Revised 5/21

NOVA COLLEGE-WIDE COURSE CONTENT SUMMARY
BIO 205 – GENERAL MICROBIOLOGY (4 CR.)

Course Description

Explores the structure and function of microorganisms and their relationship to the environment and humans. Emphasizes the various groups of microorganisms, their growth and metabolism, roles in the functioning of ecosystems, genetics, their roles in human health, the use of microbes in industrial applications and biotechnology and methods of microbial control. Lecture 3 hours. Recitation and laboratory 3 hours. Total 6 hours per week.

General Course Purpose

This course will enable biology majors to build a solid and broad foundation in their understanding of the biology of microorganisms and their roles in ecosystems, human health, and biotechnology applications. The course includes lecture and hands-on laboratory components. Both components will emphasize giving students a firm understanding of the importance of microorganisms and the techniques used to study them.

Course Prerequisites/Corequisites

Prerequisites: BIO 101, BIO 102, CHM 111, ENG 111.
Corequisite: CHM 112.

Course Objectives

Upon completing the course, the student will be able to:

Scientific Literacy

- Evaluate different perspectives, opinions, and statements about biological issues in terms of their logic, content, scientific merit, and biases.

Quantitative reasoning

- Perform accurate calculations, interpret scientific data and graphs, and use results to support conclusions.
- Analyze data collected through experiments in lab. Present and discuss the findings and conclusions derived from data, with chart/spreadsheet and graphs.

Critical thinking

- Discriminate among degrees of credibility, accuracy, and reliability of inferences drawn from given data, determine whether certain conclusions or consequences are supported by the information provided and use problem solving skills.

Introduction to Microorganisms: History and Scope of Microbiology, Comparing the structures of prokaryotic cells vs eukaryotic cells, Basics of Metabolism.

- Relate how key findings led scientists to develop theories and better understand how microorganisms shape our planet, our health and society.
- Contrast the advantages and/or disadvantages of different microscopes (bright-field, phase contrast, fluorescent, and electron) for a given situation.
- Discuss common features of all living things and contrast microbes that are non-cellular.
- Identify underlying features and differentiate between *Bacteria*, *Archaea*, and *Eukarya*.
- Compare and contrast the structure of cell membranes and cell walls in Bacteria and Archaea.
- Differentiate between aerobic respiration, anaerobic respiration and fermentation metabolic pathways and relate these metabolic reactions to microbial identification tests.

Microbial Metabolic Diversity, Growth and Control: Metabolic diversity of Bacteria and Archaea, Microbial Division and Growth, Microbial Control.

- Given an energy source and a carbon source, categorize the metabolic lifestyle of an organism (e.g., chemoheterotroph, chemolithotroph, photoheterotroph, or photoautotroph).
- Compare the differences between oxygenic and anoxygenic photophosphorylation.
- Identify and describe two or more fermentation pathways.
- Summarize the diverse roles of prokaryotes in the global carbon, sulfur and nitrogen cycles.
- Summarize an example where the waste product of one microorganism serves as an important substrate for another organism (e.g., ammonia-oxidizing bacteria or ammonia-oxidizing archaea and nitrite-oxidizing bacteria, hydrogen producers and methanogens, sulfide oxidizers and sulfate reducers, etc.).
- List the stages of biofilm formation and maturation.
- Analyze whether the mechanism of action for a given antibiotic would affect Gram-positive and/or Gram-negative cells.
- Describe how mutations and horizontal gene transfer, together with selective pressure, can lead to a rise of antibiotic resistance (or xenobiotic bioremediation or spread of virulence mechanisms).
- Given a particular situation, predict the best method (e.g., physical, chemical, biological, etc.) for controlling bacterial growth.
- Identify and summarize the different phases of a microbial growth curve.
- Given the starting concentration of a culture and the number of generations that occur, calculate the final concentration of the culture.

Microbial Genetics: Review of the Central Dogma, Regulation of Gene Expression, Horizontal Gene Transfer, Applied Genetics.

- Compare and contrast DNA replication in Bacteria, Archaea and Eukaryotes.
- Identify similarities and differences in transcription and translation between Bacteria, Archaea, and Eukaryotes.
- Explain the role of a transcriptional repressor (or activator).
- Summarize how the organization of genes in an operon affects transcription in Bacteria.
- Compare and contrast the acquisition of unique genetic information in microorganisms through mutations, conjugation, transduction, and transformation.
- Discuss two societal benefits achieved through the genetic manipulation of microbes.

