Microbiology 1
Course Number: BIO144

I. Course Objectives

Students should have a sound comprehension in biology and chemistry. At the satisfactory completion of this course, the student should have mastered the necessary pre-requisites to enter Microbiology 2.

Course Description: Microbial Metabolism; Microbial Genetics; An Introduction to Cells and Procaryotic Cell Structure and Function; Nonspecific Host Defenses; Adaptive, Specific Immunity and Immunization; Disorders in Immunity; Eucaryotic Cells and Microorganisms; Elements of Microbial Nutrition, Ecology, and Growth; Diagnosing Infections. (Laboratory participation required.)

LEARNING OUTCOMES

At the end of the end of this course, the student should be able to:

1. **Use differential analysis in qualitative identification of the various microbes in the laboratory and enhance critical thinking skills in the analysis of data.**
2. **Understand the necessity of proper sanitation and hygienic practices.**
3. **Assess the significance and efficacy of procedures in chemotherapy.**
4. **Demonstrate good laboratory techniques, including:**
    a) Proper use of laboratory equipment.
    b) Basic safety procedures and precautions.
    c) Proper recording of laboratory data and interpretation of results.
    d) An understanding of the origins of experimental error.
    e) Proper disposal of waste products.

II. Methods of Instruction

A. Lecture

1. Comprehensive course outlines written by the instructors are provided to the students. These outlines contain a portion of the material presented to the student during lecture. Students annotate and supplement their comprehensive course outline during the lecture.
2. Instructors use overhead transparencies, which duplicate the comprehensive course outlines given to students. The instructor builds the lecture around these outlines, adding comments, additional explanation and problem solutions as appropriate.
3. Overhead transparencies of textbook illustrations are used when the textbook illustrations are particularly germane but need additional explanation.
4. Demonstrations are used to introduce or elucidate some key concepts.

B. Laboratory

1. Students are introduced to the laboratory with a laboratory lecture covering the theory of the experiment, the methods to be used, and how the calculations should be carried out.
2. Students perform the experiment according to the directions given in the laboratory lecture and the printed experiment, carry out the calculations and submit a written laboratory report for evaluation and grading.

III. Course Requirements

1. Lecture room with white boards, overhead projector, VCR and large monitor.
2. Laboratory with balances sensitive to 0.01g, 6 square feet of bench space per student, complement of appropriate glassware, equipment and supplies.
3. Small conference room available for one-on-one discussions with students.
4. Library with microbiology reference works.

IV. Methods of Evaluation

There will be three tests, collectively worth $3/7^{th}$ of the course grade, a comprehensive final examination worth $3/7^{th}$ of the course grade and a laboratory grade worth $1/7^{th}$ of the course grade.

V. Course Outline

A. Lecture Topics

Chapter 1: The Main Themes of Microbiology

Microbiology is introduced and the scope of microbiology is revealed. Microorganisms are defined and their impact on Earth, as well as humans, is described. The origin and evolution of microorganisms is discussed. A history of microbiology is given, highlighting the major scientific contributions to the development of the field. The levels of classification are introduced and the basis of taxonomy is discussed.

1.1 The Scope of Microbiology
1.2 The Impact of Microbes on Earth: Small Organisms with a Giant Effect
1.3 Human Use of Microorganisms
1.4 Infectious Diseases and the Human Condition
1.5 The General Characteristics of Microorganisms
1.6 The Historical Foundations of Microbiology
1.7 Taxonomy: Organizing, Classifying, and Naming Microorganisms

Chapter 2: The Chemistry of Biology

Chemistry is introduced in this chapter. Matter, atoms, elements, and molecules are defined. Chemical bonds are discussed in terms of their strength and formation, and the concept of polar vs. non-polar substances is highlighted. Chemical reactions, such as oxidation/reduction and ionization, are examined in terms of their importance in cellular metabolism. The structures of proteins, fats, carbohydrates and lipids are elucidated. Finally, the idea that the structure of macromolecules determines their properties is discussed.

