YOUR MENTOR GURU

CSIR NET Life Sciences & Biotechnology — Unit 12

Applied Biology

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

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. Microbial Growth Kinetics
2. 2. Bioreactor Design and Operation
3. 3. Mass Transfer and Aeration
4. 4. Sterilization and Contamination Control
5. 5. Downstream Processing and Purification
6. 6. Industrial Fermentation and Bioproducts
7. 7. Bioprocess Monitoring and Control

1. Microbial Growth Kinetics

In exponential growth, $dX/dt = \mu X$ and generation time $g = \ln 2/\mu$.

Monod kinetics: $\mu = \mu_{max} S/(K_s+S)$, a simplified substrate-limited growth model.

Biomass yield $Y_{X/S}$ = biomass formed / substrate consumed, with units stated.

Maintenance energy and inhibition can cause departures from ideal yield and growth models.

Mass and energy balances describe input, output, generation, consumption and accumulation.

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: at steady state, accumulation is zero.

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

2. Bioreactor Design and Operation

Batch culture has no routine inflow/outflow during production; fed-batch adds feed without matched continuous harvest.

Continuous stirred-tank culture has inlet and outlet flows; at steady state, dilution rate $D = F/V$ equals μ under ideal assumptions.

Washout occurs when dilution exceeds sustainable growth in a chemostat.

Mixing, shear, pH, temperature and oxygen transfer shape process performance.

Mixing, heat transfer and oxygen transfer affect fermentation performance.

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: $oTR = kLa(C^* - CL)$ under a common transfer model.

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

3. Mass Transfer and Aeration

Oxygen transfer rate $OTR = kLa(C^* - CL)$ in a common well-mixed model.

kLa depends on agitation, aeration, reactor geometry and fluid properties.

Oxygen uptake rate OUR reflects cellular demand; oxygen limitation occurs when supply cannot meet demand.

Dissolved oxygen probes report liquid-phase oxygen, not directly intracellular oxygen.

Living systems are open and non-equilibrium; favorable reactions can drive unfavorable reactions through coupling.

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: thermodynamic feasibility differs from reaction speed.

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

4. Sterilization and Contamination Control

Thermal sterilization reduces viable microorganisms according to time–temperature-dependent kinetics.

D-value is time for a one-log reduction under specified conditions; z-value describes temperature sensitivity of D.

Filtration is useful for heat-sensitive fluids and gases, subject to membrane properties.

Aseptic connections, clean-in-place and steam-in-place procedures reduce contamination risks.

Monod kinetics describes substrate-limited growth using $\mu = \mu_{max} S/(K_s + S)$.

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: ks gives half the modeled maximum growth rate.

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

5. Downstream Processing and Purification

Cell removal may use centrifugation or filtration; disruption releases intracellular products.

Precipitation and extraction provide bulk separations; chromatography provides selective purification.

Ion-exchange separates by charge, size-exclusion by hydrodynamic size and affinity chromatography by specific binding.

Recovery, purity, yield and throughput must be tracked across stages.

Batch, fed-batch and continuous systems differ in feed and harvest strategies.

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: at steady chemostat operation, $\mu = D$.

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

6. Industrial Fermentation and Bioproducts

Primary metabolites are often growth-associated; secondary metabolite formation may peak under different physiological states.

Enzyme immobilization can aid reuse and process stability but may introduce diffusion limitations.

Productivity is product mass per reactor volume per time; titer is concentration; yield is product per substrate.

Scale-up requires attention to mixing, oxygen supply, heat removal and hydrodynamic similarity.

Productivity, yield, titer, sterility and scale-up govern industrial performance.

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: titer, yield and productivity are not interchangeable.

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

7. Bioprocess Monitoring and Control

pH, dissolved oxygen, temperature, gas composition and substrate concentrations are common monitored variables.

PID control adjusts manipulated inputs using proportional, integral and derivative error terms.

Soft sensors estimate difficult-to-measure variables from process measurements and models.

Process analytical technology emphasizes measurement and control of critical quality attributes.

Adsorption, covalent binding and entrapment aid enzyme recovery and reuse but may create diffusion limitations.

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: observed rate can decrease due to mass-transfer resistance.

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. Microbial Growth Kinetics and give one experimental or real-world application.

2. Explain the essential principles of 2. Bioreactor Design and Operation and give one experimental or real-world application.

3. Explain the essential principles of 3. Mass Transfer and Aeration and give one experimental or real-world application.

4. Explain the essential principles of 4. Sterilization and Contamination Control and give one experimental or real-world application.

5. Explain the essential principles of 5. Downstream Processing and Purification and give one experimental or real-world application.

6. Explain the essential principles of 6. Industrial Fermentation and Bioproducts and give one experimental or real-world application.

7. Explain the essential principles of 7. Bioprocess Monitoring and Control and give one experimental or real-world application.

Final revision checklist

- 1. Microbial Growth Kinetics
- 2. Bioreactor Design and Operation
- 3. Mass Transfer and Aeration
- 4. Sterilization and Contamination Control
- 5. Downstream Processing and Purification
- 6. Industrial Fermentation and Bioproducts
- 7. Bioprocess Monitoring and Control

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.