CYTOSKELETON (MICROTUBULES, FILAMENTS:

THICK, THIN / MICROFILAMENTS, INTERMEDIATE)

LEARNING OBJECTIVES

- By the end of the lecture, the student should be able to :

- Define Cytoskeleton.
- Describe the composition and functions of cytoskeleton.
- Enumerate the type, distribution and functions of cytoskeleton.
- Describe the details of microtubules.

WHAT IS CYTOSKELETON?

- Cytoplasm contains a complex network of filaments and microtubules which form a structural framework known as CYTOSKELETON.
- It provides structural support to the cell.
- It also functions in cell motility and regulation.

Consists of:

- Filaments.
- Microtubules.

Cytoskeleton: the skeleton of a cell

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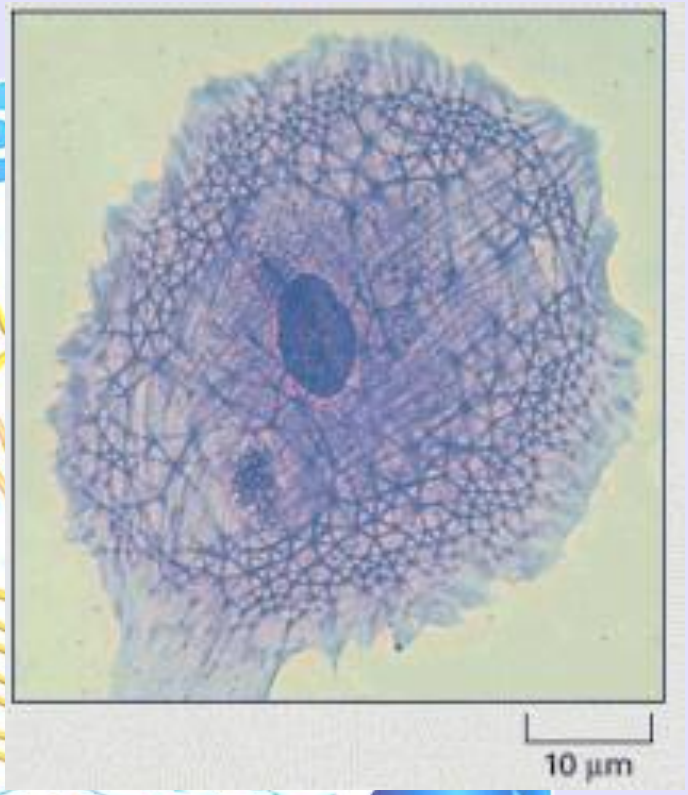
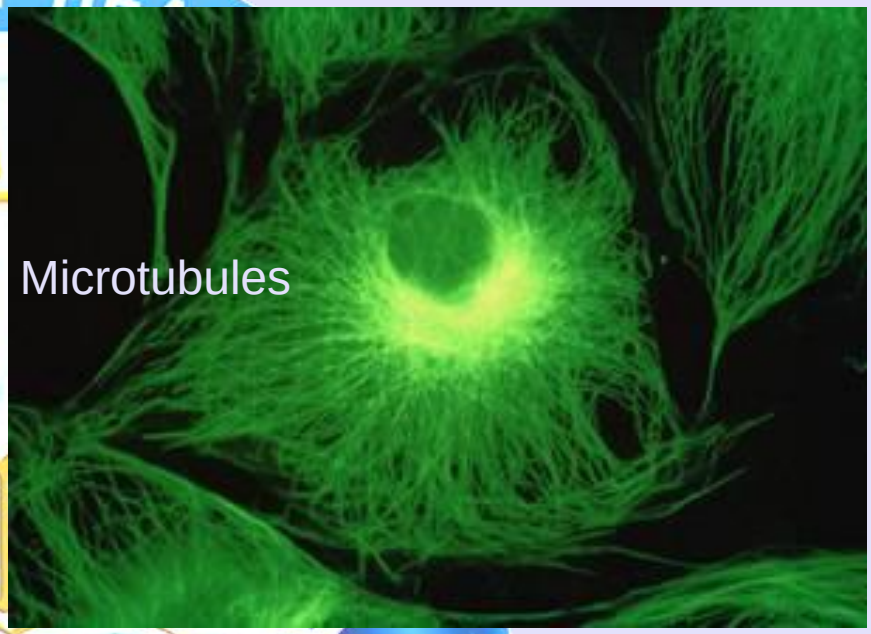


Cells need a cytoskeleton to:

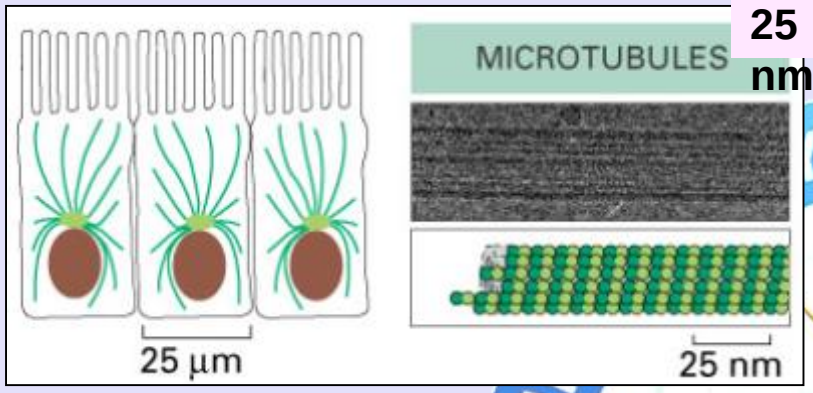
- **create shape**
- **change shape**
- **allow movement**

} dynamic!

Cells have three cytoskeletal elements.



