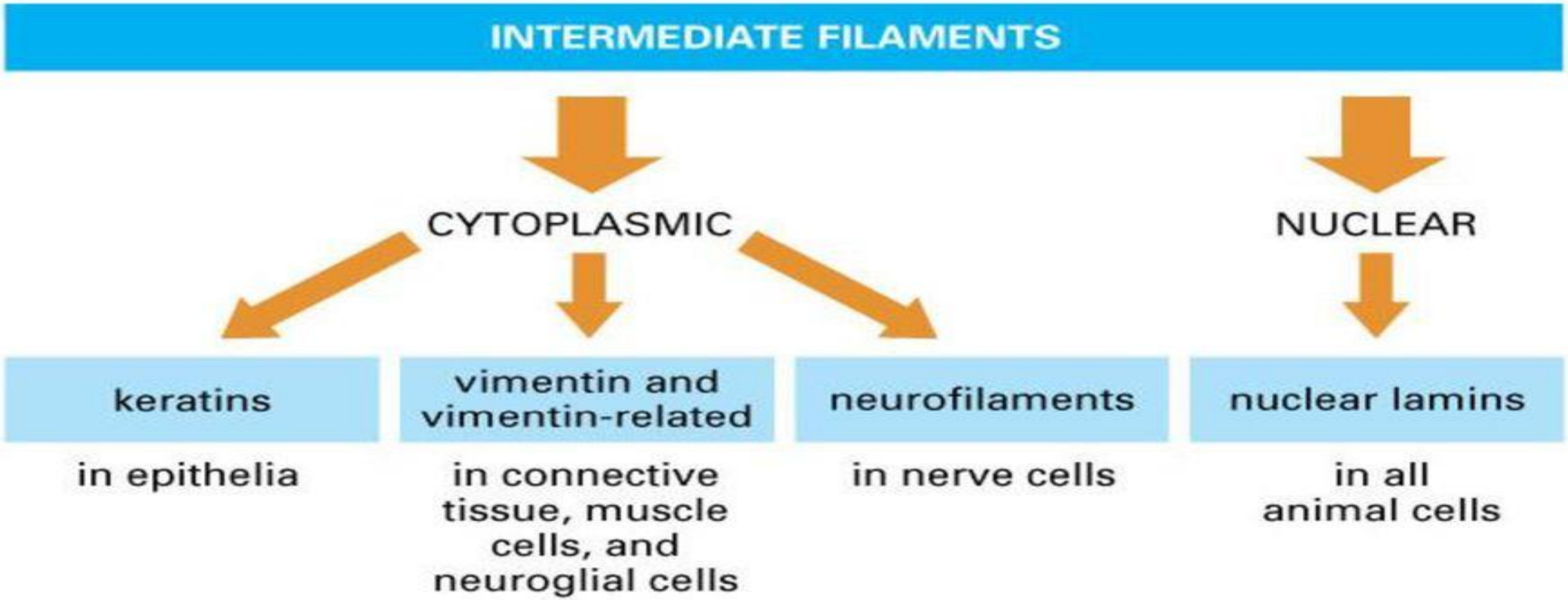
- -The tetramers will assemble end to end with the terminal C end facing the terminal N end to form a protofilament.

- -8 protofilaments will then assemble to form the intermediate filament (10 nm thickness).

Structure of an intermediate filaments



There are 4 classes of intermediate filament proteins



2. Microtubules

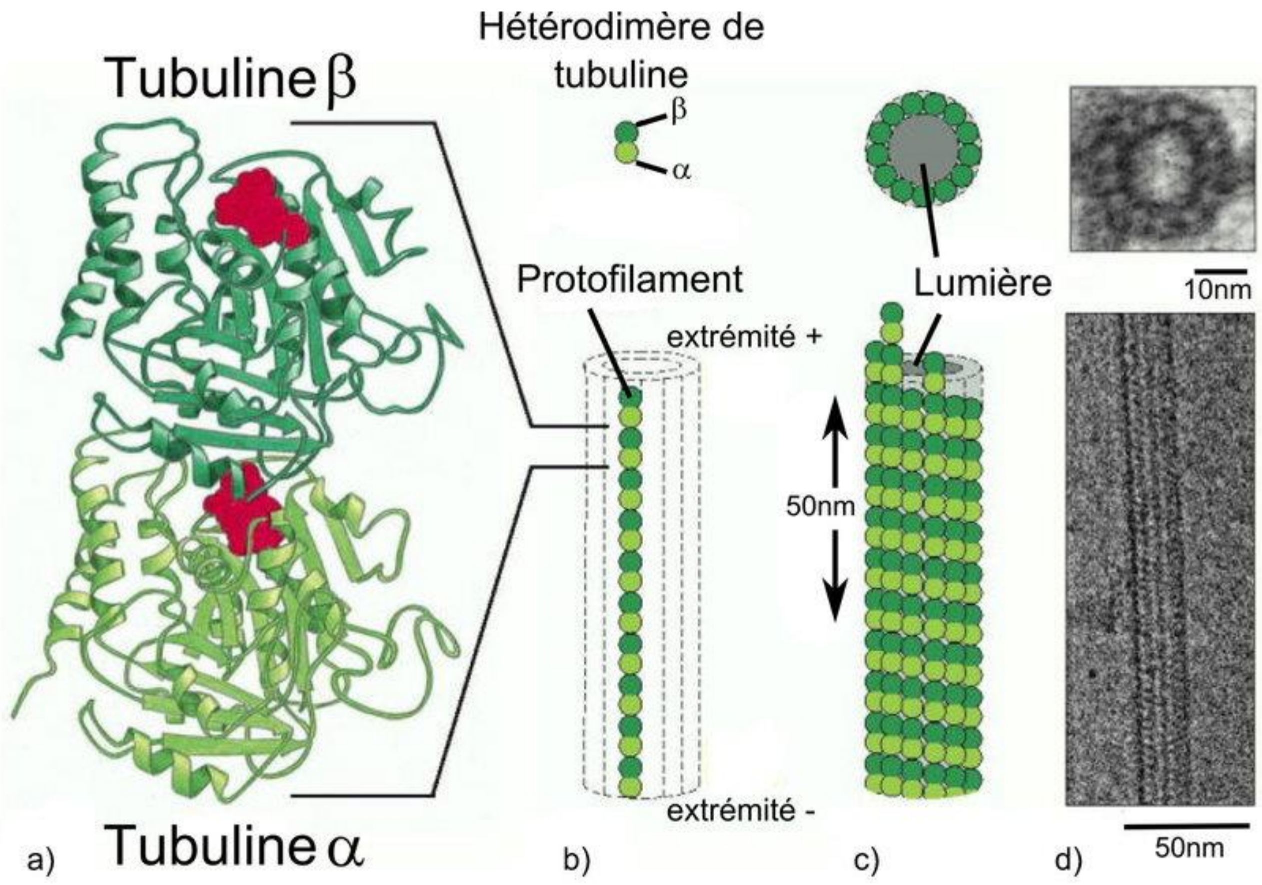
.1. Structure

They are linear tubular structures with a diameter of 25 nm.

