Full curriculum

Professional Master's Degree – Specialty: Biotechnology and Applied Microbiology

Semester: S1

Fundamental Teaching Unit: UEF1(O)
Course Title: Rhizobial Symbioses
Credits: 6
Coefficient: 3

Course Objectives

By the end of this course, students will be able to:

- **Study symbioses** involving **nitrogen-fixing bacteria and leguminous plants**.
- **Identify symbiosis types** and analyze **morphological and physiological characteristics** of these interactions.
- **Apply theoretical knowledge** through **practical lab work (TP)** to reinforce the study of these symbioses.

Recommended Prerequisites

- Knowledge of **different types of actinorhizal associations** and their role in **ecosystem stability and soil protection**.

Course Content

Lectures

1. General Overview
2. Overview of Nitrogen-Fixing Bacteria
3. Diversity and Taxonomy of Nitrogen-Fixing Bacteria
4. Plant Partners
5. Bacterial Partners
6. Establishment of Symbiosis
7. Molecular Dialogues Between Symbiotic Partners
   - Mechanisms of symbiosis establishment
   - Nodule formation and regulation
8. Temperate Symbioses
9. Tropical Symbioses

Practical Work (Lab Sessions)

I. Isolation of Bacteria from the Rhizosphere of Legumes
II. Macroscopic Study
III. Microscopic Study
IV. Characterization of Cultural Traits
V. Inoculation of Germinated Seeds
VI. Infectivity Tests

Semester: S1

Fundamental Teaching Unit: UEF1(O) – Symbiotic Microorganisms

Course Title: Actinorhizal Symbioses
Credits: 6
Coefficient: 3

Course Objectives

- Understanding different types of actinorhizal associations and their role in ecosystem stability and soil protection.

Recommended Prerequisites

- General microbiology (L2 level)
- Environmental microbiology
- Microorganisms of interest (L3 level)

Course Content

I. Symbiotic Partners in Actinorhizal Symbiosis

II. Bacterial Partner: Actinomycetes of the Genus *Frankia*

III. Isolation and In Situ Characterization

IV. Morphology and Cultural Characteristics

V. Diversity and Taxonomy of *Frankia*

VI. Saprophytic Lifestyle of *Frankia* in Soil

VII. Host Plants

VIII. Infection and Nodulation in *Frankia*

IX. Two Modes of Infection in *Frankia*

X. Development and Structure of Nodular Lobes

XI. Molecular Signals Involved in Nodulation

XII. Genetic Control of Actinorhizal Symbiosis

XIII. Biotechnological Importance of Actinorhizal Symbiosis

Evaluation Method

- Continuous assessment
- Final exam
- Personal research and oral presentation
- Evaluation of practical work (TPs)

Independent Study and Assignments

- Research on key concepts and mechanisms of actinorhizal symbiosis, assigned after each lecture.
- Preparation of technical sheets for various practical sessions, including:
  - Purification of *Frankia* strains
  - Preparation of inoculum
  - Inoculation tests
  - These sheets should be based on bibliographic research and will be corrected and evaluated.
- Students will submit their lab reports as mini-theses.

Semester: S1

Fundamental Teaching Unit: UEF1(O) – Symbiotic Microorganisms

Course Title: Mycorrhizal Symbioses
Credits: 6
Coefficient: 3

Course Objectives

- Understanding the **mechanisms of establishment, regulation, and functioning** of mycorrhizal associations.
- Recognizing the **importance of mycorrhizae** in plant development and **ecosystem stability**.

Recommended Prerequisites

- Basic knowledge of **general microbiology (L2 level), environmental microbiology, fungi, and mycorrhizae**.

Course Content

Lectures

I. Major Types of Mycorrhization and Their Organization
II. Classification of Mycorrhizae
III. Endomycorrhizae
IV. Life Cycles of Mycorrhizal Fungi
V. Infection of the Host Plant
VI. Arbuscules and Vesicles
VII. Cellular and Molecular Modifications During Mycorrhizal Development
VIII. Pseudonodules
IX. Ectomycorrhizae
X. Mycorrhizae and Mushroom Fruiting
XI. Plant-Fungus Interactions

Practical Work (Lab Sessions)

