Architecture, Cytoskeleton, and Cellular Motility

I. Introduction

The **cell** is the fundamental structural and functional unit of life.

Its **architecture** is dynamic and complex, allowing it to **maintain shape**, **organize internal components**, and **move**.

These properties are ensured by a highly organized network called the **cytoskeleton**.

The cytoskeleton provides:

- Mechanical **support**
- **Organization** of organelles
- **Intracellular transport**
- **Cell movement and division**

II. General Architecture of the Cell

1. The Cell as a Structural Unit

Cells vary in **shape and size** according to their function:

- Spherical (lymphocytes)
- Cubic (epithelial cells)
- Elongated (muscle cells)
- Star-shaped (neurons)

Each cell is organized into three main parts:

1. **Plasma membrane**
2. **Cytoplasm** (cytosol + organelles + cytoskeleton)
3. **Nucleus**

2. Cytoplasmic Organization

The **cytoplasm** is a semi-fluid matrix containing:

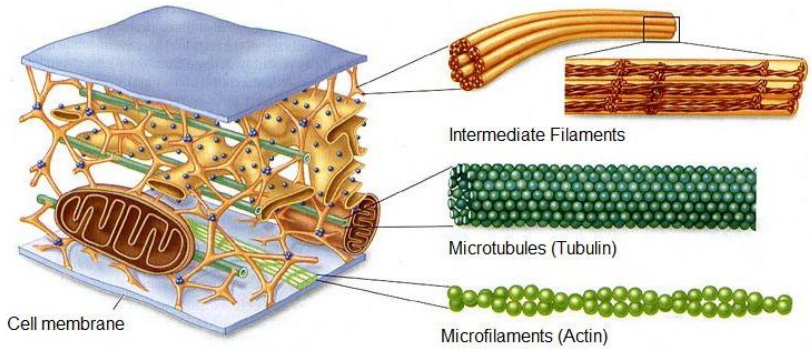
- **Organelles** (mitochondria, ER, Golgi, etc.)
- **Inclusions** (lipid droplets, pigments)
- **Cytoskeleton**: the structural framework that maintains cell shape and enables movement.

III. The Cytoskeleton

1. Definition

The **cytoskeleton** is a **three-dimensional network** of protein filaments extending throughout the cytoplasm. It provides **mechanical strength**, **shape**, and **motility** to the cell.

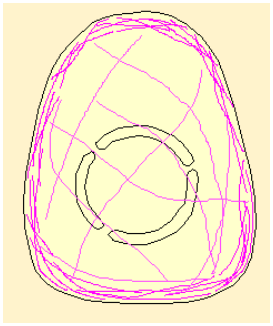
2. Main Components of the Cytoskeleton



There are **three major types of filaments**:

Type	Diameter	Protein	Main Function
Microfilaments	~7 nm	Actin	Cell shape, movement, muscle contraction
Intermediate filaments	~10 nm	Keratin, vimentin, etc.	Mechanical strength
Microtubules	~25 nm	Tubulin	Intracellular transport, cilia, flagella, mitosis

IV. Microfilaments (Actin Filaments)

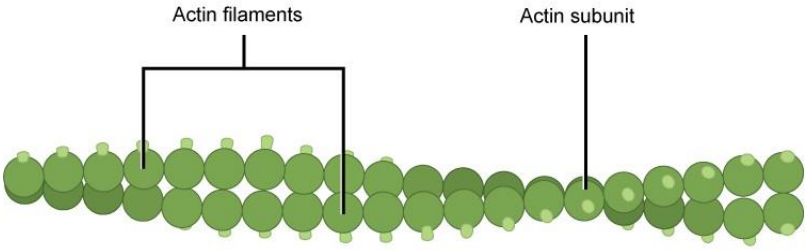


1. Structure

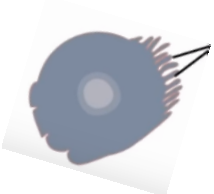
- Composed of **actin**, a globular protein (G-actin) that polymerizes into **filamentous actin (F-actin)**.
- Thin, flexible filaments located under the **plasma membrane**.

2. Organization

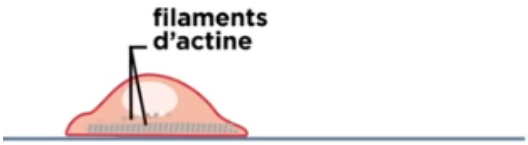
- Can form **bundles**, **networks**, or **contractile rings**.
- Interact with **myosin** (a motor protein) to produce movement.

