

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

Cell Sensing and Signaling

Cellular Communication

Long Range:

- Endocrine
- into blood stream
- affect whole organism

Short Range:

- Paracrine
- affect local tissue

Neural

- in neurons (electric)
- at synapses (chemical)

Contact Dependent

- direct binding

Signal is:

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

Receptors

Ion-channel-coupled

(A) voltage-gated
 (B) ligand-gated (agonist)
 (C) mechanically-gated

Enzyme-coupled

inactive catalytic domains → active catalytic domains

G-protein-coupled receptors

inactive receptor → activated receptor binds to G protein → activated enzyme

- 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

Growth

Exponential Growth: $N(t) = N_0 e^{rt}$

Logistic Growth: Carrying capacity K , stationary phase. $N(t) = \frac{N_0 e^{rt}}{1 + \frac{N_0}{K} (e^{rt} - 1)}$

Clonal Population: $\log(N) = \frac{1}{r_d} t$, Doubling time: r_d

Genotype:

ensemble of all the genes of a cell ("all available genes")

Phenotype:

output of set of expressed genes ("all visible genes")

Clonal population:

same genotype and phenotype, identical cells, can differ due to mutations in genotype

Cell Death

Apoptosis:

- controlled cell death
- directed by extracellular signals
- controlled by intracellular signal cascade
- apoptotic cell gets phagocytosed by macrophages

Necrosis:

- death as result of injury
- cells burst and release their contents

4 Culture medium

Source of nutrients to support the growth of cells.

Composition:

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

5 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: no additions

Fed-batch: small volume of concentrated nutrient solution added

Perfusion: fresh medium addition balances removal of product-rich culture broth

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