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Text update: April 28, 2010  
Date reviewed: Spring 2014  
C&GE Approved: March 10, 2014  
Board Approved: April 9, 2014

Biology (BIOL) 2260 General Microbiology (5 Units) CSU:UC  
[formerly Microbiology 8]

Prerequisite: Successful completion in Biology 1500 or Biology 1510 or one year of high school biology with a grade of "C" or better; and Chemistry 1510 or one year of high school chemistry with a grade of "C" or better

Advisory: Eligibility for English 1500 strongly recommended

Prerequisite knowledge/skills: Before entering the course the student should be able to

1. understand, explain, and demonstrate the logical problem solving methods of chemistry.
2. understand pertinent examples, analogies, and special topics used to introduce and illustrate basic chemical concepts,
3. analyze the fundamentals of chemical science and have an enhanced understanding of the physical environment,
4. use of the scientific method,
5. understand the basic concepts of chemistry in order to be adequately prepared to continue the study of more advanced chemistry classes,
6. possess a general introduction to biology,
7. develop the fundamental principles of biology as illustrated by plants and animals,
8. develop an understanding of the scientific method,
9. develop the ability to make critical observations,
10. develop an understanding of their interaction with their biological environment, and
11. develop practical laboratory experiences in the life sciences.

Total hours: 48 hours lecture; 96 hours lab (144 hours total)

Catalog Description: As an introduction to the microbes, this course will include the morphology, metabolism, and pathogenicity of bacteria, fungi, viruses, prions, protozoa, and helminths. Special emphasis will be placed on human immunology and those etiological agents of human disease. Laboratory exercises will include aseptic techniques, culturing and identification of common microbes, cataloging results in structured, notebook format, presentation skills of technical material to peers, drawing fungus micro and macro morphology, and drawing micro and macro parasite morphology.

Type of Class/Course: Degree Credit

Lecture Text:

Tortora, Gerard J., Berdell. R. Funk, and Christine L. Case. *Microbiology: An Introduction. 11th ed.* San Francisco: Cummings, 2012. Print.

Laboratory Text:

Golling, Greg. *Golling's Guide to Microbiology: Learning to Love Bacteria*. Bakersfield: Kinko's. 2015. Print.

Course Objectives:

By the end of the course, a successful student will be able to

1. classify and describe microorganisms,
2. demonstrate knowledgeable use of the nomenclature of the microbes,
3. analyze the growth characteristics of microbes using routine laboratory culture techniques,
4. compare and contrast the eukaryotic and prokaryotic cells,
5. demonstrate basic proficiency in using the Gram stain technique,
6. exercise aseptic techniques in handling microbes,
7. demonstrate sterilization and disinfection of the laboratory and laboratory materials,
8. describe the interaction of antibiotics with microbes,
9. describe host-parasite interaction,
10. describe the cytology and physiology of the human immune system,
11. demonstrate proficient use of the light microscope for the viewing of microorganisms,
12. describe the genetic material and the replication of the nucleic acids of both the eukaryotic and prokaryotic microbes,
13. demonstrate and recognize the mutability of the microbial genome,
14. describe the use of plasmids and bacteriophage for use in genetic engineering, and
15. describe the life cycle, nutrition and possible pathogenicity of important representative of bacteria, viruses, prions, fungi, and protozoa, and helminths.

Means of Achieving Course Objectives:

1. Assigned reading from text and selected references
2. Study published lecture outlines
3. Lecture and demonstrations given by instructor
4. Study above materials using the published, course specific study objectives as a guide

Course Scope and Content: (Lecture)

Unit I The Microbial World and You

- A. Identify the importance of Koch's postulates,
- B. Identify the contributions to microbiology made by Pasteur, Hooke, van Leeuwenhoek, Lister, Ehrlich, Fleming, and Jenner,
- C. Define bacteriology, mycology, parasitology, immunology, virology, and microbial genetics,
- D. Recognize the system of scientific nomenclature that uses genus and specific epithet names,
- E. Differentiate among the major groups of organisms studied in microbiology, and
- F. Define normal microbiota (normal flora).