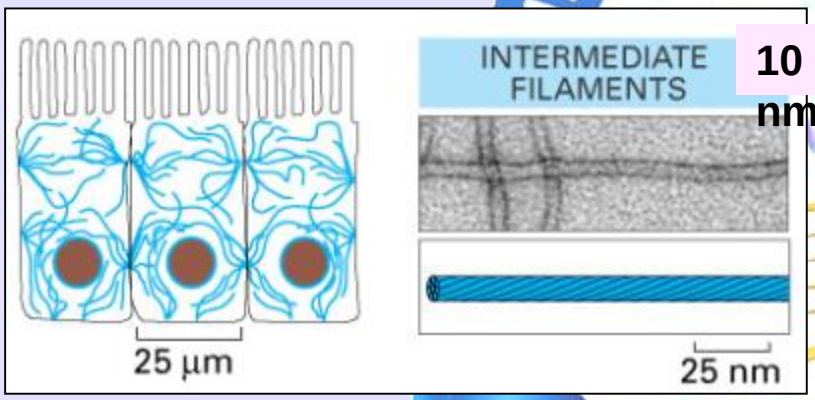
Three filamentous networks in eukaryotic cells



25 nm

MICROTUBULES:

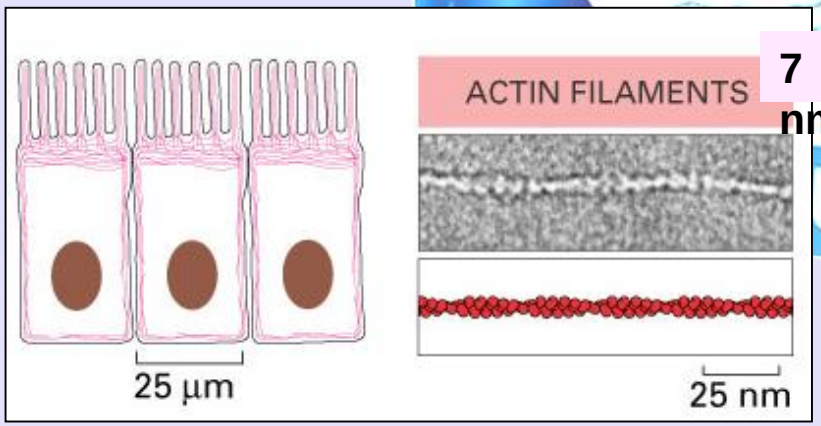
- hollow **tubes** made of tubulin
- **rigid**, long, straight



10 nm

INTERMEDIATE FILAMENTS:

- **heterogenous** group filamentous proteins
- **rope-like** structure used to give cell mechanical strength

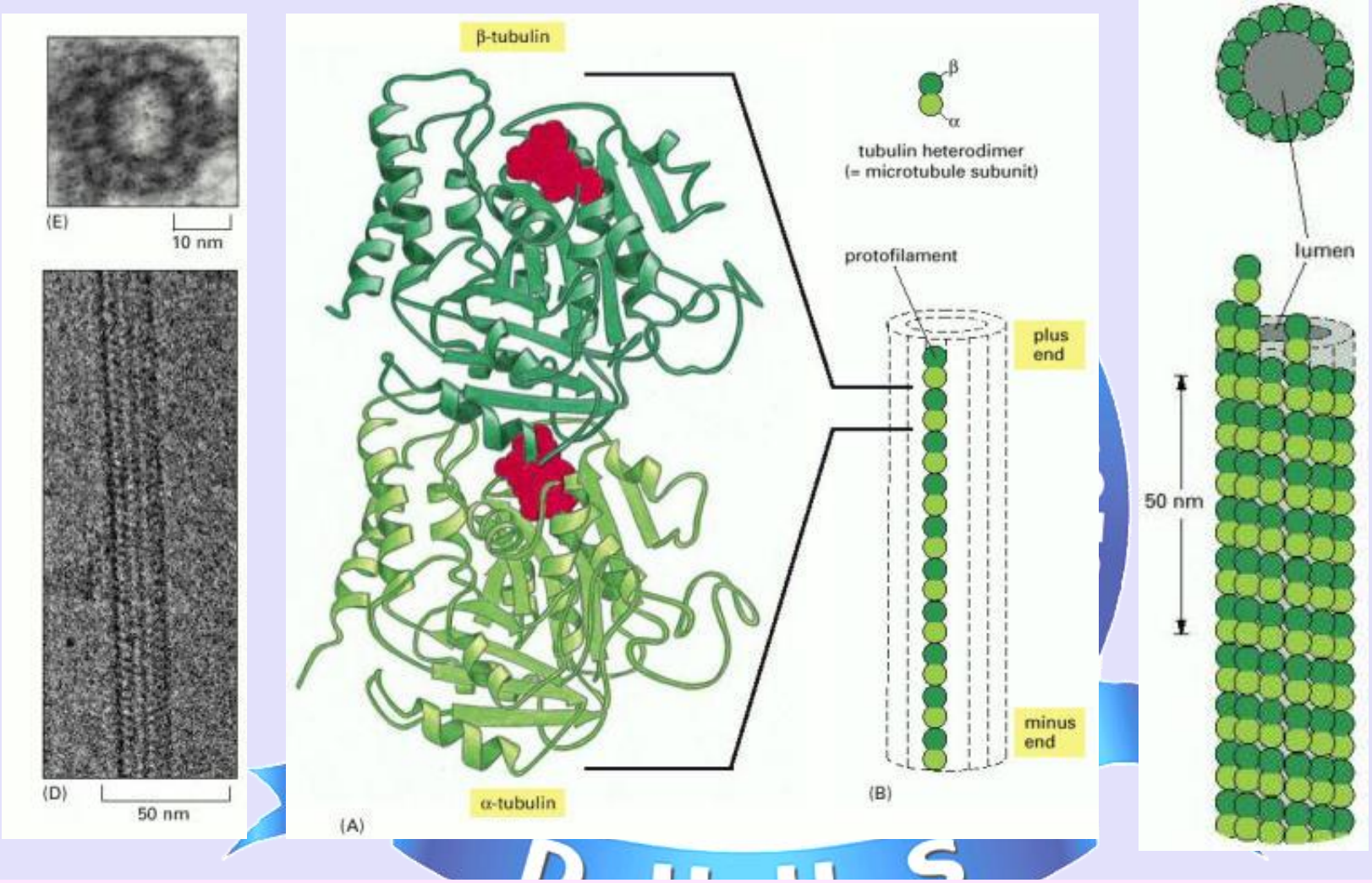


7 nm

ACTIN FILAMENTS:

