



### Intracellular Transport

- chemical energy (ATP) to mechanical work
- directed motion
- Kinesin: carry out microtubule-based retrograde transport (towards cell edge)
- Dynein: carry out retrograde transport (towards cell nucleus)

### Growth and Differentiation

#### Cell Cycle

**G1:** Cell growth  
**S:** DNA Synthesis  
**G2:** Growth and preparation for Mitosis  
**M:** Mitosis (cell division)

Quiescent cells: cells pause before replication. Reversible growth arrest (G0 phase)

### Transfection

Insert DNA that codes for the wanted biomolecule into cell. Use:  

- viruses
- electroporation
- carriers

store transfected cells in cryogenic conditions

### Actin Filaments

- Provide support, change the cell shape (division) and drive movement
- Assemble from globular proteins ("G-Actin") like microtubules and form hierarchical structures by crosslinking
- Polar with no preferred direction
- Can form protrusions → exploring and sensing environment
- "Myosin motors" → participate in cargo transport and muscle contraction

### Cell Sensing and Signaling

### Cellular Communication

**Long Range:**  
 Endocrine • into blood stream  
 Neural • in neurons (electric)  
 • affect whole organism

**Short Range:**  
 Paracrine • affect local tissue  
 Contact Dependent • direct binding

### Signal is:

- Amplified
- Distributed
- Integrated
- Modulated (feedback loop)

### Receptors

#### Ion-channel-coupled

#### Enzyme-coupled

### G-protein-coupled receptors

- Ligands (ex.: hormones, neurotransmitters) bind to GPCR (G-protein coupled receptor) which changes conformation
- Activated receptor causes G-protein to exchange its GDP for GTP gets activated
- G-protein modulates the activity of effector molecules generate intracellular second messenger

### Stem Cells – Cell Differentiation

Differentiated cells in adult organisms contain all the genetic information to form a new organism. But, they express **only a fraction** of genes specific to their function.

Stem cells can differentiate to tissue-specific cell, but also renew themselves.

**Pluripotent stem cells** can give rise to all cell types.  
**Multipotent stem cells** can give rise to a limited number of cell types tissue specific.

### Bioprocesses

Bioprocesses rely on several key components, including biological components, such as the target molecule and the cells used to produce it; culture medium and one or more bioreactors; as well as a process.

Modern technology used:

- DNA sequencing and synthesis
- Precise gene editing
- Genetic circuit design

### Cell source:

Mammalian cells:	E. coli:
- slow growth	+ fast
- complex growth media	+ simple growth media
+ proper folding	- refolding required
+ glycosylation	- no glycosylation

### Culture medium

Source of nutrients to support the growth of cells.  
 Composition:  

- building blocks (sugars, aa)
- water
- salts/ions

### Bioreactor

Carefully designed **culture medium** that provides nutrients (building blocks, water, ions, energy) and a **suitable environment** for cells to grow and generate biomolecules of interest.

**Batch:** Feed solution enters vessel containing cells. No addition.

**Perfusion:** Fresh medium enters vessel containing cells. Removal of product-rich culture broth.

### Cell and tissue architecture

### Cytoskeleton – "Bones and muscles of the cell"

- Resistance to deformation
- Drives movement
- Organizes the cell interior (shape and cargo)
- Physical interactions with the environment
- Present in all eukaryotic cells

### Intermediate Filaments

- Toughest and most durable filaments
- Primary function: **Withstanding mechanical stress**
- Assembled from  $\alpha$ -helical proteins → Rope-like structures
- Without preferred direction (Diameter 10nm)
- Major types: Keratins, Vimentins, Neurofilaments, Lamins

### Microtubules

- Essential for spatial organization
- Polar, have a **distinct orientation**, centrosome → cell membrane
- Are assembled from globular proteins:  $\alpha$ - and  $\beta$ -tubulins that assemble in tubulin dimers (25nm diameter)
- Dynamic → constantly grow or shrink
- Can form Cilia, help in cell division or transport

### Muscle contraction:

In a **sarcomere**, myosin II binds to actin and proceeds towards the **plus** side. This sliding of myosin on actin filaments **shortens the strands** and leads to muscle contraction

### Extracellular Matrix (ECM)

Fibrous elements outside the cell that hold cells and tissues together

**Functions:**

- Structural support and mechanical scaffold
- Resistance to stretch and compression
- Boundary between tissues
- Water retention
- Reservoir for signaling molecules

Plants have cell walls (cellulose and pectin) instead of ECM.

### Composition of ECM

**Protein fibres:** Collagen and Elastin provide strength and elasticity

**Glycoproteins:** Fibronectin and Laminin provide adhesion and signaling

**Glycosaminoglycans (GAGs) and Proteoglycans:**

- Linear, rigid polysaccharide chains → form large volumes of porous gels
- They carry **negative charges** → retention of water
- Often covalently linked to protein cores called proteoglycans that also provides lubrication
- Resistance to compression**

All components are **produced** and **matured** in the cells then **secreted** in extracellular environment  
 → Cells engineer their local extracellular matrix

### Physical Cell-Cell and Cell-ECM Interactions

Mechanical, electrical, metabolic coupling at cell-cell junctions (desmosome). Physical cell-cell and cell-ECM communication (e.g. via integrins)

