YOUR MENTOR GURU

CSIR NET Life Sciences & Biotechnology — Unit 2

Cellular Organization

Study & revision companion | Topic explanations, core facts, and active-recall questions

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How to use this guide

Read each topic, explain the key mechanism in your own words, then answer the self-check prompts without looking at the notes. Use your detailed textbook or class notes for full derivations and additional examples.

Topic overview

1. 1. Cell Membranes and Transport
2. 2. Organelles and Protein Targeting
3. 3. Cytoskeleton and Cell Motility
4. 4. Cell Cycle and Checkpoints
5. 5. Chromosome Organization and Mitosis
6. 6. Cell Death, Senescence and Autophagy
7. 7. Microbial Growth and Cell Organization

1. Cell Membranes and Transport

Fluid mosaic model: lipids form a dynamic bilayer and integral proteins perform transport, recognition and signaling.

Simple diffusion moves down a gradient without a carrier; facilitated diffusion uses a channel or carrier but no direct ATP hydrolysis.

Primary active transport uses an energy source such as ATP; secondary active transport couples uphill movement to an existing ion gradient.

The Na^+/K^+-ATPase exports three Na^+ and imports two K^+ per ATP cycle.

Phospholipid bilayers restrict ions; channels and carriers allow selective movement. Active transport moves solutes against electrochemical gradients.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: distinguish simple diffusion, facilitated diffusion, primary active transport and secondary cotransport.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

2. Organelles and Protein Targeting

The nucleus stores chromosomes; nucleolus supports rRNA synthesis and ribosomal assembly.

Rough ER synthesizes many secretory and membrane proteins; smooth ER contributes to lipid synthesis and detoxification.

Golgi cisternae modify and sort cargo; lysosomes contain acid hydrolases and maintain an acidic lumen.

Nuclear localization signals guide import through nuclear pores; N-terminal signal peptides commonly target nascent chains to ER.

The ER supports secretory-protein synthesis; Golgi compartments modify and sort cargo. Mitochondria generate ATP and lysosomes digest macromolecules.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: cOPII supports ER-to-Golgi transport; COPI often mediates retrograde traffic.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

3. Cytoskeleton and Cell Motility

Microtubules are polarized tubulin polymers; kinesins usually move toward plus ends and many dyneins toward minus ends.

Actin filaments support cell crawling, cytokinesis and muscle contraction through myosin motors.

Intermediate filaments provide mechanical resilience and lack intrinsic motor-driven transport.

Motile cilia typically contain a 9+2 axoneme; basal bodies resemble centrioles with nine microtubule triplets.

Actin drives contraction and motility; microtubules organize spindles and intracellular traffic; intermediate filaments resist stress.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: kinesin generally moves toward microtubule plus ends, while dynein generally moves toward minus ends.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

4. Cell Cycle and Checkpoints

G1 prepares for DNA replication; S duplicates DNA; G2 prepares for mitosis; M partitions chromosomes.

Cyclin–CDK activity controls transitions, while checkpoints monitor DNA damage, replication completion and spindle attachment.

APC/C promotes securin degradation, allowing separase to cleave cohesin and initiate anaphase.

p53 can induce p21 after DNA damage, limiting CDK activity and delaying cycle progression.

DNA wraps around histone octamers in nucleosomes. Euchromatin is generally more accessible than heterochromatin.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: chromatin modifications can alter gene expression without changing DNA sequence.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

5. Chromosome Organization and Mitosis

Eukaryotic nucleosomes contain histone octamers around which DNA wraps; linker histone H1 helps higher-order organization.

Euchromatin is generally more accessible; heterochromatin is more condensed, although regulation is context dependent.

Kinetochores attach chromosomes to spindle microtubules; cohesin holds sister chromatids until separation.

Mitosis maintains ploidy in typical somatic division, while meiosis reduces chromosome sets.

Cyclin–CDK activity coordinates G1, S, G2 and M phases; checkpoints respond to DNA damage and spindle errors.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: crossing over occurs in prophase I; homologues separate in meiosis I.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

6. Cell Death, Senescence and Autophagy

Intrinsic apoptosis involves mitochondrial outer-membrane permeabilization, cytochrome c release and caspase-9 activation.

Extrinsic apoptosis is initiated by death receptors and commonly activates caspase-8.

Apoptosis generally avoids the membrane rupture and inflammatory response typical of necrotic injury.

Autophagy delivers cytoplasmic material to lysosomes; senescence is a durable arrest with altered signaling.

Apoptosis uses regulated caspase cascades; necrosis involves membrane disruption. Autophagy recycles cellular material through lysosomes.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: autophagy is not synonymous with apoptosis.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

7. Microbial Growth and Cell Organization

Bacteria generally lack membrane-bound nuclei; archaea have distinct membrane lipids and molecular machinery.

Binary fission replicates the chromosome and separates daughter cells; FtsZ organizes the bacterial division ring.

Batch culture shows lag, exponential, stationary and death phases; generation time $g = \ln 2/\mu$.

Gram-positive walls have thick peptidoglycan; Gram-negative envelopes have an outer membrane containing LPS.

Microbial growth includes lag, exponential, stationary and decline phases. Stress responses and horizontal gene transfer affect survival and antimicrobial resistance.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: during exponential binary fission, $N = N_0 \times 2^n$.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

Active-recall practice

1. Explain the essential principles of 1. Cell Membranes and Transport and give one experimental or real-world application.

2. Explain the essential principles of 2. Organelles and Protein Targeting and give one experimental or real-world application.

3. Explain the essential principles of 3. Cytoskeleton and Cell Motility and give one experimental or real-world application.

4. Explain the essential principles of 4. Cell Cycle and Checkpoints and give one experimental or real-world application.

5. Explain the essential principles of 5. Chromosome Organization and Mitosis and give one experimental or real-world application.

6. Explain the essential principles of 6. Cell Death, Senescence and Autophagy and give one experimental or real-world application.

7. Explain the essential principles of 7. Microbial Growth and Cell Organization and give one experimental or real-world application.

Final revision checklist

- 1. Cell Membranes and Transport
- 2. Organelles and Protein Targeting
- 3. Cytoskeleton and Cell Motility
- 4. Cell Cycle and Checkpoints
- 5. Chromosome Organization and Mitosis
- 6. Cell Death, Senescence and Autophagy
- 7. Microbial Growth and Cell Organization

Further study

Use the corresponding unit notes, topic-wise detailed lessons, MCQs, practice tests and full-length mock tests on yourmentorguru.com. This compact PDF is a revision companion, not a replacement for full syllabus textbooks.