- helical polymers made of actin
- **flexible**, organized into 2D networks and 3D gels

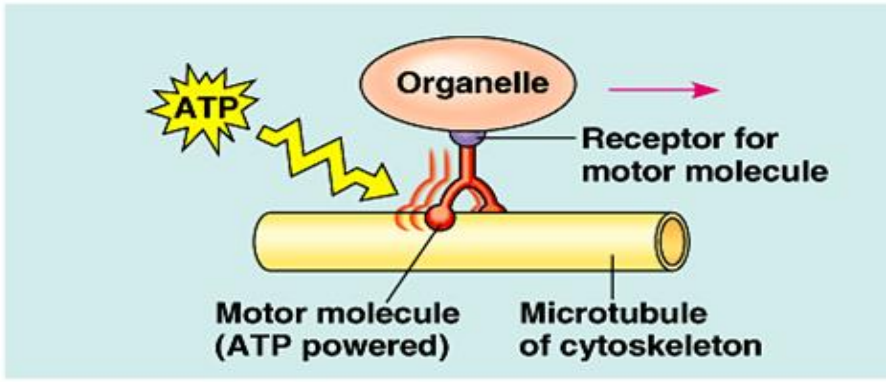
Microtubules



- conserved (there is a bacterial homolog: FtsZ)
- heterodimer (α-tubulin and β-tubulin) which assembles into 13 polarized protofilaments
- GTP bound to α-subunit is hydrolyzed during assembly (requires energy)

MICROTUBULES

- Microtubules, the **thickest** fibers, are hollow rods about **25 microns** in diameter.
  - Microtubule fibers are made up of the globular protein, **tubulin**, and they grow or shrink as more tubulin molecules are added or removed.
- They **move chromosomes** during **cell division**.



(b)

MICROTUBULES

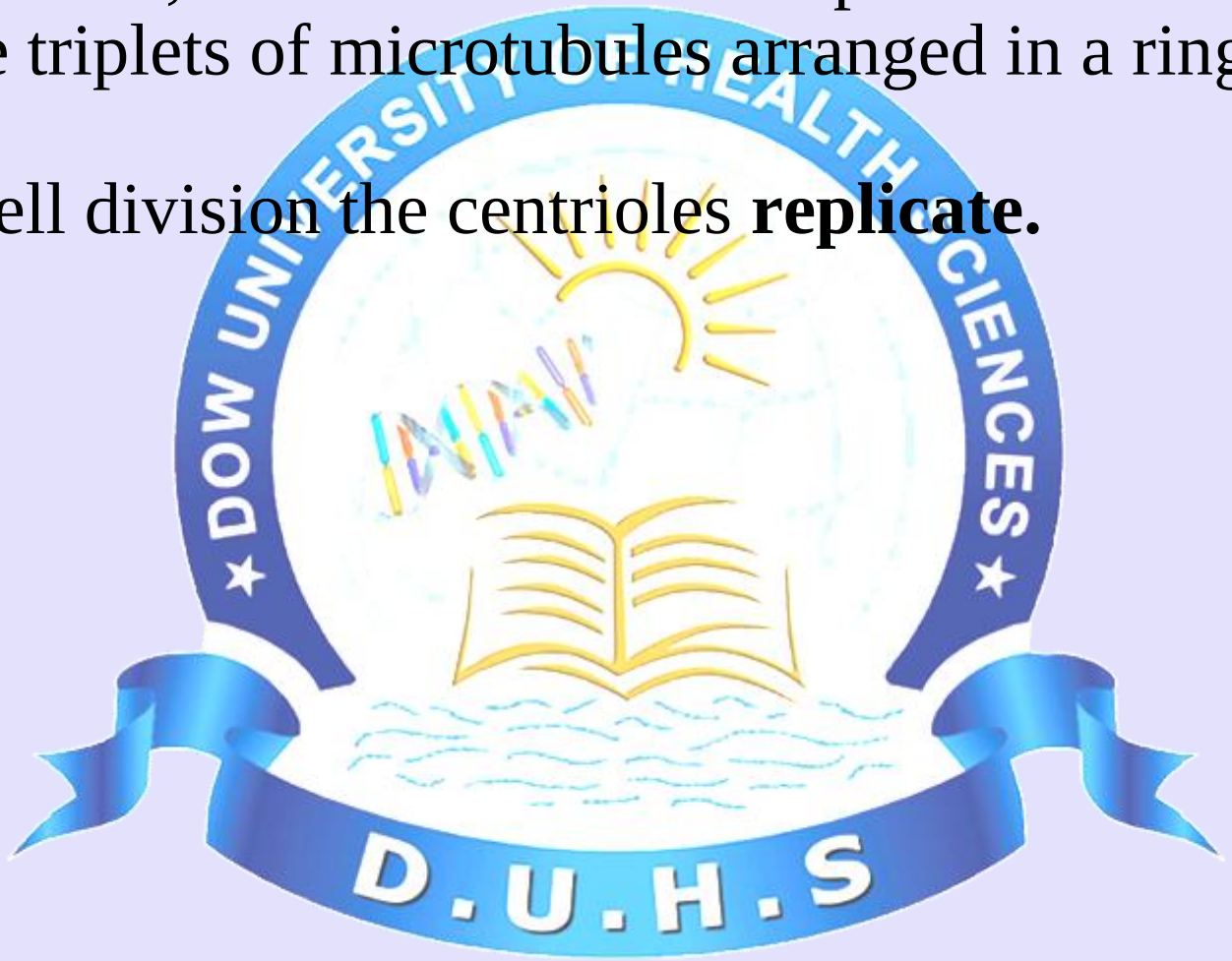
- Another function is that it **guides motor proteins** carrying organelles to their destination.