Unit II Observing Microorganisms Through a Microscope

- A. List the units of measurements used for microorganisms,

- B. Calculate total magnification and define resolution. Know the names of the lenses,
- C. Identify a use for darkfield, phase-contrast, fluorescence, and electron microscopy, and compare each with brightfield illumination. Explain the principle behind each,
- D. Compare simple, differential, and special stains. Give an example of the use of each one,
- E. List the steps in preparing a Gram stain, and describe the appearance of gram-positive and gram-negative cells after each step, and
- F. Explain why each of the following is used: capsule stain, endospore stain, and flagellar stain.

Unit III            Functional Anatomy of Prokaryotic and Eucaryotic Cells

Note: Emphasis will be on bacterial (prokaryotic) cells except as noted in the objectives

- A. Compare and contrast the overall cell structure of prokaryotes and eukaryotes,
- B. Identify the three basic shapes and their variations of bacteria and correlate the name with the arrangement after division,
- C. Describe the structure and function of the glycocalyx, flagella (types of), axial filaments, fimbriae, pili, and plasma membrane. Give a specific example of how these structures are important in bacteria,
- D. Describe cilia and their role in eukaryotic cells,
- E. Compare and contrast the cell walls of gram-positive, gram-negative, archaea, and mycoplasmas,
- F. Explain how the chemistry of the bacterial cell wall relates to the gram stain,
- G. Give an example of the importance of the cell wall chemistry in antibiotic resistance,
- H. Identify the functions of the nuclear area, ribosomes, and inclusions,
- I. Characterize the role of the plasmid and describe its function in antimicrobial resistance and biogenetic engineering,
- J. Describe the function of endospores and describe how they allow the organisms to survive, and
- K. List the composition of the cell walls of plants, yeasts, fungi, and protozoa.

Unit IV            Microbial Metabolism

- A. Define metabolism, and describe the basic differences between anabolism and catabolism,
- B. Characterize enzymes, their structure and function,
- C. Compare and contrast aerobic respiration, anaerobic respiration, and fermentation,
- D. Describe the importance of ATP, and give examples of energy requiring activities of the cell,
- E. Explain the overall function of metabolic pathways,
- F. Describe the catabolism of glucose, and
- G. Define chemoheterotrophs.

Unit V            Microbial Growth

- A. Classify microbes into the main groups on the basis of preferred temperature range,
- B. Identify the group that is the most common cause of food spoilage and disease,
- C. List the preferred pH range,
- D. Explain the importance of osmotic pressure to bacteria,
- E. List the chemical elements required for growth,
- F. Match the oxygen requirements with the descriptive term. Example: obligate aerobe,
- G. Justify the use of each of the following: anaerobic techniques, living host cells, candle jars, selective and differential, enrichment media. Be able to state an example of the media,
- H. Define bacterial growth, including binary fission, and
- I. Identify the phases of microbial growth curve, and describe the relation to generation time.

Unit VI            The Control of Microbial Growth

- A. Define the terms sterilization, disinfection, antisepsis, germicide, bacteriostasis, asepsis, degerming, sanitation, and pasteurization,
- B. Describe the effects of microbial control agents on cellular structures,
- C. Match the mechanism of action with the common methods used to control microbial growth,
- D. Discuss the concern of bacterial spores in this process, and
- E. Match the methods of action with the common chemical disinfectants.