Diversity and Evolution of Microorganisms: Diversity of Bacteria, Diversity of Archaea, Diversity of Microbial Eukarya, Virology.

- List the three Domains of the phylogenetic tree of life. Discuss one or more unique characteristics of each Domain.
- Discuss why the traditional definition of species using reproductive isolation does not apply to Bacteria and Archaea.
- Explain what features of 16S rRNA make it useful to compare the evolutionary relationship between organisms.
- Outline the major taxonomic groups within Bacteria, Archaea and microbial Eukarya.
- Summarize the diversity of prokaryotes involved in nutrient cycling.
- Predict the replication cycle of a virus based on the genome it carries.
- Compare and contrast the multiplication of animal viruses and bacteriophages.

Impact of Microorganisms: Immunology, Epidemiology, Host-Microbe Interactions, Applied Microbiology.

- Describe how the presence of microorganisms or their structures (e.g., peptidoglycan, lipopolysaccharides, flagella, etc.) stimulate an immune response.
- Distinguish between the terms: endemic, epidemic, and pandemic.
- Predict how public health policies (e.g., quarantine and vaccination) can alter epidemic/pandemic progression.
- Name two sites on the human body colonized by the normal microbiota and identify examples of the type of organisms found at those sites.
- Given a particular pathogen (or symbiont), describe how it creates cell damage (or benefits) in its host.
- Provide the following for selected diseases caused by microorganisms:
    - Causative organism; occurrence; reservoir; mode of transmission; incubation period; period of communicability; method of control including specific treatment.
- Relate the importance of microbial fermentation to the production of food, beverages, and other

products useful to human society (e.g., cheese, yogurt, wine, beer, pharmaceuticals, cosmetics, solvents).
- Identify and describe examples of how microbes can be used to solve environmental or energy problems.
- Relate two specific tools of modern biotechnology that are derived from naturally occurring microbes (e.g., cloning vectors, restriction enzymes, *Taq* polymerase, CRISPR-Cas9, etc.) to their societal benefits.

Laboratory Skills and Scientific Thinking
- Use aseptic technique in handling microorganisms.
- Demonstrate the proper use of PPE and code of conduct for Biosafety Level-2.
- Proficiently prepare and view specimens for examination using appropriate staining techniques and microscopy (bright field and, if possible, phase contrast).
- Use pure culture and selective techniques to enrich for and isolate microorganisms.
- Use appropriate methods to identify microorganisms (media-based, molecular and serological).
- Use appropriate microbiological methods to estimate the number of microorganisms in a sample (direct count, viable plate count, filtration, or spectrophotometric methods).
- Use appropriate microbiological and molecular genetics lab equipment and methods.
- Use appropriate methods for evaluating environmental samples or culturing food samples containing microorganisms.
- Document and report on experimental protocols, results and conclusions.
- Identify credible scientific sources and interpret and evaluate the information therein.

Major Topics to be Included

- Scientific Literacy
- Quantitative reasoning
- Critical thinking
- **Introduction to Microorganisms:** History and Scope of Microbiology, Comparing the structures of prokaryotic cells vs eukaryotic cells, Basics of Metabolism.
- **Microbial Metabolic Diversity, Growth and Control:** Metabolic diversity of Bacteria and Archaea, Microbial Division and Growth, Microbial Control
- **Microbial Genetics:** Review of the Central Dogma, Regulation of Gene Expression, Horizontal Gene Transfer, Applied Genetics
- **Diversity and Evolution of Microorganisms:** Diversity of Bacteria, Diversity of Archaea, Diversity of Microbial Eukarya, Virology
- **Impact of Microorganisms**: Immunology, Epidemiology, Host-Microbe Interactions, Applied Microbiology
- **Laboratory Skills and Scientific Thinking**

Optional Topics

The instructor may wish to include coverage of eukaryotic algae and parasitic worms.
Field Trips: Field trips may be taken to one or more of the following places depending upon the time available and student interests.
- American Type Culture Collection
- Anaerobe Lab, V.P.I. & State University
- National Agricultural Library
- National Institutes of Health
- Local brewery
- Local dairy
- Local research and development firm
- Local water purification plant