- In many cells, microtubules grow out from a **centrosome** near the nucleus.

These microtubules **resist compression** to the cell.

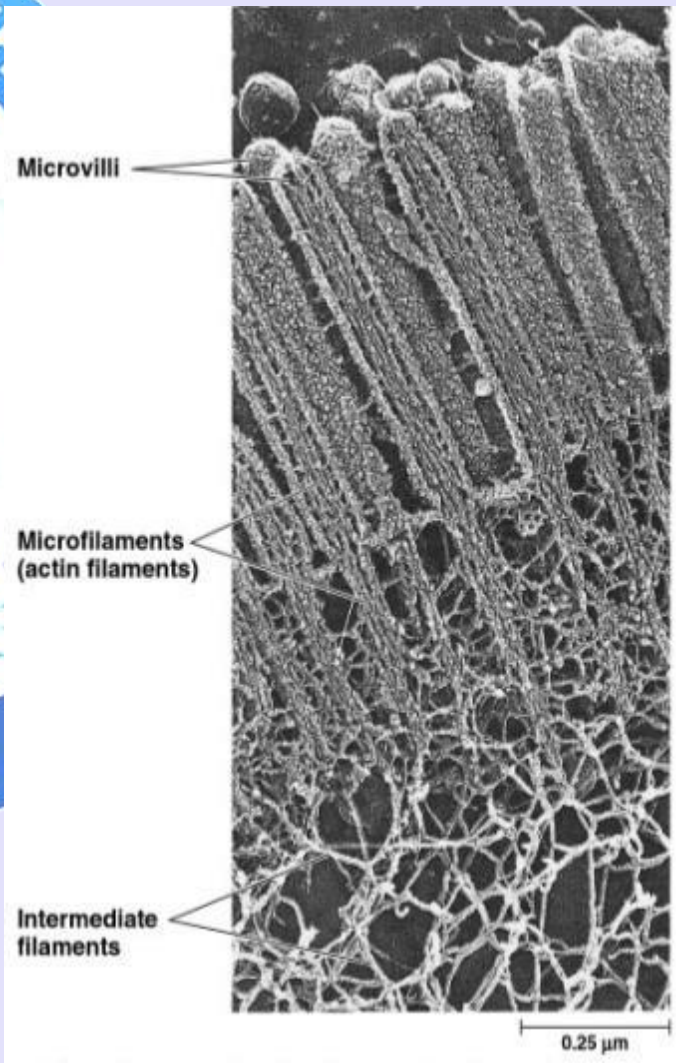
MICROTUBULES

- 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.**



INTERMEDIATE FILAMENTS

- Intermediate in size at **9 - 11 nanometers,** are specialized for bearing tension.
  - Intermediate filaments are built from a diverse class of subunits from a family of **protein**s called **keratins.**
- Intermediate filaments are more permanent fixtures of the cytoskeleton than are the other two classes.
- They **reinforce cell shape** and fix organelle location.



INTERMEDIATE FILAMENTS

Five types:

1. Vimentin filaments.
2. Desmin filaments.
3. Neurofilaments.
4. Glial filaments.
5. Keratin filaments.

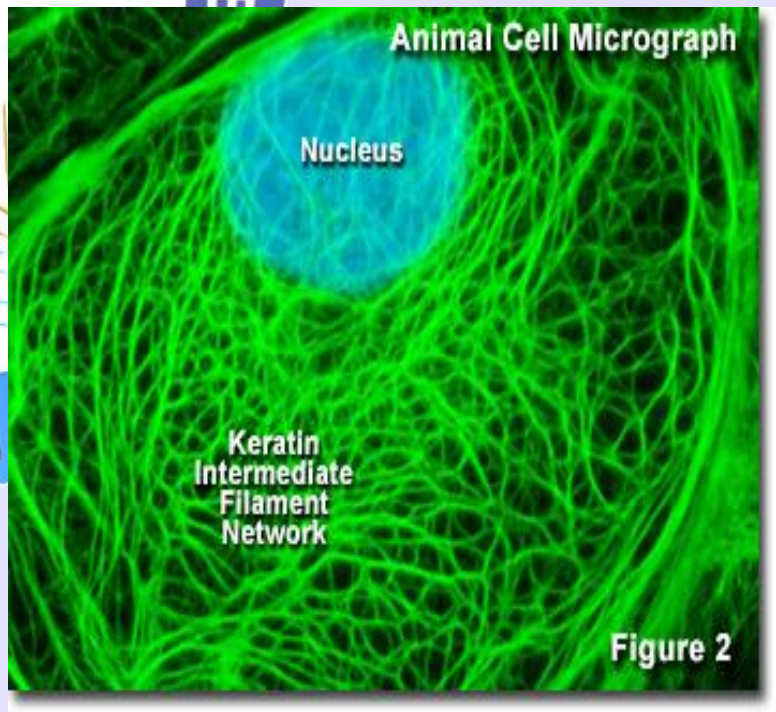
1. Keratin filaments:

- Found in **epithelial** cells.

- Most abundant in stratified squamous epithelium of epidermis.