Unit VII            Microbial Genetics

- A. Briefly explain the components of DNA, and explain its functional relationship to RNA and protein,
- B. Explain DNA replication using these terms: replication fork, semiconservative replication, hydrogen bonds, DNA polymerase, and DNA ligase,
- C. Explain the regulation of gene expression in bacteria using the operon model,
- D. Classify mutations by type, and describe how mutations are prevented or repaired,
- E. Define mutagen,
- F. Compare the mechanisms of genetic recombination in bacteria: transformation, conjugation, and transduction,
- G. Define the functions of plasmids and transposons, and
- H. Relate the mechanisms for genetic change (mutation and recombination) to microbial evolution (natural selection).

Unit VIII            Biotechnology Tools and Techniques

- A. Define recombinant DNA,
- B. Describe an overview of recombinant DNA procedures,
- C. Identify the roles of a clone and a vector in genetic engineering,
- D. Define restriction enzymes, and outline how they are used to make recombinant DNA,
- E. Describe five ways genetic engineers get foreign DNA into a cell,
- F. Describe how a gene library is made and the process used to create synthetic DNA,
- G. Explain how each of the following is used to locate a clone; antibiotic-resistant genes, DNA probes, gene product, and
- H. List at least four applications of genetic engineering used in medicine.

Unit IX            Classification of Microorganisms

- A. Define taxonomy,
- B. Define binomial as it relates to bacteria,
- C. Explain taxonomic hierarchy and be able to order the correct sequence from most general to the most specific,
- D. Compare and contrast classification and identification, and
- E. Describe how staining and biochemical tests are used to identify bacteria.

Unit X            Bacteria

- A. Recall characteristics and examples of organisms and their diseases as discussed in lecture, and
- B. Categorize bacterial species into groups based upon cell morphology and Gram reaction characteristics.

Unit XI            Fungi, Algae, Protozoa, and Multicellular Parasites

- A. List the defining characteristics of the Kingdom Fungi,
- B. Differentiate fungi from bacteria on a nutritional basis,
- C. Differentiate between asexual and sexual reproduction,
- D. Be able to identify representative asexual spores as pictured in the text,
- E. Differentiate between the molds and yeast, and dimorphic fungi,
- F. List the defining characteristics of the four divisions of fungi described in lecture and recognize the given examples,
- G. Differentiate between systemic, subcutaneous, and cutaneous mycoses,
- H. List the defining characteristics of protozoa,
- I. Describe the outstanding characteristics of the six phyla of protozoa discussed in lecture and given examples,
- J. Be able to identify representative amoeba and flagellates as pictured in the text,
- K. Differentiate between an intermediate host and a definitive host,
- L. Differentiate between dioecious and monoecious (hermaphroditic),
- M. List the distinguishing characteristics of parasitic helminthes,
- N. List the characteristics of the three groups of parasitic helminths as discussed in lecture and recognize given examples,
- O. Be able to identify the group to which a drawing of the general anatomy of each worm belongs, and
- P. Define arthropod vector.

#### Unit XII Viruses

- A. List the general characteristics of a virus,
- B. Describe the chemical and physical structure of both an enveloped and a nonenveloped virus,
- C. Give an example of a common name for a virus. Explain how these names are derived,
- D. Describe the common methods used for culture in the clinical laboratory for viruses that affect humans,
- E. Discuss the lytic cycle in viral reproduction,
- F. Discuss lysogeny,
- G. Define oncogene,
- H. Provide an example of a latent viral infection,
- I. Differentiate between persistent (slow) viral infections and latent viral infections, and
- J. Discuss prions. Include what they are and diseases they are associated with.

#### Unit XIII Principles of Disease and Epidemiology

- A. Define pathology, etiology, infection, and disease,
- B. Define normal microbiota (flora),
- C. Compare commensalism and parasitism and give an example of each,
- D. Compare and contrast normal flora with opportunistic microorganisms,
- E. List Koch's Postulates,
- F. List seven probable reasons for emerging infectious diseases, and name one example for each reason,
- G. Define reservoir of infection,
- H. Explain three methods of disease transmission: contact, vehicle, and vector transmission,
- I. Define nosocomial infections, and explain their importance,
- J. Define compromised host,

- K. Put the following in proper sequence, according to the pattern of disease: period of decline, period of convalescence, period of illness, prodromal period, incubation period,
- L. Define epidemiology, and
- M. Define the following terms: morbidity, mortality, and notifiable (reportable) disease.