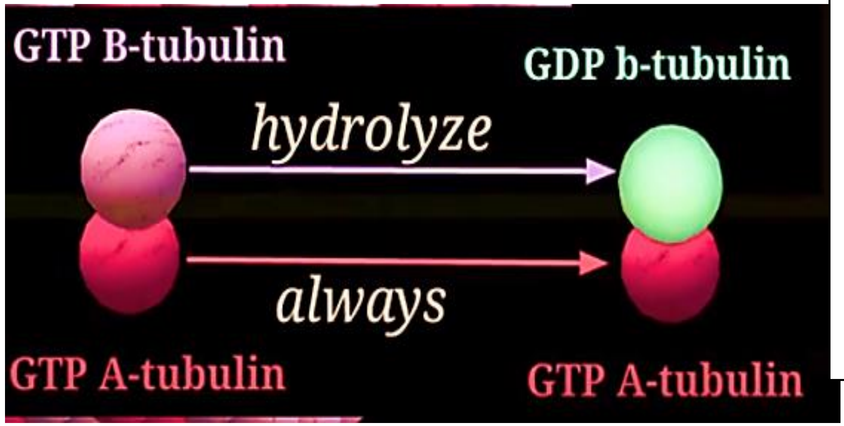
They appear in the form of "rails" in longitudinal section and in circular form in transverse section.

The main constituent is a 50 kDa globular protein capable of Associer et dissocier: Tubulin with 2 tubulin subunits. α and β.

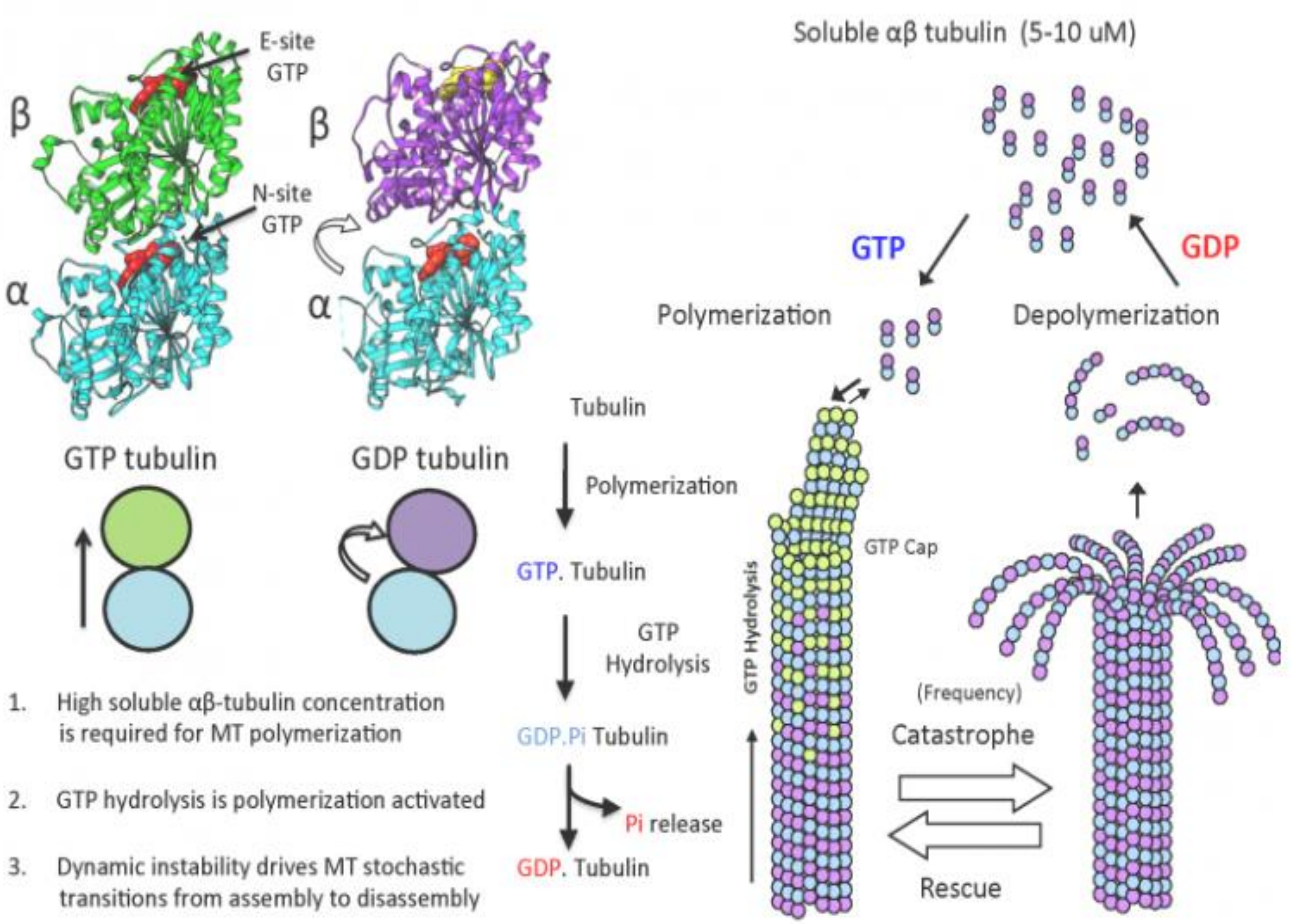
These spontaneously form linear filaments called protofilaments which, grouped side by side in groups of 13, make up the wall of the microtubule.