2.1 Atoms, Bonds, and Molecules: Fundamental Building Blocks
2.2 Macromolecules: Superstructures of Life

Chapter 3: Tools of the Laboratory: The Methods for Studying MicroorganismsThe tools and techniques of microbiology are introduced in this chapter. The methods for culturing microorganisms (the Five "I"s) are presented. The various types of media are discussed based on composition and function. Light and electron microscopy are investigated and background is giving on their operational principles. Finally, the need and use of staining is discussed.

3.1 Methods of Culturing Microorganisms—The Five "I"s
3.2 The Microscope: Window on an Invisible Realm

Chapter 4: An Introduction to Cells, and Procaryotic Cell Structure and Function

The components of cells and the structures of procaryotic cells are introduced in this chapter. Features of the procaryotic cell that are presented include motility, cell envelope, cell wall, cell membrane, chromosomes, ribosomes, inclusion bodies, and cytoskeleton. The structural and functional differences between the gram-positive cell wall and the gram-negative cell wall are elucidated. Unique capabilities of some bacteria are discussed such as the ability to form endospores and perform photosynthesis. The bacterial shapes, arrangements, and classification systems are stressed. Methods used in procaryote identification are examined. Archaea are presented, their extreme adaptability and unique metabolism are discussed.

4.1 Characteristics of Cells and Life
4.2 Procaryotic Profiles: The Bacteria and Archaea
4.3 External Structures
4.4 The Cell Envelope: The Boundary Layer of Bacteria
4.5 Bacterial Internal Structure
4.6 Bacterial Shapes, Arrangements, and Sizes
4.7 Classification Systems in the Procaryotes
4.8 Archaea: The Other Procaryotes

Chapter 5: Eucaryotic Cells And Microorganisms

The structure of eucaryotic cells is covered and a survey of the eucaryotic microscopic organisms is given. A detailed look at the external and internal structures of a typical eucaryotic cell is presented. The Kingdom Mycetae (Fungi), the Kingdom Protista (Algae and Protozoa), and the Kingdom Animalia (Helminths) are outlined. Examples of the basic life cycles (asexual and sexual) are presented.

5.1 The History of Eucaryotes
5.2 Form and Function of the Eucaryotic Cell: External Structures
5.3 Form and Function of the Eucaryotic Cell: Internal Structures
5.4 The Kingdom of the Fungi
5.5 The Protists
5.6 The Parasitic Helminths

Chapter 7: Elements Of Microbial Nutrition, Ecology, And Growth

This chapter introduces the conditions and requirements that are necessary for microbial growth. Temperature, pH, nutrients, osmotic pressure, atmospheric

pressure, energy sources, and oxygen requirements for microbial growth are discussed. Transportation of nutrients across the cellular membrane is reviewed, and the concepts of diffusion, osmosis, and active transport are introduced. The various types of microbial associations, including—symbiotic relationships, synergism and antagonism, are presented. Quorum sensing is introduced as an explanation of the behavior of biofilms. The study of microbial growth, the rate of population growth, and the four phases of a normal growth curve are described. Methods for analyzing population growth are discussed.

7.1 Microbial Nutrition
7.2 Environmental Factors That Influence Microbes
7.3 The Study of Microbial Growth

Chapter 8: Microbial Metabolism: The Chemical Crossroads of Life

Metabolism is defined and a broad overview of the main anabolic and catabolic reactions performed by microorganisms is given. The structure of enzymes, the function of enzymes, and the ways to control enzymes are examined. The three pathways of cellular respiration are reviewed: glycolysis, the TCA cycle, and electron transport. Fermentation is presented in terms of organisms living in anaerobic environments. The formation of macromolecules and the tremendous efficiency of microorganisms are highlighted.

8.1 The Metabolism of Microbes
8.2 The Pursuit and Utilization of Energy
8.3 Pathways of Bioenergetics
8.4 Biosynthesis and the Crossing Pathways of Metabolism

Chapter 9: Microbial Genetics

This chapter introduces students to the study of genetics. The structure of DNA (which was introduced in Ch. 2) is reviewed and genes are introduced. The replication of DNA is presented and the need for fidelity is discussed. The processes of transcription and translation are presented in both eucaryotic and procaryotic cells. The regulation of protein synthesis in terms of bacterial operons is discussed. Mutations are defined and the various types of mutations are explained. The three major types of bacterial recombination (conjugation, transformation, and transduction) are presented and transposons are introduced.