Unit XIV      Microbial Mechanisms of Pathogenicity

- A. Differentiate between pathogenicity and virulence,
- B. Identify the principle portals of entry,
- C. Using examples given in lecture, explain how microbes adhere to host cells and list examples as given in lecture,
- D. Explain how capsules and cell wall components contribute to pathogenicity,
- E. Compare the effects of leukocidins, hemolysins, coagulases, hyaluronidase, and collagenase,
- F. Contrast the nature and effects of exotoxins and endotoxins,
- G. Recall a brief description of the mechanism of action of the diphtheria toxin, botulinum toxin, tetanus toxin, cholera toxin, staphylococcal toxin, and lipid A,
- H. Describe the role of plasmids and lysogeny in pathogenicity,
- I. Explain bacteriophages,
- J. Recall seven cytopathic effects of viruses as listed in lecture,
- K. Discuss the pathogenic mechanisms of fungi listed in lecture, and
- L. Discuss the pathogenic properties and causes of symptoms for Plasmodium, Trypanosomes, Giardia, Wucheria bancrofti, and Clostridium as described in lecture.

Unit XV      Nonspecific Defenses of the Host

- A. Define resistance and susceptibility,
- B. Define nonspecific resistance,
- C. Describe the role of the skin and mucous membranes in nonspecific resistance,
- D. List and differentiate between mechanical and chemical factors,
- E. Define phagocytosis and phagocyte,
- F. Classify phagocytic cells and describe the roles of granulocytes and monocyte,
- G. Describe the role of lymphocytes and eosinophils,
- H. Define differential white blood cell count,
- I. List the signs and stages of inflammation,
- J. Explain the mechanisms during the stage of inflammation called vasodilation,
- K. Describe the cause of fever,
- L. Describe three consequences of complement activation, and
- M. Discuss interferons in terms of the three types. Explain how they work to prevent infection with viruses.

Unit XVI      Specific Defenses of the Host: The Immune Response

- A. Define innate resistance and immunity,
- B. Contrast the four types of acquired immunity,
- C. Differentiate between humoral (antibody-mediated) and cell-mediated immunity,
- D. Define antigen, hapten, and antibody,
- E. Explain the function of antibodies and describe their structural and chemical characteristics,
- F. Name one function of each of the classes of antibodies,

- G. Name the function of B cells,
- H. Describe the clonal selection theory,
- I. Explain how an antibody reacts with an antigen, and identify the consequences,
- J. Distinguish between a primary and a secondary immune response,
- K. Identify the function of cytokines and interleukins in cell-mediated immunity,
- L. Be able to match the name of each of the following: Th cell, Tc cell, Td cell, Ts cell, APC, MHC, and activated macrophage, with its function, and
- M. Compare and contrast cell-mediated and humoral immunity.

#### Unit XVII Practical Applications of Immunology

- A. Define vaccine. Differentiate between natural versus artificial, and, active versus passive immunity,
- B. Define herd immunity,
- C. Differentiate between the following, and provide an example of each: attenuated, inactivated, toxoid, and conjugated vaccines, and
- D. Discuss the value versus risks of vaccines.

#### Unit XVIII Disorders Associated with the Immune System

- A. Differentiate among four types of hypersensitivity reactions, and
- B. Describe one example of each of the four types of hypersensitivity reactions.