- The plus end of a growing microtubule contains tubulin bound to GTP = *GTP cap*
- Tubulin is a **GTPase** and hydrolyzes its GTP soon after incorporation into the microtubule
- If new GTP tubulin is not added to the plus end fast enough, GDP-tubulin is exposed at the plus end
- This allows the microtubule to disassemble



Microtubule Dynamic Polymerization & GTP hydrolysis



1. High soluble αβ-tubulin concentration is required for MT polymerization
2. GTP hydrolysis is polymerization activated
3. Dynamic instability drives MT stochastic transitions from assembly to disassembly

Catastrophe → Addition Rate < Hydrolysis Rate

Microtubule Associated Proteins (MAPs)

Microtubule-associated proteins (MAPs) structure the cytoskeleton

MAPsstructcyto

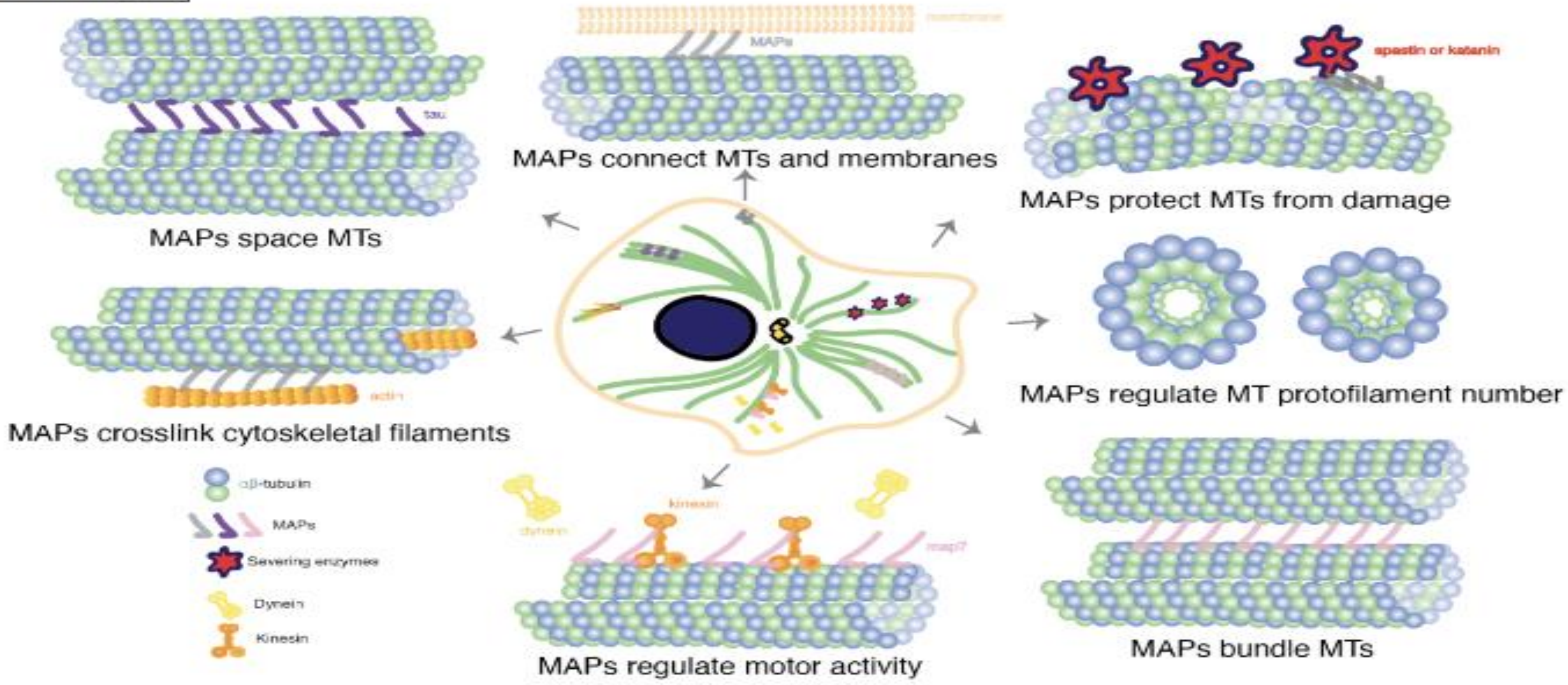


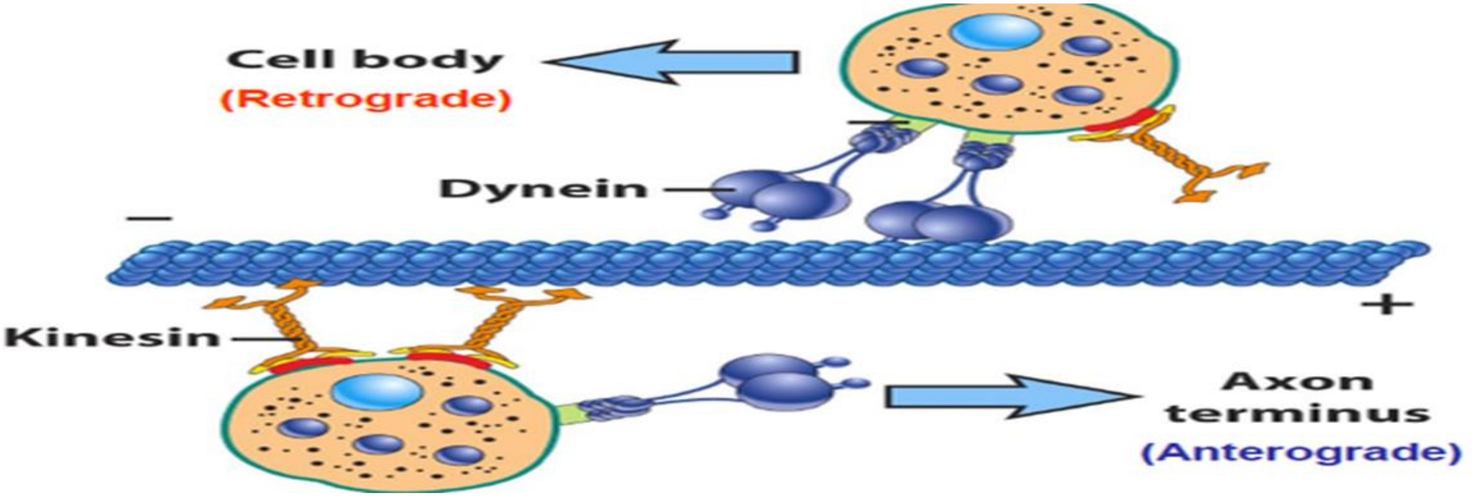
Figure 1. Schematic of the multiple ways MAPs can influence MT structure, behavior, and function, as well as other MAPs and motors. MAPs can change MT spacing, connect MTs with membranes, protect MTs from severing, crosslink cytoskeletal filaments, control PF number, regulate motor motility, bundle MTs[5].

