Full curriculum Master Microbial biotechnology

Subject 1: Molecular Biology

Credits: 8
Coefficient: 4

Course Objectives

- Organization and expression of genetic material in prokaryotes and eukaryotes.
- Mechanisms and levels of regulation.

Recommended Prerequisites

- Knowledge of **biochemistry, genetics, and molecular biology** at the **L3 level**.

Course Content

1. Organization of genetic material in prokaryotes and eukaryotes
2. Sequences involved in gene expression
3. Transcription machinery in eukaryotes
4. Regulation of gene expression in prokaryotes and eukaryotes
5. Post-transcriptional modifications and transport in eukaryotes
6. Post-transcriptional regulation
7. Specifics of the translation mechanism in eukaryotic cells
8. Surveillance mechanisms
9. Genome conservation and fluidity

Tutorials

- **6 sessions** on **transcription, translation, and gene expression regulation**
- **6 sessions** on **eukaryotic transcription regulation and alternative splicing**

Practical Work

- **DNA extraction** (genomic and plasmidic) from different microorganisms (bacteria, yeast)
- **DNA quantification and sizing**
- **Bacterial transformation**
- **DNA amplification (PCR)**
- **Enzymatic digestion of DNA and restriction map construction**

Personal Work

- **Bibliographic research and presentations**

Evaluation Method

- **Continuous assessment and final exam**

Subject 2: Advanced Enzymology

Credits: 6
Coefficient: 3

Course Content

1. Thermodynamics and Enzyme Kinetics

- Thermodynamic principles of enzyme kinetics

2. Enzymatic Catalysis

2.1. Concept of catalysis
2.2. Enzyme classification and nomenclature
2.3. Enzyme specificity and the active site concept
2.4. Cofactor function
2.5. Mechanisms of enzymatic catalysis

3. Enzyme Kinetics

3.1. Reaction rate concepts
3.2. Michaelis-Menten kinetics

4. Allosteric Enzymes

4.1. Homotropic and heterotropic effects
4.2. Theoretical approach to cooperativity

5. Two-Substrate Reactions

5.1. Random binding
5.2. Ordered mechanism
5.3. Ping-pong mechanism

Tutorials

- Fundamental reaction concepts (order, molecularity)
- Kinetic equations for reversible and irreversible reactions with one or two substrates
- Graphical representation and determination of kinetic parameters
- Allosteric enzyme regulation and cooperative transition models (Scatchard and Hill plots)

Personal Work

- **Bibliographic research and presentations**

Evaluation Method

- **Continuous assessment and final exam**

Subject 3: Structure and Physicochemistry of Biological Macromolecules

Credits: 4
Coefficient: 2

Course Content

1. Physicochemical Approaches to Macromolecule Structure

1.1. Protein folding and conformational stability

- Equilibrium and kinetics of denaturation-renaturation
- Disulfide bond formation and localization
  1.2. **Hydrodynamic properties**
- Gel filtration
- Electrophoresis
- Sedimentation velocity and equilibrium ultracentrifugation
  1.3. **Chemical modifications of proteins**

2. Modeling Approaches for Structural and Interaction Properties of Macromolecules

2.1. Basic concepts of **bioinformatics and programming**
2.2. Major modeling domains:

- **Homology modeling**
- **Conformational property exploration**
- **Dynamic properties and molecular interactions**

Tutorials

- **Exercises, problem-solving, article analysis, and 3D structure visualization software** (RasMol, Swiss-PDBViewer) covering:
  1. Protein and nucleic acid structures
  2. Protein folding mechanisms
  3. Protein-ligand, protein-protein, and protein-DNA interactions
  4. Homology modeling
  5. Qualitative and quantitative analysis of experimental data from hydrodynamic and spectroscopic methods
  6. Bioinformatics tools for sequence and 3D structure analysis

Personal Work

- **Bibliographic research and presentations**

Evaluation Method

- **Continuous assessment and final exam**

Semester: 2

Fundamental Teaching Unit: UEFS2

Subject 1: Microbiological Engineering

Credits: 4
Coefficient: 2

Course Content

1. Introduction
2. Different Experimental Approaches to Microbial Ecosystems
3. Microbial Ecosystems in Fermented Dairy Products (Example: Cheese)
4. Microbial Ecosystems in Bread-Making Processes
5. Microbial Ecosystems in Meat Products
6. Microbial Ecosystems in Fermented Beverages
7. Microorganism Collections, GMOs, and Regulations