#### Unit XIX Antimicrobial Drugs

- A. State the problem of chemotherapy for viral, fungal, protozoan, and helminthic infections versus bacteria,
- B. Define broad spectrum antibiotic, bacteriostatic, and bactericidal,
- C. List the five modes of action of antimicrobial drugs,
- D. Explain why the commonly used antimicrobial drugs are specific for bacteria,
- E. List the advantages of each of the following over penicillin: semisynthetic penicillins, cephalosporins, and vancomycin,
- F. State the mode of action of penicillin and how the beta-lactamase producing organisms are able to evade the action of penicillin,
- G. Explain why isoniazid (INH) is an antimycobacterial agent,
- H. Recall that the following inhibits protein synthesis: aminoglycosides, tetracyclines, chloramphenicol, macrolides,
- I. State the mode of action of polymyxin B, bacitracin, and neomycin,
- J. Describe how rifamycins and quinolones kill bacteria,
- K. Describe how sulfonamides inhibit microbial growth,
- L. Name and give examples from lecture of two of the following drugs: antifungal, antiviral, antiprotozoan, and antihelminthic, and
- M. Describe the mechanism of drug resistance.

#### Unit XX Microbial Diseases of the Skin and Eyes

- A. Briefly describe the structure of the skin and mucous membranes and how pathogens invade the skin,
- B. Provide examples of normal skin flora,
- C. Differentiate between staphylococci and streptococci, and recall skin infections caused by each: sty, furuncle (boil), impetigo, scalded skin syndrome, toxic shock syndrome, and erysipelas,
- D. Describe skin, eye, and ear infections by *Pseudomonas*,
- E. Differentiate between cutaneous (Dermatomycosis) and subcutaneous mycoses, and recall examples given in lecture of Tinea and Sporotrichosis,
- F. Be able to match the name of the body with the Tinea infections,
- G. Describe candidiasis and name the diseases caused by this organism, and
- H. List the causative agent and describe the epidemiology of acne, warts, smallpox, chickenpox, cold sores, measles (Rubeola), rubella, scabies, conjunctivitis, and trachoma.

Unit XXI      Microbial Diseases of the Nervous System

- A. Define central nervous system and blood-brain barrier. Explain how the blood-brain barrier makes infections of the CNS hard to treat,
- B. Differentiate between meningitis and encephalitis,
- C. Discuss the epidemiology of meningitis caused by *Haemophilus*, influenza, *Streptococcus pneumoniae*, *Neisseria meningitidis*, and *Listeria monocytogenes*,
- D. Discuss the epidemiology and etiology of tetanus and leprosy,
- E. State the causative agent, symptoms, suspect foods, and treatment for botulism,
- F. List the virus and viral diseases of the nervous system discussed in lecture,
- G. Identify the causative agent and describe the epidemiology for cryptococcosis and African trypanosomiasis. What test is used to detect *Cryptococcus* in the CNS,
- H. List the characteristics of diseases caused by prions and name the disease of humans similar to scrapie, and
- I. List the characteristics of TSE diseases caused by prions and name the disease of humans similar to scrapie. Explain how is BSE related to human vCJD.

Unit XXII      Microbial Diseases of Cardiovascular and Lymphatic Systems

- A. List the signs and symptoms of septicemia,
- B. Describe the epidemiology and state the common agent of puerperal sepsis (child birth fever) and subacute bacterial endocarditis,
- C. Name the cause and treatment of, and explain the preventative measures for, rheumatic fever,
- D. Describe the epidemiology and list the causative agent of tularemia, brucellosis, anthrax, gas gangrene, and plague,
- E. List the pathogens given in lecture that are transmitted by animal bites and scratches, which cause systemic disease,
- F. List the diseases given in lecture transmitted by ticks,
- G. Compare and contrast yellow fever, dengue, and dengue hemorrhagic fever,
- H. List the emerging viral hemorrhagic fevers and describe the epidemiology and pathogenesis of CMV, and
- I. List the causative agents and describe the epidemiology for American trypanosomiasis (Chagas Disease), toxoplasmosis, and malaria.