Microtubule functions

Cell Transport

Microtubules aid the movement of organelles inside the cytoplasm of the cells. They also help various areas of the cell to communicate with each other.

There are two major classes of motor protein associated with movement along microtubules: the kinesins and dyneins. Both classes of microtubule motor protein display ATPase activity, with the energy required for moving proteins across the microtubule derived from the hydrolysis of ATP.



The movement of kinesins across microtubules mostly occurs in the direction of the plus end, meaning cellular cargo is transported from the center of the cell to the periphery.

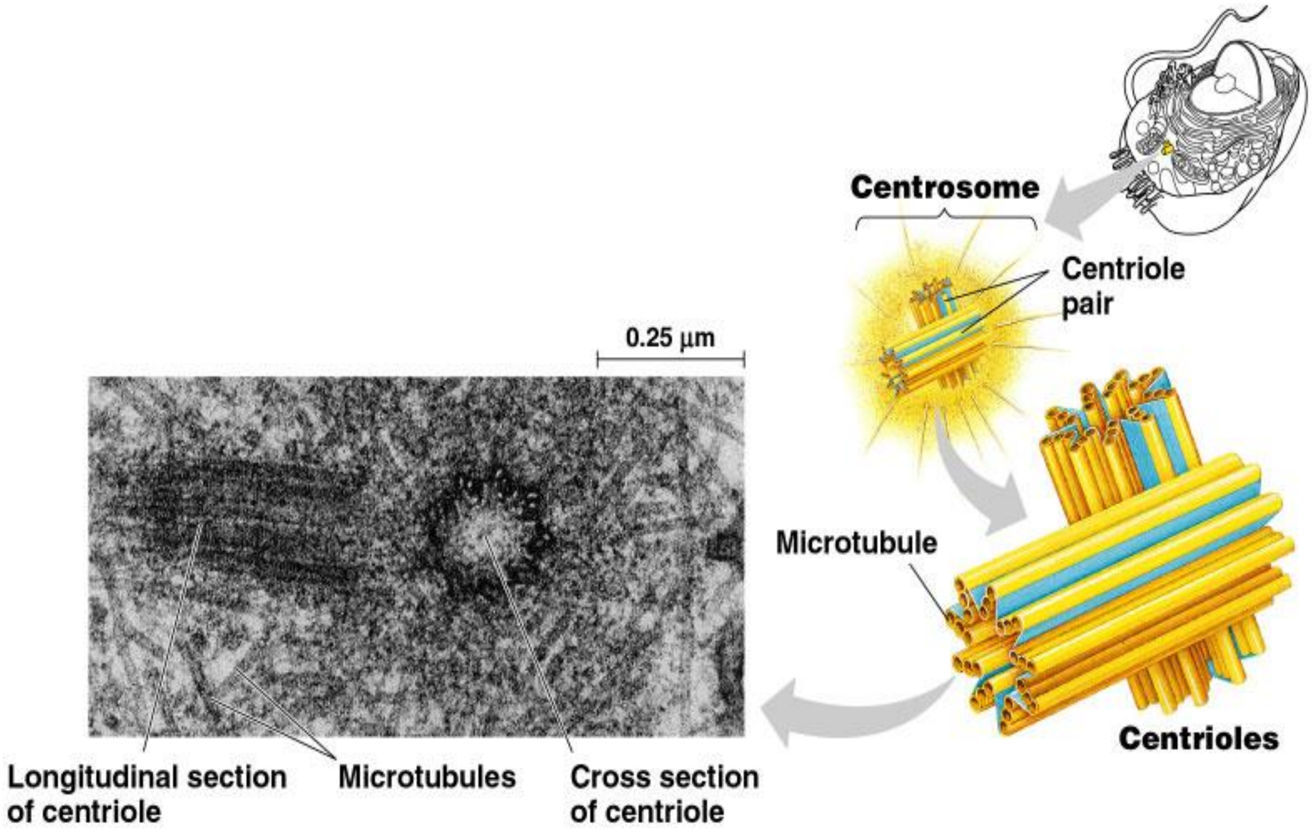
Cell Division

Microtubules play a major role in forming the mitotic spindles. These mitotic spindles organize and separate the chromosomes during cell division.

- In many cells, microtubules grow out from a **centrosome** near the nucleus.
  - These microtubules resist compression to the cell.

- In animal cells, the centrosome has a pair of **centrioles**, each with nine triplets of microtubules arranged in a ring.

- During cell division the centrioles replicate.