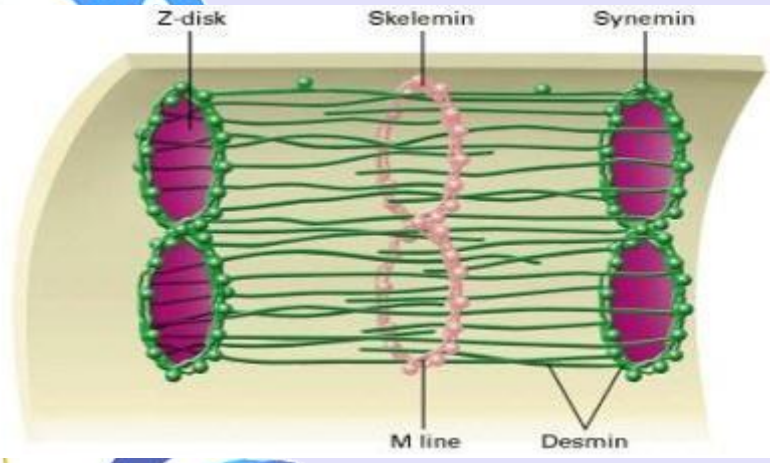
Function:

- Mechanical.
- Stabilize cell shape.
- Strengthen its attachment to basal lamina and neighbouring cells.



2. Desmin filaments:

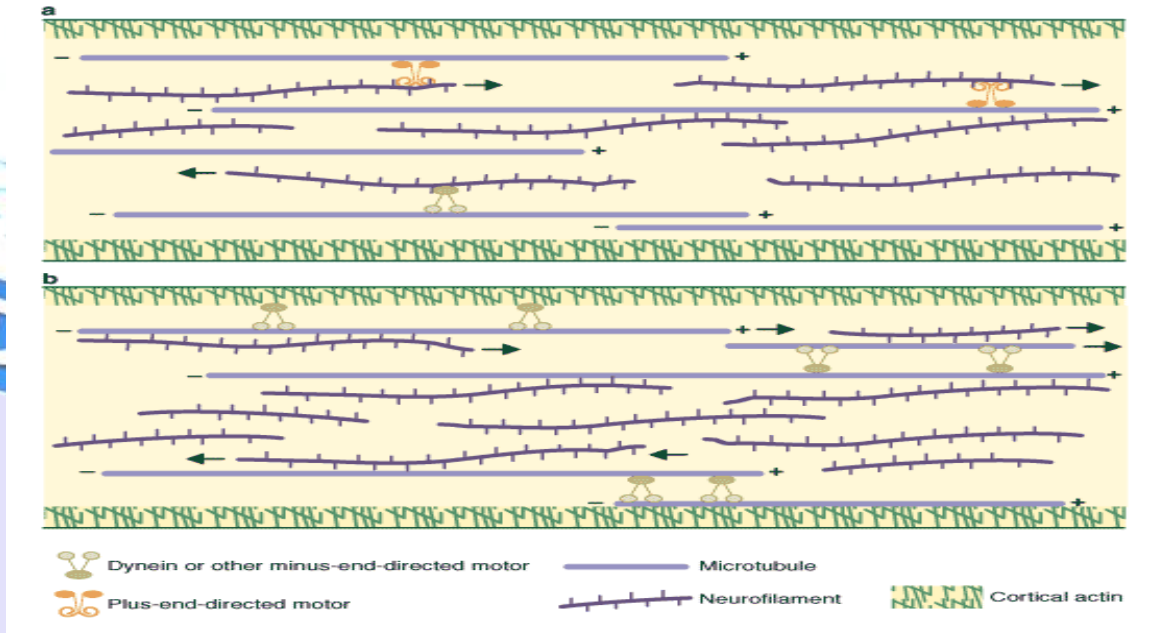
- Most abundant in **smooth muscle cells.**
- They form a cytoskeleton that transmits pull of contractile proteins.
- Ensures a uniform distribution of tensil force through smooth muscle cell.
- Also found in skeletal and cardiac muscle cells.
- Where they link the Z- bands of peripheral myofibrils to plasma membrane of cell.



3. Neurofilaments:

- Found in **nerve cells.**

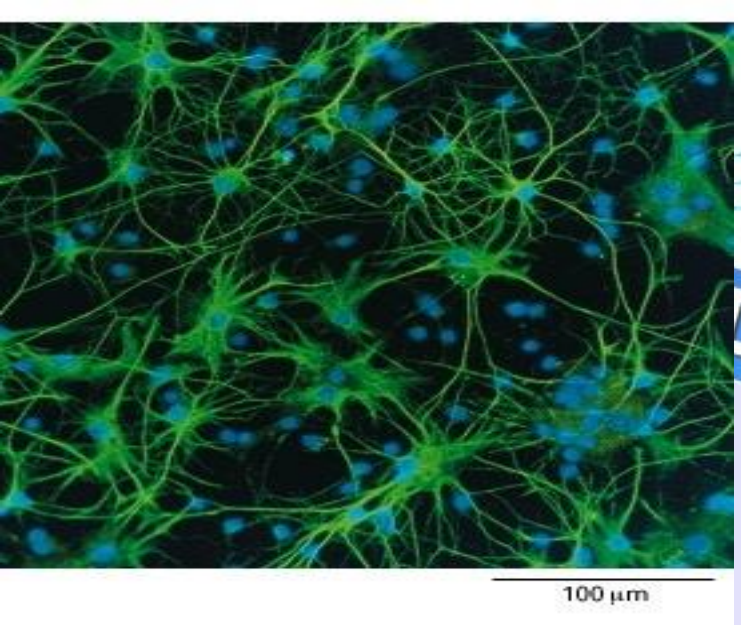
- They **provide internal support** to the cell body and its processes.