Unit XXIII      Microbial Diseases of the Respiratory System



- A. Describe how microorganisms are prevented from entering the respiratory system,
- B. Differentiate among pharyngitis, laryngitis, tonsillitis, and sinusitis,
- C. List the causative agent and describe the epidemiology for streptococcal pharyngitis, scarlet fever, diphtheria, otitis media, and the common cold,
- D. List the causative agent and prevention for pertussis and tuberculosis,
- E. List and describe the causative agents of the pneumonia's discussed in lecture, and
- F. List the causative agent and describe the epidemiology of coccidiomycosis.

#### Unit XXIV      Microbial Diseases of the Digestive System

- A. Name the structures of the digestive system associated with food borne illness,
- B. List examples of normal flora for each part of the gastrointestinal tract,
- C. Describe the events that lead to dental caries and periodontal disease. Name the major organism involved,
- D. List the causative agents, suspect foods, signs and symptoms (incubation times), describe the epidemiology of staphylococcal food poisoning, shigellosis, salmonellosis, typhoid fever, cholera, gastroenteritis, traveler's diarrhea, and peptic ulcer disease,
- E. Describe the diagnostic method for gastroenteritis caused by *Campylobacter*,
- F. Differentiate between gastrointestinal diseases as a result of a toxin and those due to the organism's pathogenicity itself,
- G. Differentiate among hepatitis A, B, C, D, and E especially mode of transmission,
- H. List the causative agents and symptoms of viral gastroenteritis as discussed in lecture,
- I. Identify the causes of ergot poisoning and aflatoxin poisoning,
- J. List the causative agents and describe the epidemiology for giardiasis, amoebic dysentery, cryptosporidiosis, and *Cyclospora* diarrheal infection, and
- K. List the causative agents and symptoms for tapeworms, pinworms, hookworms, ascariasis, and trichinosis.

#### Unit XXV      Microbial Diseases of the Urinary and Reproductive Systems

- A. List the antimicrobial features of the urinary tract system,
- B. Identify the portals of entry for microbes into the reproductive system,
- C. Describe the normal microbiota of the upper urinary tract, the male urethra, and the female urethra and vagina,
- D. Describe methods of transmission for urinary and reproductive system infections,
- E. List the microorganisms that cause cystitis, pyelonephritis, and leptospirosis,
- F. Describe the cause of glomerulonephritis,
- G. List the etiologic agents and epidemiology for gonorrhea, PID, syphilis, NGU, vaginitis, lymphogranuloma venereum, chancroid, *Gardnerella* vaginosis, candidiasis, and trichomoniasis, and
- H. Discuss the epidemiology of genital herpes and warts.

#### Course Scope and Content: (Laboratory)

#### Unit I              Basic Microbiology Lab Procedures and Safety Precautions

- A. Review laboratory safety practices,
- B. Review nosocomial infections and universal precautions,

- C. Review specimen collection procedures, and
- D. Perform and record results for hand-washing exercise.

Unit II                    Culturing and Viewing Organisms

- A. Collecting and culturing throat specimens,
- B. Use and Care of the Light Microscope, and
- C. Identify bacterial morphology using a light microscope.

Unit III                    Cell and Colony Morphology

- A. Prepare slides for staining and perform the gram stain,
- B. Stain clinical specimens: Perform and record results for plaque and throat secretions, and
- C. Practice culture techniques for isolating colonies.

Unit IV                    Gram-Positive Cocci: Staphylococcus

- A. Perform and record results for identification of the members of the genus Staphylococcus, and
- B. Perform and record results for separating Staphylococcus from Streptococcus bacteria exercise.

Unit V                    Gram-Positive Cocci: Streptococci

- A. Perform and record results for identification of members of the genus Streptococcus, and
- B. Separate bacteria based upon hemolytic profiles.

Unit VI                    Antibiotic Sensitivity

- A. Perform and record results for antimicrobial sensitivity testing, and
- B. Record results for beta lactamase testing demonstration.