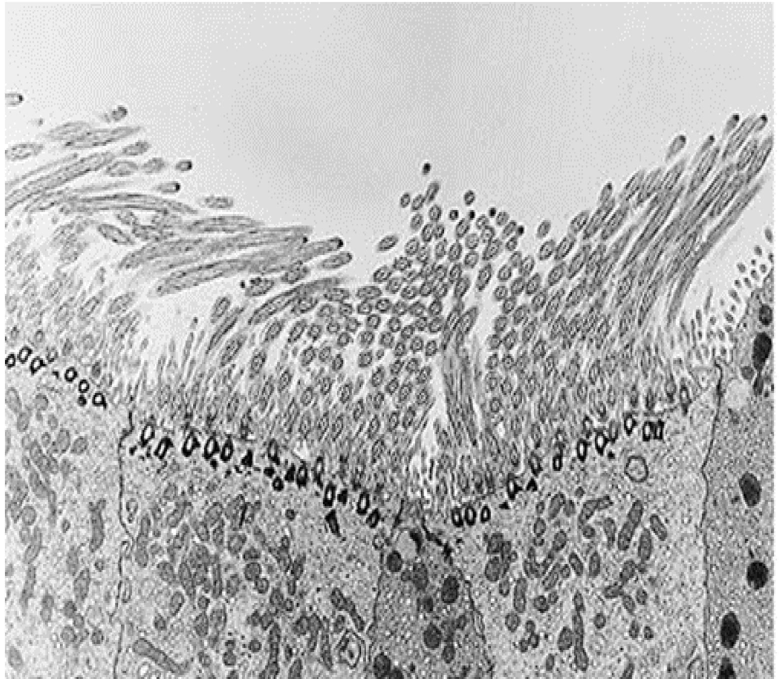


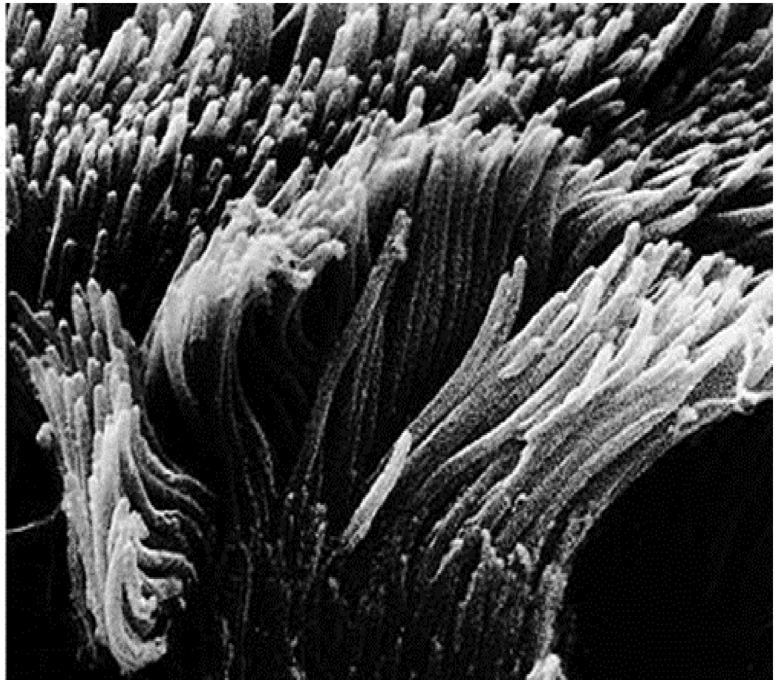
Cell Movement

Microtubules give structures to cilia and flagella. They also facilitate the contraction and expansion of the cell helping them to move from one place to another.

If these structures are anchored in a large structure, they move fluid over a surface.

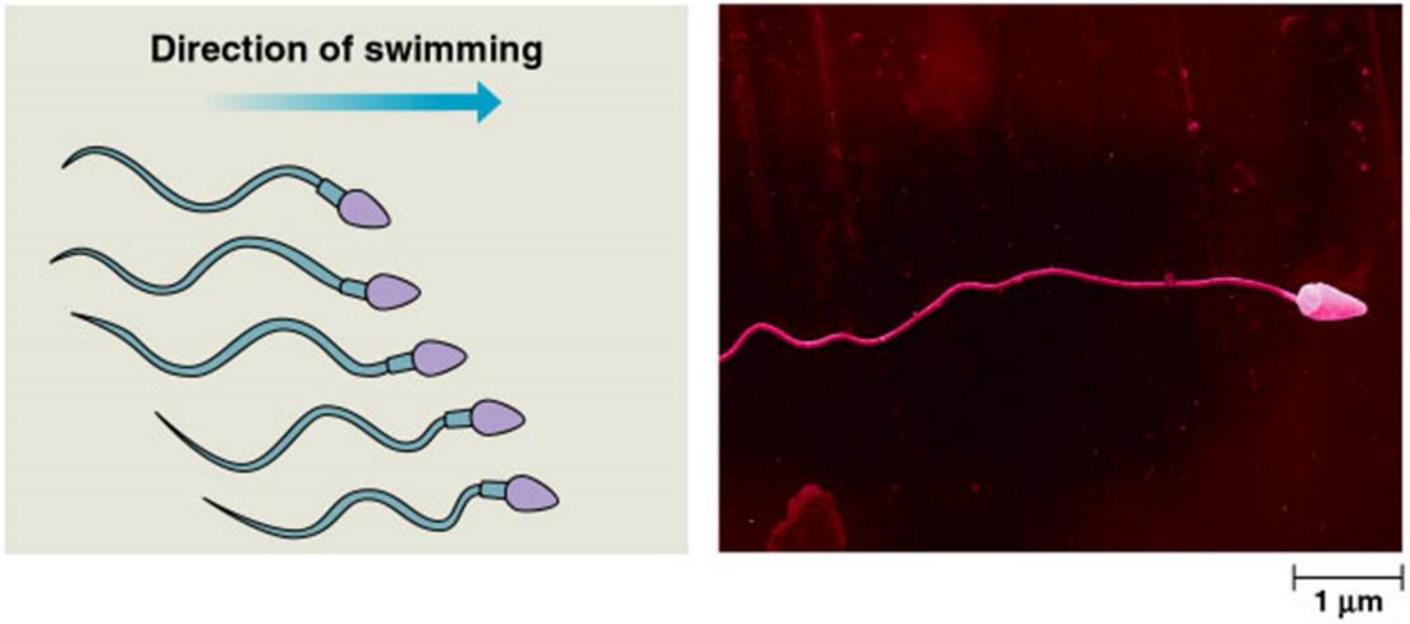
- For example, cilia sweep mucus carrying trapped debris from the lungs.