I. Search and Isolation of Mycorrhizae from Different Biotopes
II. Detection of Endomycorrhizal Structures
III. Identification of Endomycorrhizal Structures
IV. Microscopic Observation of Endomycorrhizal Structures
V. Evaluation of Mycorrhization Rate and Frequency
VI. Spore Extraction
VII. Description of Mycorrhizal Structures (Arbuscules, Vesicles)
VIII. Spore Counting and Identification
IX. Assessment of Mycorrhization Frequency and Rate

Independent Work and Research Topics

- Study on the feasibility of producing and commercializing fungi as biofertilizers.
- Development of a mini-project on the production and commercialization of edible mushrooms.
- Market potential analysis of mycorrhiza-based biofertilizers.
- Economic impact study of biofertilizer commercialization at a regional scale (in collaboration with agricultural stakeholders).
- Final project presentation before the academic committee, evaluated at the end of the semester.

Evaluation Method

- Continuous assessment
- Final exam
- Independent research, bibliographic study, and oral presentation

Semester: S2

Fundamental Teaching Unit: UEF1

Course Title: Methods for Evaluating the Efficiency of Microbial Symbioses
Credits: 3
Coefficient: 6

Course Objectives

- Acquire **practical techniques for estimating symbiotic nitrogen fixation**, enabling the assessment of **soil fertility** and its **potential for agricultural valorization**.

Recommended Prerequisites

- Knowledge of **physiology and biochemistry**.
    - Understanding of **plant-associated microorganisms** (acquired in L3).

Course Content

I. Overview of Microbial Symbioses
II. Mechanisms of Nitrogen Fixation (*Functioning of Nitrogenase*)
III. Different Estimation Methods
IV. Measurement of Acetylene Reduction Activity (ARA)
V. Measurement of Fresh and Dry Weight
VI. Total Nitrogen Quantification
VII. Protein Quantification
VIII. Estimation of Ureides
IX. 15N Isotope Labeling Technique

Independent Work and Research Topics

- Research on nitrogen fixation mechanisms and related concepts.
- Preparation of technical sheets for various practical sessions, including:
    - Inoculation in hydroponic and solid media
    - Indirect evaluation methods (dry weight estimation with statistical analysis)
    - Protein quantification methods
- Bibliographic research for establishing experimental protocols and methodological approaches.

Evaluation Method

- Final exam
- Continuous assessment
- Oral presentations

References

- Books, academic papers, and online resources (to be specified by the faculty team).

Semester: S2

Fundamental Teaching Unit: UEF1

Course Title: Endophytes – Diversity and Role in Microbial Symbioses
Credits: 3
Coefficient: 6

Course Objectives

- Discover and apply **microorganisms living within plant tissues** that play a crucial role in **enhancing plant growth**.

Recommended Prerequisites

- Basic knowledge in **microbiology and plant-microbe interactions**.

Course Content

I. Introduction and Historical Background
II. Different Groups of Endophytes (Bacteria and Fungi)
III. Mechanisms for Plant Growth Promotion (PGP)
IV. Isolation and Study Techniques
V. Characterization, Taxonomy, and the Role of Molecular Tools in Endophyte Identification
VI. Endophyte Colonization Mechanisms
VII. Associated Plant Partners – Selection Mechanisms
VIII. Fundamental and Applied Importance of Endophytes
IX. Association with Legumes
X. Association with Grasses (Case Study: Rice)
XI. Influence of Environmental Factors on Endophyte Growth and Efficiency
a. Biotic Factors
b. Abiotic Factors

Independent Work and Research Topics

- Research on Endophyte Colonization Mechanisms and techniques for in planta visualization of microorganisms.
- Preparation of technical sheets for practical sessions, including:
  - Isolation and purification of endophytic strains
  - Characterization and inoculation testing
- Oral presentations on molecular biology techniques used for endophyte identification.

Evaluation Method

- Continuous assessment
- Final exam
- Oral presentations and research reports

Semester: S2

Fundamental Teaching Unit: UEF2

Course Title: Microorganisms and the Environment
Credits: 3
Coefficient: 6

Course Objectives

- Provide students with a **comprehensive understanding** of **microorganism-environment interactions**.
- Explore the **role of microbial communities** in maintaining ecosystem balance and their **spatiotemporal evolution**.

Recommended Prerequisites

- Basic knowledge of **microbial physiology, biochemistry, and general microbiology**.