9.1 Introduction to Genetics and Genes: Unlocking the Secrets of Heredity
9.2 Applications of the DNA Code: Transcription and Translation
9.3 Genetic Regulation of Protein Synthesis and Metabolism
9.4 Mutations: Changes in the Genetic Code
9.5 DNA Recombination Events

Chapter 14: Nonspecific Host Defenses

The components of the nonspecific immune system are introduced. The three lines of the immune systems' defense are outlined. The blood, lymphatics, and reticuloendothelial systems are presented. The composition and flow of the blood and lymph are highlighted. The role of the inflammatory response in immunity is discussed, and phagocytosis and complement are presented.

14.1 Defense Mechanisms of the Host in Perspective
14.2 Structure and Function of the Organs of Defense and Immunity
14.3 Actions of the Second Line of Defense

Chapter 15: Adaptive, Specific Immunity and Immunization

The concept of adaptive immunity is discussed. The ability to acquire immunity actively, passively, naturally or artificially is outlined. The structure and development of specific B and T cell receptors is presented, the clonal selection theory is discussed, and the development of immune cell memory is introduced. The maturation and activation of B and T cells are surveyed. Antigen presenting cells are introduced and the manner in which they present antigen to T cells is highlighted. Characteristics of effective antigens are evaluated and the various kinds of immunizations are presented.

15.1 Specific Immunity: The Adaptive Line of Defense
15.2 Development of the Immune Response System
15.3 Lymphocyte Responses and Antigens
15.4 Cooperation in Immune Reactions to Antigens
15.5 B-Cell Responses
15.6 T-Cell Responses
15.7 Immunization: Methods of Manipulating Immunity for Therapeutic Purposes

Chapter 16: Disorders in Immunity

Dysfunctions in the immune system due to heightened immune response, decreased immune response, and incorrect immune response are presented. The four states of hypersensitivity are outlined. The nature of allergens and the mechanisms and cells involved in developing allergies are described. The lyses of foreign cells by complement mediated destruction is presented. Mechanisms of immune complex disease, and T cell mediated delayed hypersensitivity are reviewed. The origin, genetics, and examples of autoimmune diseases are described. The inability of the immune system to fight certain types of cancer is highlighted.

16.1 The Immune Response: A Two-Sided Coin
16.2 Type I Allergic Reactions: Atopy and Anaphylaxis
16.3 Type II Hypersensitivities: Reactions That Lyse Foreign Cells
16.4 Type III Hypersensitivities: Immune Complex Reactions
16.5 Immunopathologies Involving T Cells
16.6 Autoimmune Diseases—An Attack on Self
16.7 Immunodeficiency Diseases: Hyposensitivity of the Immune System
16.8 The Functions of the Immune System in Cancer

Chapter 17: Diagnosing Infections

The techniques to identify microbes that are responsible for clinical symptoms are presented. First, the importance of aseptic and accurate specimen collection is explained. Phenotypic identification methods such as microscopic observation, the cultivation of the specimen using selective and differential media, and

biochemical tests are presented. Genotypic methods including DNA analysis, sequencing PCR, and G+C base composition are described. Immunological methods including agglutination, precipitin, western blot, complement fixation, fluorescent antibodies, and immunoassays are highlighted. The techniques used to diagnose viral infections are summarized.

17.1 Preparation for the Survey of Microbial Diseases
17.2 On the Track of the Infectious Agent: Specimen Collection
17.3 Phenotypic Methods
17.4 Genotypic Methods
17.5 Immunological Methods

VI. Experiments

1. Introduction to Lab
2. Growing and Staining Microorganisms
3. Human Flora and Isolation of Organisms
4. Antibiotics and Chemical Agents
5. Biochemical Tests and Identification of Bacteria
6. Tests for Gram Negative Bacteria
7. Tests for Gram Positive Bacteria

VII. Bibliography

The course text is comprehensive so no additional reading assignments are required of the students. The focus of the course is on the student's mastery of key concepts and the ability to solve standard problems associated with these key concepts. The text is more than adequate for both of these purposes.