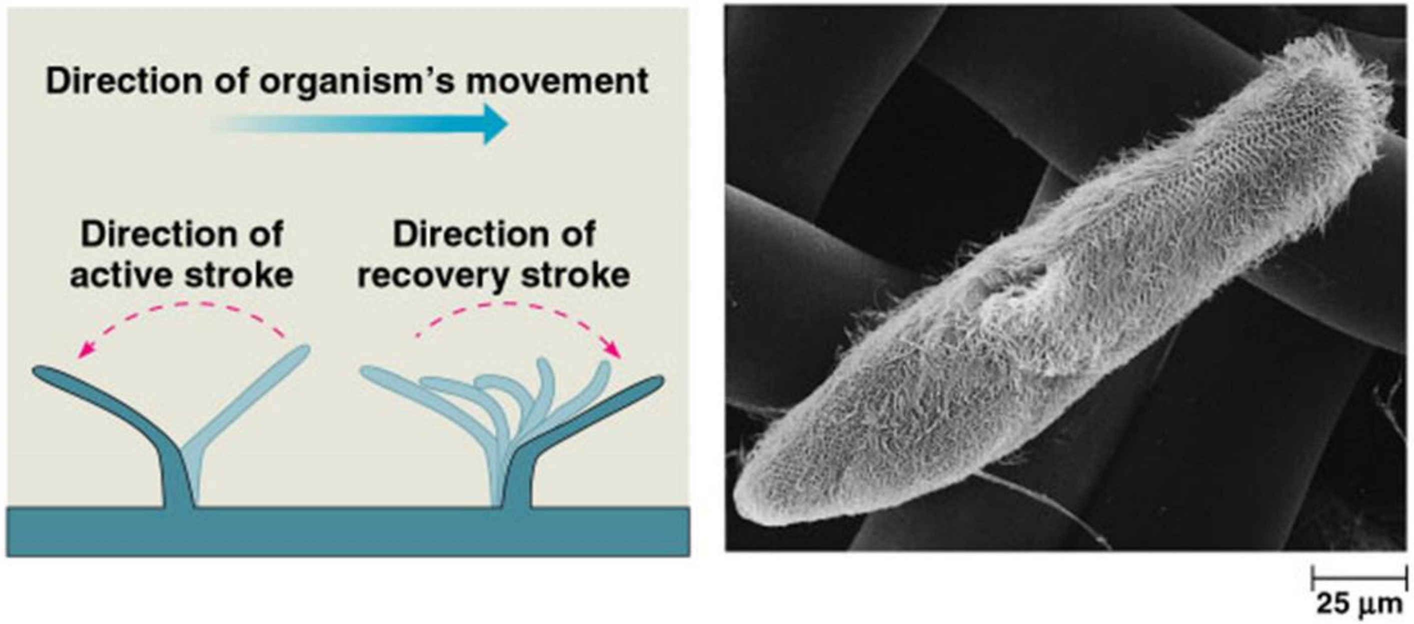
- Cilia usually occur in large numbers on the cell surface.
  - They are about 0.25 microns in diameter and 2-20 microns long.
- There are usually just one or a few flagella per cell.
  - Flagella are the same width as cilia, but 10-200 microns long.

- A flagellum has an undulatory movement.
  - Force is generated parallel to the flagellum's axis.



(a) Motion of flagella

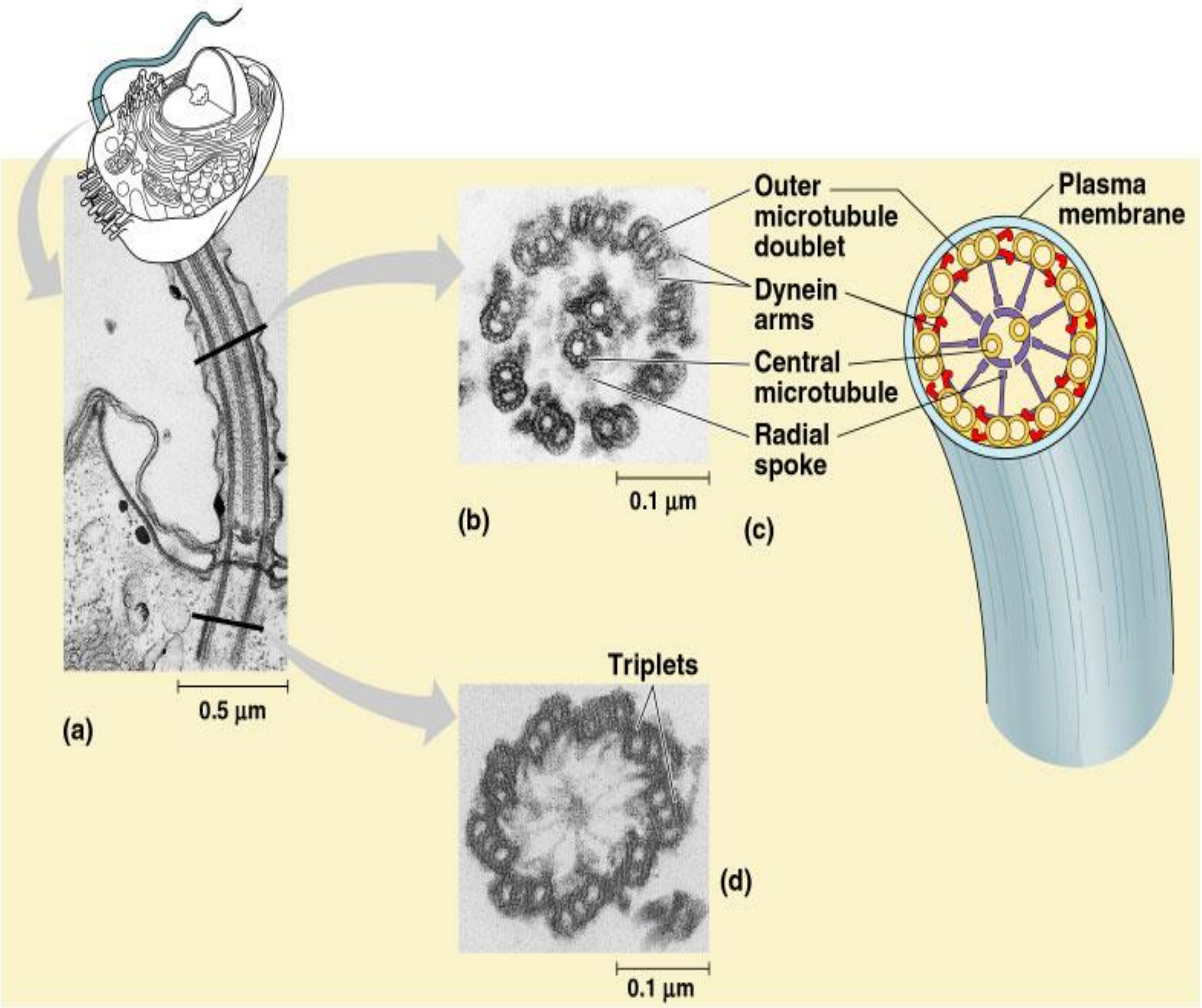
- Cilia move more like oars with alternating power and recovery strokes.
  - They generate force perpendicular to the cilia’s axis.