Course Content

I. Introduction and Historical Overview

II. Microbial Ecology Overview

III. Economic and Environmental Importance of Microorganisms

IV. Spatiotemporal Evolution of Microorganisms in an Ecosystem

V. Habitat Study and Distribution of Bacterial Species

- Cyanobacteria and Anoxygenic Photosynthetic Bacteria

VI. Microbial Diversity in the Environment

VII. Identification Methods

- Fluorescent Antibody Techniques
- Fluorescent **In Situ** Hybridization (FISH)
- Microautoradiography

VIII. Microbial Activities in the Environment

IX. Quantification Methods for Microbial Activities

X. Microbial Population Density and Activity

XI. Concepts of Microbial Niches, Microenvironments, and Micro-Ecosystems

XII. Microorganisms and Fundamental Biogeochemical Transformations

XIII. Microbial Communities

- **Primary Producers**
- **Consumers**
- **Decomposers**

XIV. Biofilms, Microbial Mats, and Biomass: Economic and Environmental Importance

---

Practical Work (Lab Sessions)

- **Isolation of Microorganisms** from Different Environments
- **Purification of Isolates**
- **Study of Microbial Diversity** in Isolated Populations
- **Partial Characterization of Microbial Strains**
- **Preservation of Pure Strains**
- **Study of Microbial Interactions**
- **Antibiosis Studies**
- **Analysis of Proteolytic Activities**

Independent Work and Field Activities

- **Field Visits**:
  - Wastewater treatment plants
  - Waste valorization facilities
- **Project Presentation**:
  - Proposal for solving an environmental issue
  - Compost preparation
  - Waste valorization techniques

Evaluation Method

- **Final Exam**
- **Continuous Assessment**
- **Oral Presentations**

Semester: S3

Fundamental Teaching Unit: UEF2 – Biotechnological Applications

Course Title: Microbial Inocula – Production, Quality Control, and Inoculation Technology

Credits: 6
Coefficient: 3

Course Objectives

By the end of this course, students will:

- **Master the techniques for producing and applying microbial inocula** (biofertilizers) in controlled mycorrhization.
- **Ensure quality control** and **monitor the sustainability of biofertilizers** while adhering to legal regulations and commercialization standards.

Recommended Prerequisites

- Knowledge of **symbiotic microorganisms and their importance** (L3 level).
- Understanding of **mycorrhizal fungi** (*Endomycorrhizae and Ectomycorrhizae*).
- Familiarity with **legume-nodulating bacteria** (L3 level).

Course Content

I. Introduction to Inoculation

- Definition of inoculation
- When and why inoculation is necessary
- Objectives of inoculation

II. Types of Inocula

III. Selection and Conditioning of Inoculum Carriers

IV. Inoculum Preparation

- Characteristics of a **high-quality inoculum**
- **Microbial growth** and its study methods
- **Laboratory-scale production**
- **Industrial-scale production**
- **Bioreactors**: Description and operating modes
- Types of bioreactors used in microbial biomass production
- **Preservation of microbial inocula**

V. Microbial Inoculum Quality Control

- **Microbiological control**
- **Genetic control**
- **Quality standards and norms**

VI. Legislation, Commercialization, and Management of Microbial Inocula

VII. Inoculation Techniques

Practical Work (Lab Sessions)

I. **Isolation of Rhizosphere Microorganisms** (Rhizobia, Mycorrhizae, PGPR, etc.)
II. **Identification and Selection of Microbial Inocula**
III. **Selection of Carriers** (peat, waste, compost, etc.)
IV. **Efficacy Testing at Lab and Nursery Scale**
V. **Quality Control and Long-Term Monitoring of Inocula**
VI. **Demonstration and Field Testing with Farmers**
VII. **Inoculum Formulation and Packaging**
VIII. **Preservation Methods**
IX. **Approval and Certification (Homologation)**

Independent Work and Research Topics

- Study of **commercialized microbial inocula**.
- Research on **different carriers used for inoculum preservation**.
- Selection of **bioreactors used in microbial inocula production**.
- Effect of **inoculation on plant productivity**.
- Impact of **inoculation on soil bioremediation**.
- Influence of **inoculation on soil microbial flora**.

Evaluation Method

- **Final exam (EMD)**
- **Continuous assessment**
- **Technical reports**
- **Oral presentations**