Personal Work

- Bibliographic research and presentations

Evaluation Method

- Continuous assessment and final exam

Subject 2: Microbial Taxonomy Methods

Credits: 6
Coefficient: 3

Course Content

Introduction to the Polyphasic Approach for Microbial Identification

1. Phenotypic Analysis

1.1. Observation Methods Applied to Bacterial Biomass

- Microscopy techniques
- Flow cytometry
- Image analysis

1.2. Biochemical, Physiological, and Metabolic Characterization

- Automated methods (API system, VITEK system, PHOENIX system...)
- Immunological methods

1.3. Analysis of Methyl Ester Fatty Acid Composition (FAME Analysis)

2. Molecular Methods

2.1. Genotypic Methods

- Biological material and enzymatic tools in molecular biology
- Molecular hybridization
- Molecular cloning
- DNA amplification techniques
- DNA sequencing

2.2. Protein-Based Methods

Practical Work

- Laboratory experiments related to microbial taxonomy techniques

Personal Work

- Bibliographic research and presentations

Evaluation Method

- Continuous assessment and final exam

Semester: 3

Fundamental Teaching Unit: UEFS3

Subject 1: Bioengineering and Fermentation

Credits: 8
Coefficient: 4

Course Content

1. Introduction

1.1. Selection and improvement of microbial strains
1.2. Bioreactors and fermentation

2. Transfer and Fermentation

2.1. Oxygen
2.2. Agitation
2.3. Heat

3. Bioreactors

3.1. Batch Fermentation: "Batch" and "Fed-batch"
3.2. Continuous Fermentation
3.3. Continuous Fermentation with Biomass Recycling

4. Different Types of Bioreactors

4.1. Mechanically Agitated Bioreactor
4.2. Air-lift Bioreactor
4.3. Jet Bioreactor

5. Fermentation Facilities

5.1. Sterilization and Asepsis Control
5.2. Air Distribution
5.3. Auxiliary Equipment (valves, pumps, sensors, antifoam systems, etc.)
5.4. Regulation and Automation

6. Fermentation Process Modeling

6.1. Models and Modeling
6.2. Kinetic Models
6.3. Physiological Growth Models (Bacteria, Yeast)

- 6.3.1. Sugar Consumption
- 6.3.2. Alcohol or Other Metabolite Production
- 6.3.3. CO_2 Production
  6.4. Fermentation Examples (e.g., lactic acid fermentation)

Tutorials

- Study of microbial kinetics and metabolism before practical application
- Theoretical modeling examples

Practical Work

- Fermentation Process Development
  - Conducting a fermentation
  - Microbial kinetics (biomass growth, substrate utilization, product formation)
  - Monitoring a fermenter culture: biomass and/or metabolite production
- Physicochemical Monitoring: pH, temperature, oxygen
- Microbiological Monitoring: Biomass estimation
- Biochemical Monitoring: Substrate/metabolite tracking
- Analysis of Production Curves
- Calculation of Culture Parameters
- Yield and Productivity Calculation

Personal Work

- Bibliographic research and presentations

Evaluation Method

- Continuous assessment and final exam

Subject 2: Analysis and Quality Control

Credits: 6
Coefficient: 3

Course Content

1. Introduction

2. Main Factors Influencing Quality

2.1. Intrinsic Parameters
2.2. Extrinsic Parameters

3. Control Methods

3.1. Control Levels
3.2. Genetic Control
3.3. Microbiological Control
3.4. Biochemical Control

4. Applications

4.1. Raw Materials
4.2. Finished Products
4.3. Water Treatment
4.4. Agro-industrial Waste Treatment

5. Foodborne Illness Outbreaks (TIAC)

5.1. Definition of TIAC
5.2. Examples of TIAC
5.3. Microbiological Diagnosis

Personal Work

- Bibliographic research and presentations

Evaluation Method

- Continuous assessment and final exam