4. Glial filaments:

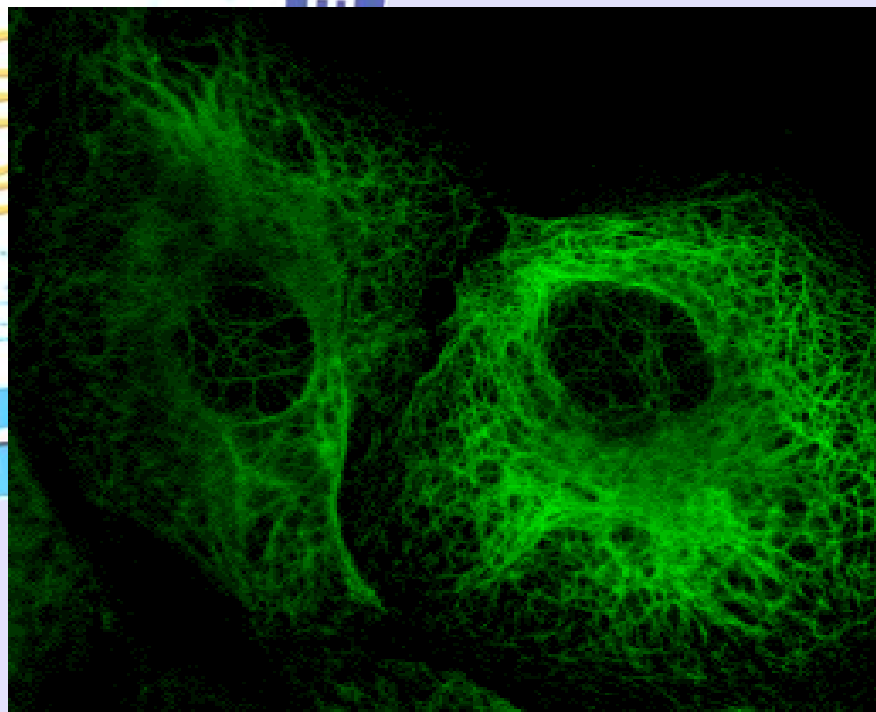
- These are intermediate filaments of neuroglial cells.

- Abundant in **astrocytes.**



5. Vimentin filaments:

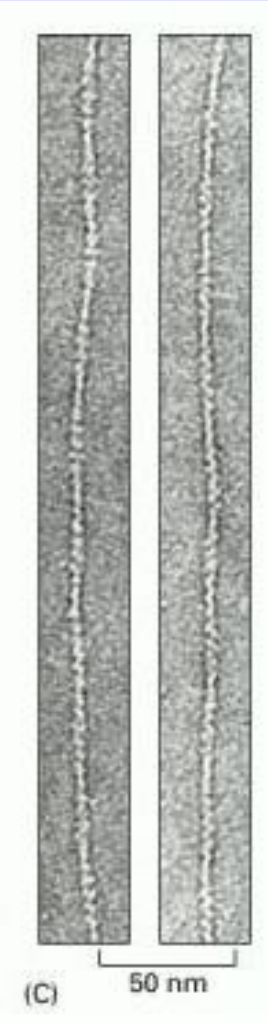
- Found in **fibroblasts** and other cells of **mesenchymal** origin.
- They are randomly distributed in cytoplasm in the form of network or gathered in bundles.