Unit VII                    Genetic Transformation

- A. Perform and record results for genetic transformation demonstration using E. coli., and
- B. Perform and record results for examination of gene regulation.

Unit VIII                    Gram-Positive Bacilli

- A. Perform and record results for identification of members of the gram positive rod group, and
- B. Perform and record results for endospore staining.

Unit IX                    Gram-negative Bacilli

- A. Perform and record results for identification of the gram negative rod group,
- B. Perform and record results for demonstration of a multi test system for gram negative identification,

- C. Perform and record results for demonstration of differential media, and
- D. Perform and record results for techniques for separating mixed cultures of gram positive and negative bacteria using selective media.

Unit X                    Gram-negative Cocci/Coccobacilli

- A. Perform and record results for identification of members of the gram negative cocci (*Neisseria* sp.), and
- B. Perform and record results for identification of *Haemophilus* species.

Unit XI                    Unknown Bacteria Identification

- A. Perform and record results for isolation of two unknown bacteria from a broth culture, and
- B. Perform and record results for identification of two unknown bacteria.

Unit XII                    Mycobacteria and Anaerobic Bacteria

- A. Observe cultures and perform and record results for acid fast stain non pathogenic *Mycobacteria* cultures, and
- B. Perform and record results for culture anaerobic bacteria exercise.

Unit XIII                    Mycology

- A. Draw micro and macro fungus morphology from representative specimens,
- B. Perform and record results for a wet mount of a fungus culture, and
- C. Perform and record results for a germ tube test.

Unit XIV                    Parasitology

- A. Draw micro and macro parasitology morphology from representative specimens, and
- B. Describe the sites of infection of representative parasites.

Unit XV                    Oral Presentations

- A. Preparation and presentation of oral presentation concerning a specific bacterial species to class peers during laboratory session, and
- B. Preparation and presentation of oral presentation concerning infectious disease to class peers during laboratory session.

Learning Activities Required Outside of Class:

The students in this class will spend a minimum of 6 hours per week outside of the regular class time doing the following:

1. Studying lecture outlines, text, and objectives.
2. Documenting all laboratory observations in a notebook according to the evaluation rubric.
3. Completing required reading.
4. Completing written work

Methods of Instruction:

1. Lectures
2. Class discussions
3. Audiovisual presentations
4. Laboratory exercises and demonstrations

Methods of Evaluation:

1. Writing assignments, including:
  - a. Essays,
  - b. Laboratory reports, and
  - c. Laboratory questions.
2. Computational or non-computational problem-solving demonstrations, including:
  - a. Exams,
  - b. Quizzes,
  - c. Laboratory reports, and
  - d. Laboratory questions.
3. Other examinations, including:
  - a. Multiple choice,
  - b. Matching items,
  - c. True/False items,
  - d. Completion, and
  - e. Essays.

Laboratory Category: Extensive Laboratory

Pre delivery criteria: All of the following criteria are met by this lab.

1. Curriculum development for each lab.
2. Published schedule of individual laboratory activities.
3. Published laboratory activity objectives.
4. Published methods of evaluation.
5. Supervision of equipment maintenance, laboratory setup, and acquisition of lab materials and supplies.

During laboratory activity of the laboratory: All of the following criteria are met by this lab.

1. Instructor is physically present in lab when students are performing lab activities.
2. Instructor is responsible for active facilitation of laboratory learning.
3. Instructor is responsible for active delivery of curriculum.
4. Instructor is required for safety and mentoring of lab activities.
5. Instructor is responsible for presentation of significant evaluation.

Post laboratory activity of the laboratory: All of the following criteria are met by this lab.

1. Instructor is responsible for personal evaluation of significant student outcomes (lab exercises, exams, practicals, notebooks, portfolios, etc.) that become a component of the student grade that cover the majority of lab exercises performed during the course.
2. Instructor is responsible for supervision of laboratory clean up of equipment and materials.