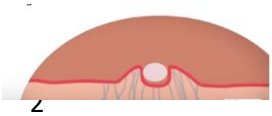


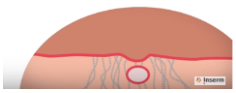
3. Functions



- **Maintain cell shape**
- **Muscle contraction** (actin + myosin)
- **Cytoplasmic streaming**
- **Cell motility** (pseudopodia, lamellipodia, filopodia)
- **Cytokinesis**: formation of the contractile ring during cell division

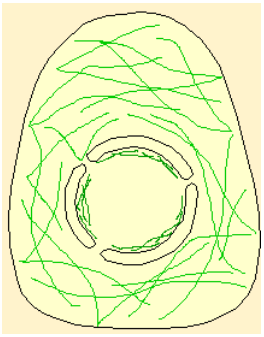




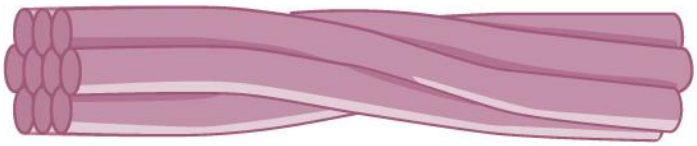


V. Intermediate Filaments

1. Structure



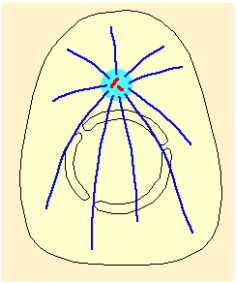
- Rope-like fibers, more stable and durable than actin or microtubules.
- Made of various proteins depending on the cell type:
  - **Keratins** in epithelial cells
  - **Vimentin** in mesenchymal cells
  - **Neurofilaments** in neurons
  - **Lamin** in the nucleus (nuclear lamina)



2. Functions

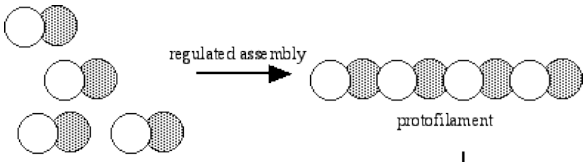
- Provide **mechanical resistance** to stretching and stress.
- Maintain **cell integrity and shape**.
- Anchor **organelles** (like the nucleus).
- Form the **nuclear lamina** that supports the nuclear envelope.

VI. Microtubules



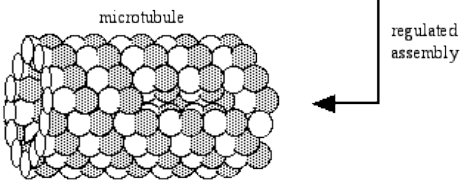
1. Structure

- Hollow cylinders.
- They are composed of **13** protein **protofilaments** arranged in a **ring**.
- Each protofilament is made up of **tubulin dimers**: the assembly of two **globular proteins**: **α** and **β**
- Exhibit **polarity** (+ and – ends).
- Constantly **assembled and disassembled** (dynamic instability).



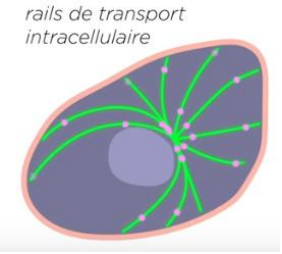
2. Organization

- Originate from **microtubule-organizing centers (MTOCs)** such as the **centrosome**.
- The centrosome contains a pair of **centrioles** surrounded by pericentriolar material.

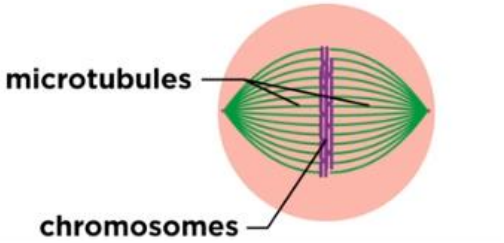


3. Functions

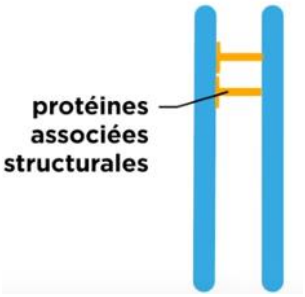
- **Maintain cell shape** (resist compression).
- Form **tracks** for intracellular transport (via motor proteins: kinesin and dynein).



- Participate in **mitotic spindle formation** during cell division.



- Form the internal structure of **cilia and flagella** (9 + 2 microtubule arrangement).



VII. Cellular Motility

1. Definition

Cellular motility refers to the **movement of the whole cell** or **movement of materials within the cell**.

2. Types of Cellular Movement

Type	Description	Example
Amoeboid movement	Extension of cytoplasm as pseudopodia	White blood cells
Ciliary and flagellar movement	Beating of cilia or flagella	Respiratory cells, spermatozoa
Muscular contraction	Sliding of actin and myosin filaments	Skeletal and smooth muscles
Intracellular transport	Movement of vesicles and organelles along microtubules	Neurons, secretory cells