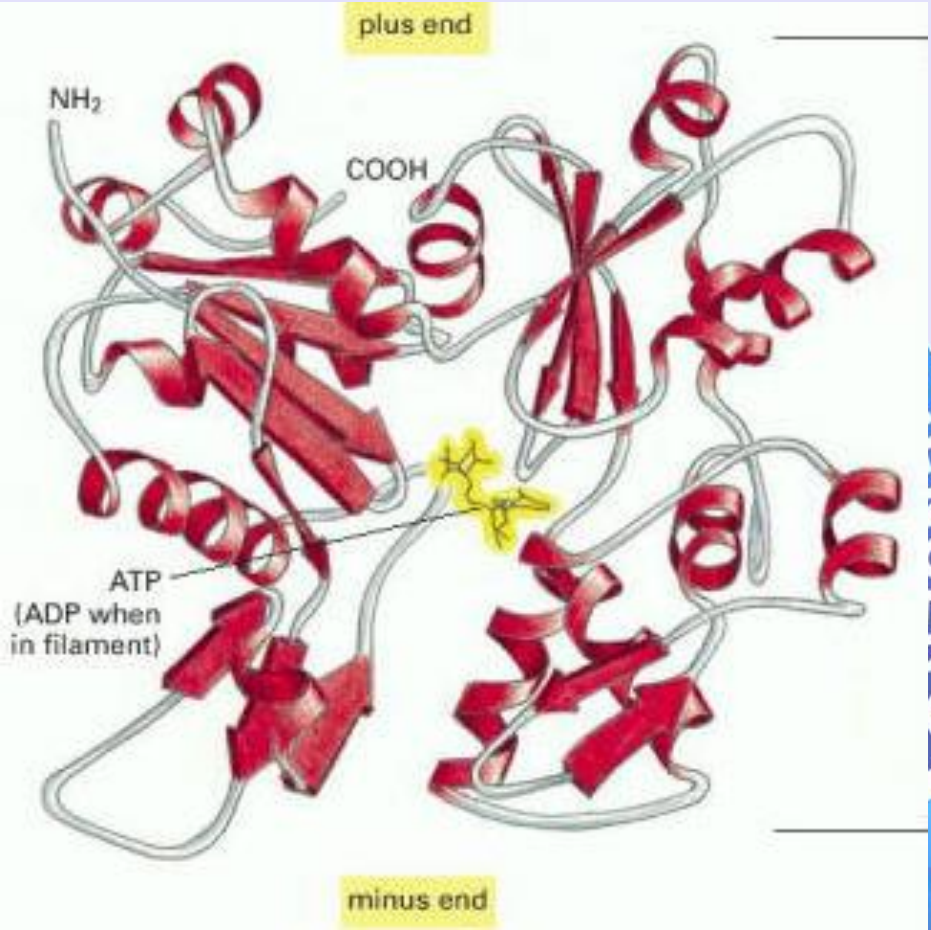


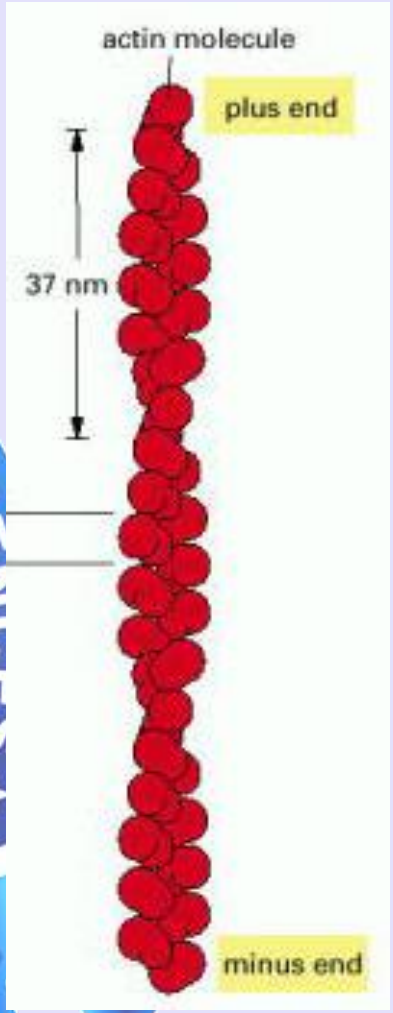
THIN FILAMENTS OR MICROFILAMENTS

- 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.

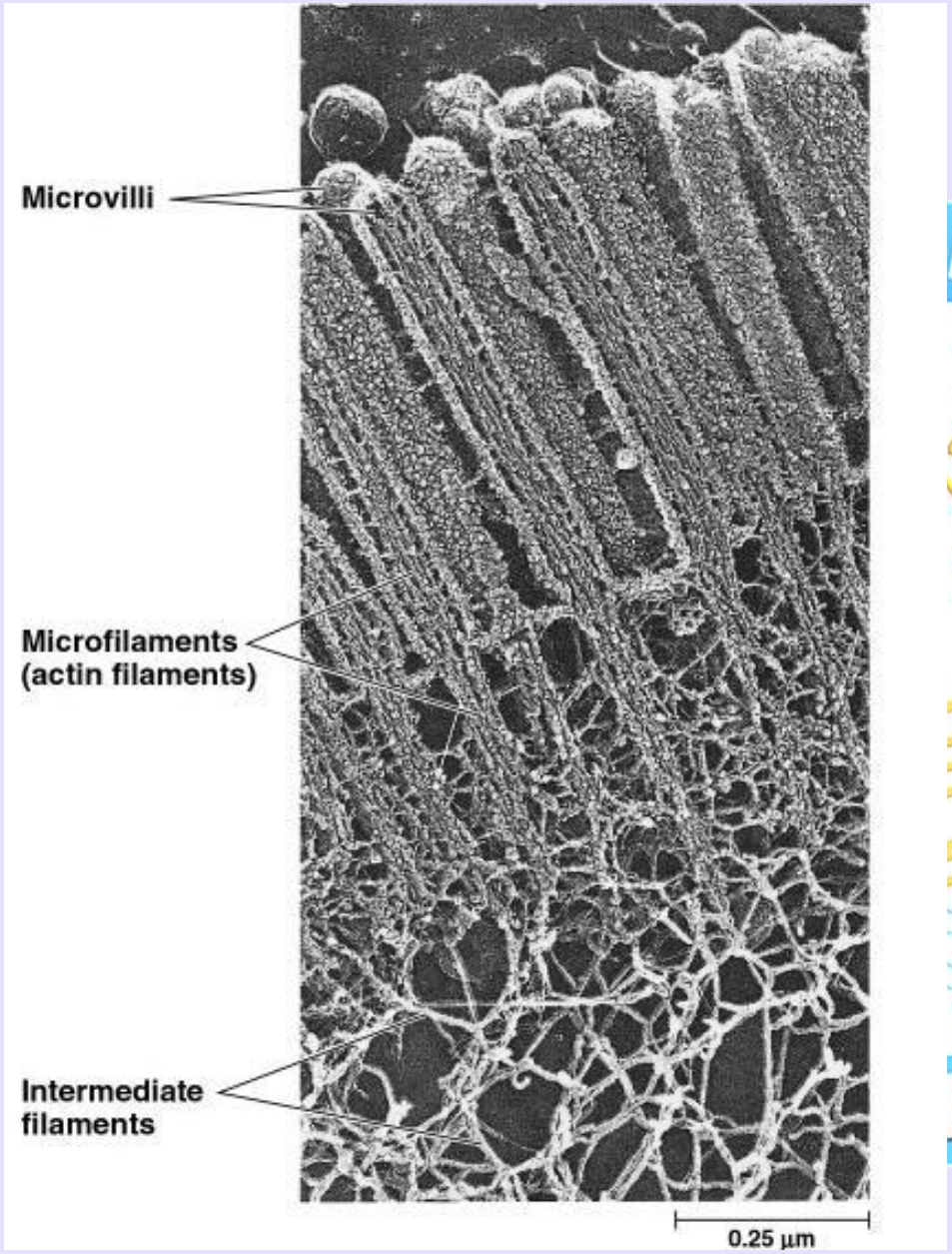
Actin







- conserved (bacteria homolog (MreB)
- *G-actin* (monomer) assembles into *F-actin*, a polarized helical polymer
- filament assembly depends on ATP hydrolysis (requires energy)



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

THIN FILAMENTS OR MICROFILAMENTS

- 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.