(b) Motion of cilia

• Cilia and flagella ultrastructure.

- In spite of their differences, both cilia and flagella have the same ultrastructure.
  - Both have a core of microtubules sheathed by the plasma membrane.
  - Nine doublets of microtubules arranged around a pair at the center, the “9 + 2” pattern.
  - Flexible “wheels” of proteins connect outer doublets to each other and to the core.
  - The outer doublets are also connected by motor proteins.
  - The cilium or flagellum is anchored in the cell by a **basal body,** whose structure is identical to a centriole.



3. Microfilaments

- Microfilaments, the thinnest class of the cytoskeletal fibers, are solid rods of the globular protein **actin**.
  - An actin microfilament consists of a twisted double chain of actin subunits.
- Microfilaments are designed to resist tension.
- With other proteins, they form a three-dimensional network just inside the plasma membrane.

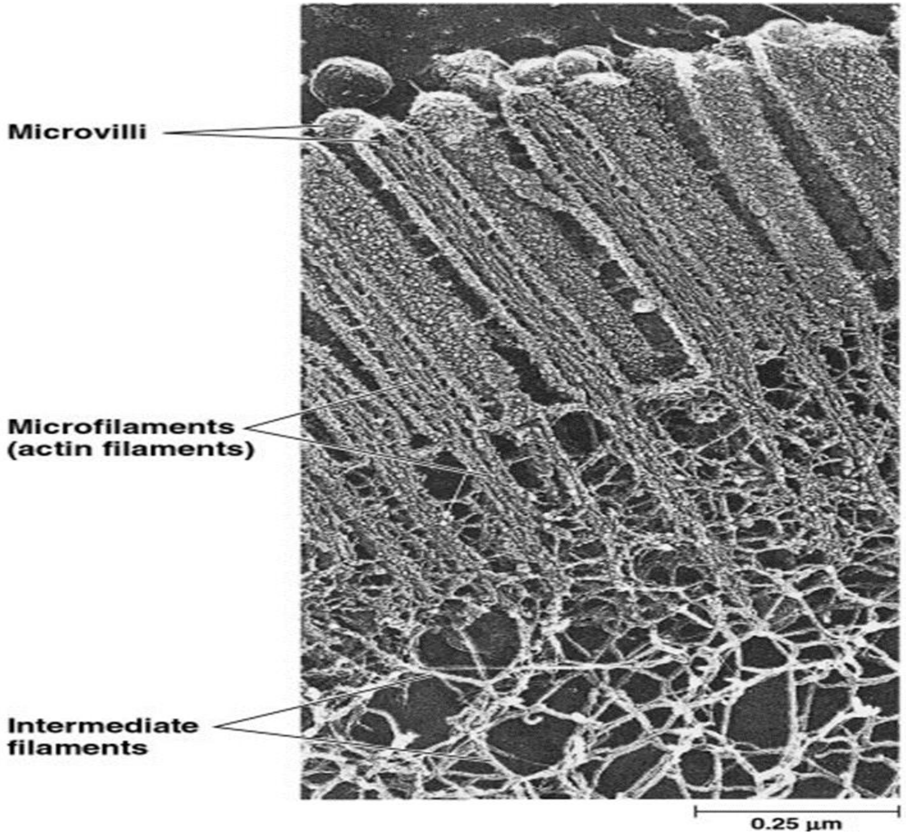
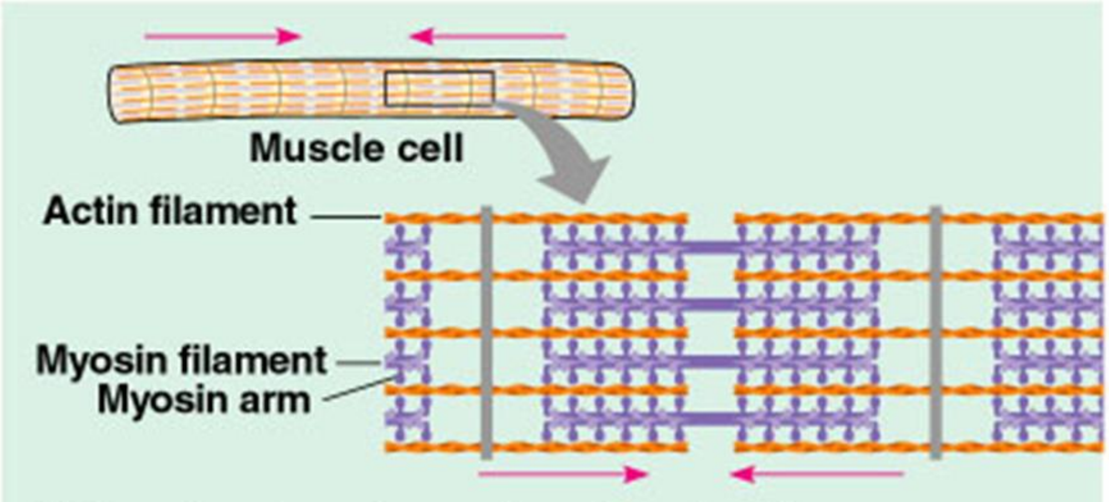