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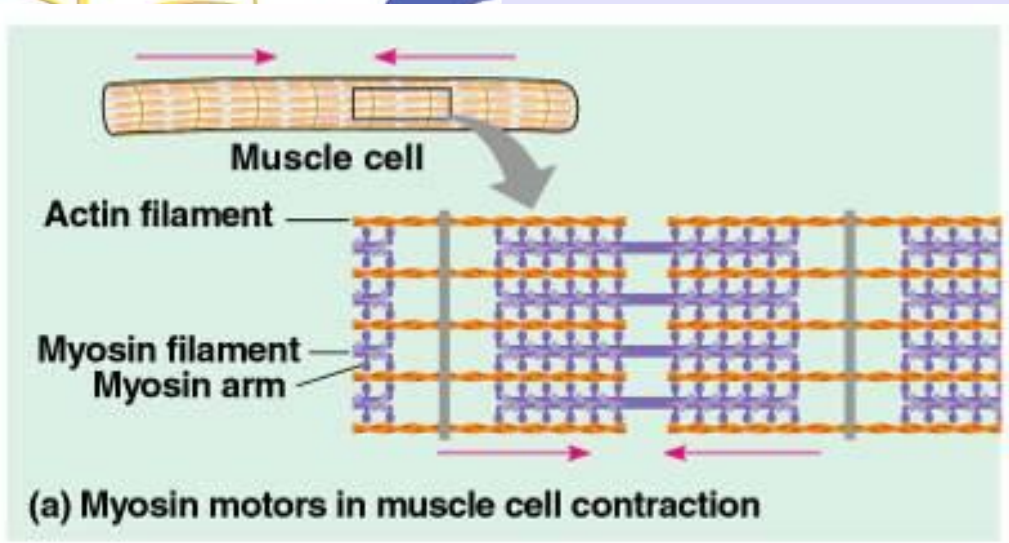
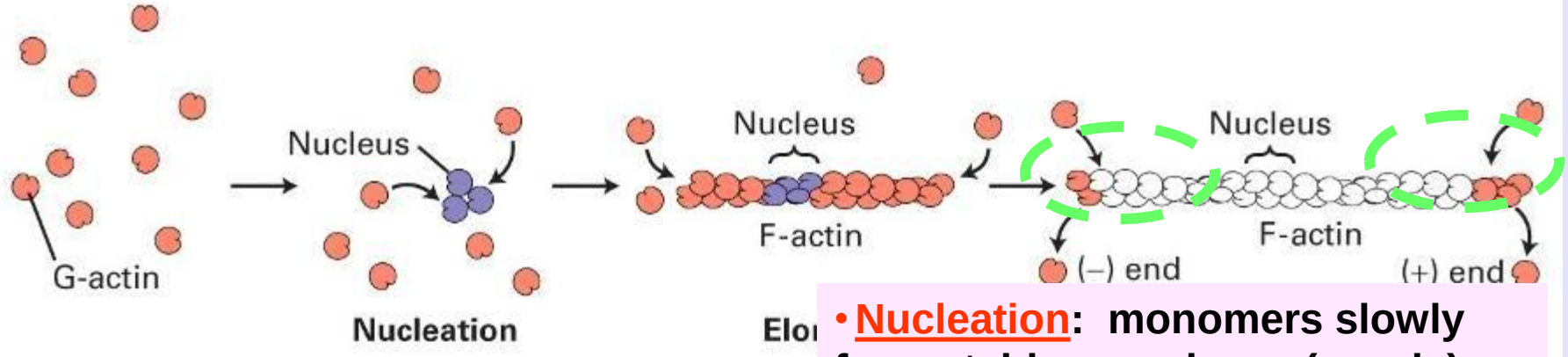
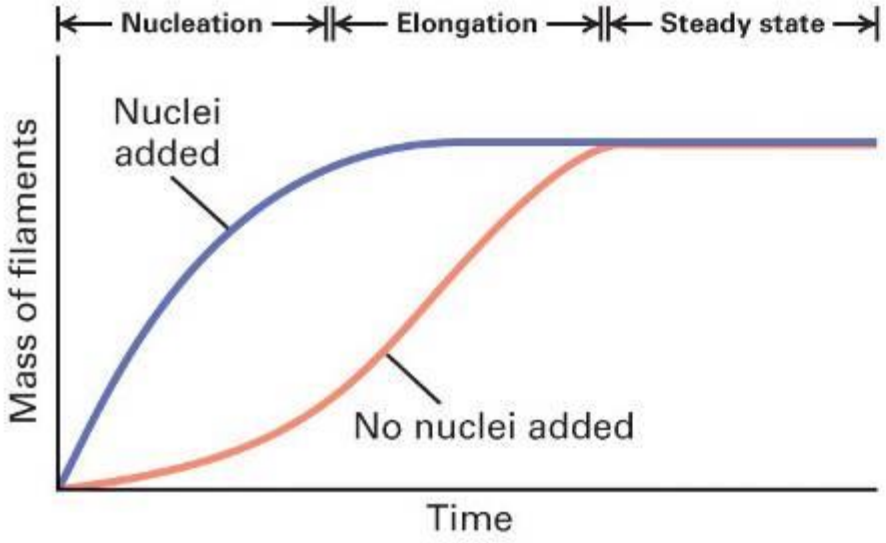


What is the rate-limiting step during filament formation?





- **Nucleation: monomers slowly form stable complexes (purple)**
- **Elongation: rapid elongation of filament by addition of subunits to both ends**
- **Steady state: subunits added/removed at a similar rates at each end**

REFERENCES

- BASIC HISTOLOGY BY JUNQEIRA PAGE # 43-48.