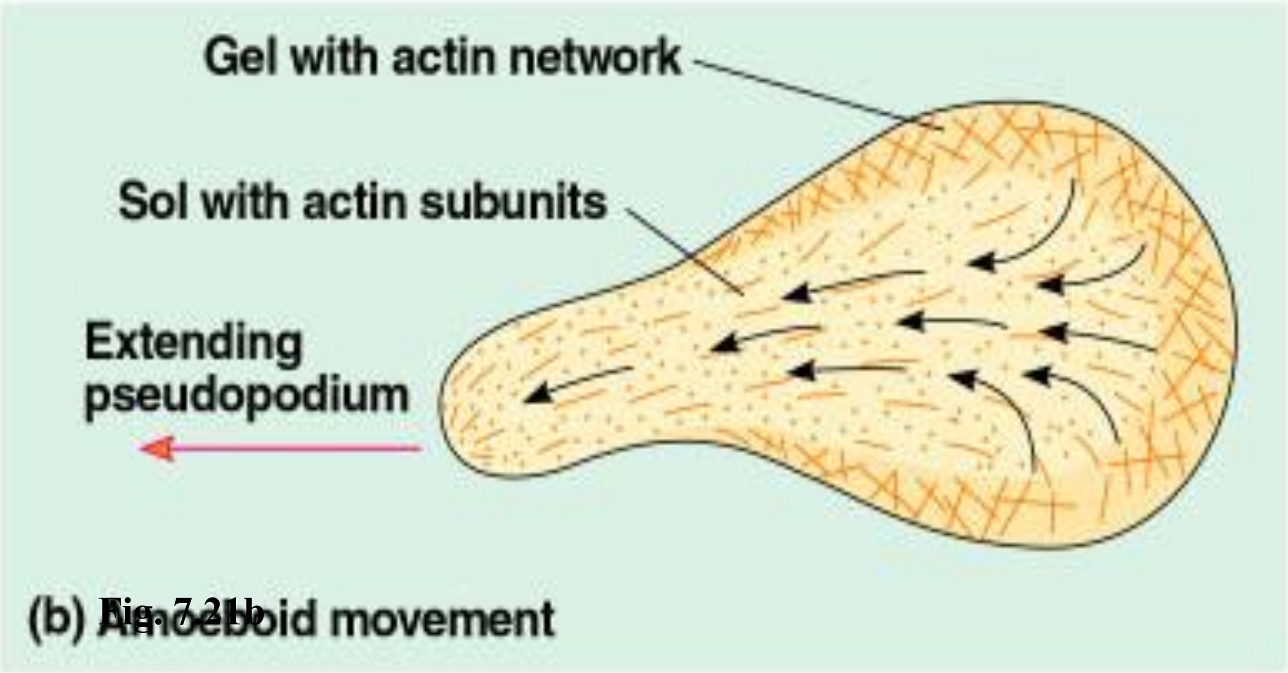
Fig. 7.26 The shape of the microvilli in this intestinal cell are supported by microfilaments, anchored to a network of intermediate filaments.

- In muscle cells, thousands of actin filaments are arranged parallel to one another.
- Thicker filaments, composed of a motor protein, **myosin**, interdigitate with the thinner actin fibers.
  - Myosin molecules walk along the actin filament, pulling stacks of actin fibers together and shortening
    the cell.



(a) Myosin motors in muscle cell contraction

- In other cells, these actin-myosin aggregates are less organized but still cause localized contraction.
  - A contracting belt of microfilaments divides the cytoplasm of animals cells during cell division.
  - Localized contraction also drives amoeboid movement.
    - **Pseudopodia**, cellular extensions, extend and contract through the reversible assembly and contraction of actin subunits into microfilaments.



(b) Amoeboid movement

Fig. 7.21b

- In plant cells (and others), actin-myosin interactions and sol-gel transformations drive **cytoplasmic streaming**.
  - This creates a circular flow of cytoplasm in the cell.
  - This speeds the distribution of materials within the cell.

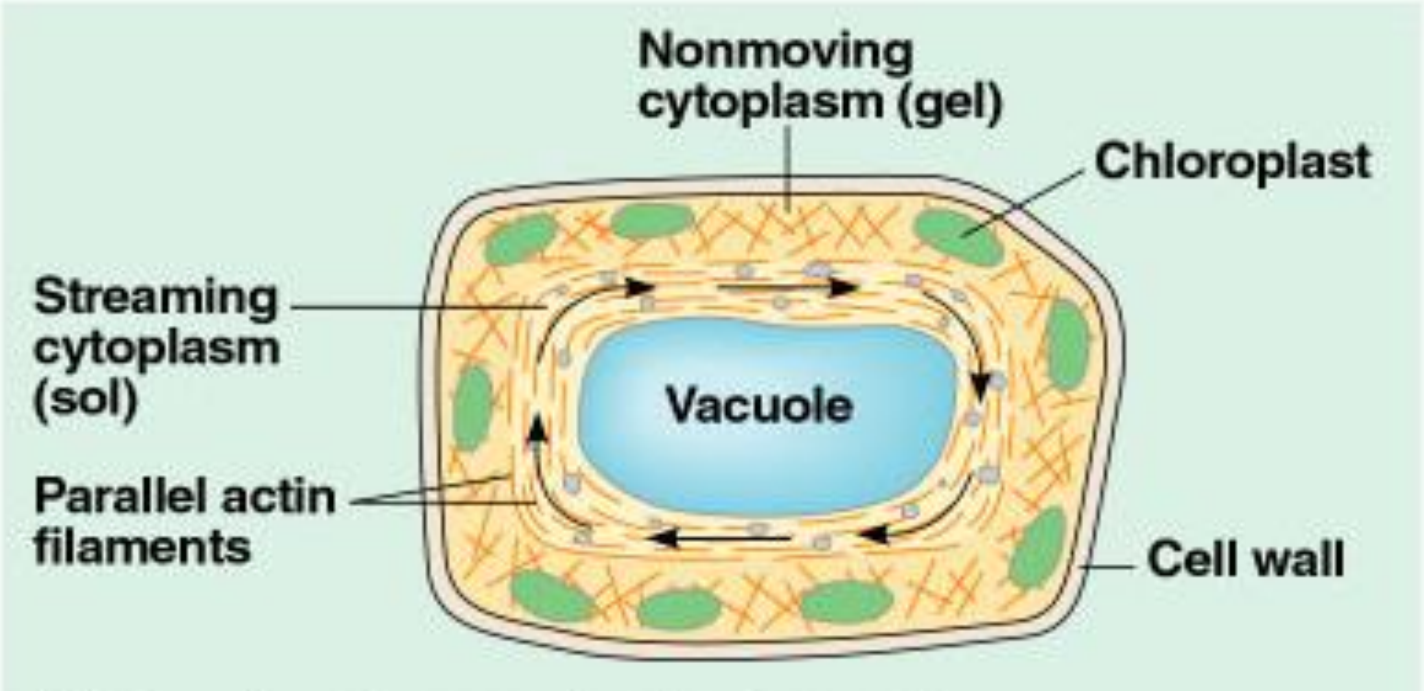


Fig. 7.21c (c) Cytoplasmic streaming in plant cells