

BIOL 251 MICROBIOLOGY LEARNING OBJECTIVES

Introduction – Cell Theory

1. Define the science of microbiology and describe some of the general methods used in the study of microorganisms
2. Discuss the historical concept of spontaneous generation and the experiments that were performed to disprove this erroneous idea
3. Discuss how Koch's postulates are used to establish the causal link between a suspected microorganism and a disease
4. Describe some of the various activities of microorganisms that are beneficial to humans
5. Describe prokaryotic and eukaryotic morphology, the two types of cellular anatomy, and also the distribution of microorganisms among the various kingdoms or domains in which living organisms are categorized
6. Discuss the importance of the field of microbiology to other areas of biology and to general human welfare

Biological Chemistry

1. Explain the relationship between atoms and elements.
2. List and define 4 types of chemical bonds.
3. Differentiate between a solute and a solvent.
4. Give a brief definition of pH.
5. Name the four main families of biochemicals.
6. Provide examples of cell components made from each of the families of biochemicals.
7. Explain primary, secondary, tertiary and quaternary structure as seen in proteins.
8. List the three components of nucleic acids.
9. Name the nucleotides of DNA and of RNA.
10. List the three components of ATP.
11. Point out 3 characteristics all cells share.

Microscopy

1. Describe how lenses bend light rays to produce enlarged images of small objects
2. Describe the various parts of the light microscope and how each part contributes to the functioning of the microscope
3. Describe the preparation and simple staining of specimens for observation with the light microscope
4. Describe the gram-staining procedure and how it is used to categorize bacteria
5. Describe the basis for the various staining procedures used to visualize specific structures associated with microorganisms
6. Compare the operation of the transmission and scanning electron microscopes with each other and with light microscopes
7. Describe confocal microscopy and scanning probe microscopy
8. Compare and contrast light microscopes, electron microscopes, confocal microscopes, and scanning probe microscopes in terms of their resolution, the types of specimens that can be examined, and the images produced

Prokaryotic cell structure

1. Identify major prokaryotic cell structures in a drawing or photomicrograph
2. Describe the various sizes, shapes, and cellular arrangements exhibited by prokaryotes
3. Describe the bacterial plasma membrane and the limited internal membrane structures found in prokaryotes
4. Describe the appearance, composition, and function of the various internal structures found in prokaryotic organisms (such as inclusion bodies, ribosomes, and the nucleoid)
5. Compare the structure of gram-positive and gram-negative bacterial cell walls and explain how the differences between the two contribute to their gram reaction
6. Describe external structures such as capsules, fimbriae and flagella diagram and describe the various arrangements of bacterial flagella
7. Describe how bacteria use their locomotive ability to swim toward chemical attractants and away from chemical repellents
8. Describe the production of the bacterial endospore and how it enables endospore-forming bacteria to survive harsh environmental conditions and renew growth when the environment becomes conducive to growth

Eukaryotic Cells and Microorganisms

1. Relate both prokaryotic and eukaryotic cells to the Last Common Ancestor.
2. List the types of eukaryotic microorganisms and denote which are unicellular and which are multicellular
3. Differentiate between cilia and flagella in eukaryotes, and between flagella in prokaryotes and eukaryotes.
4. Describe the important characteristics of a glycocalyx in eukaryotes.
5. List which eukaryotic microorganisms have a cell wall.
6. List similarities and differences between eukaryotic and prokaryotic cytoplasmic membranes
7. Describe the important component parts of a nucleus.
8. Diagram how the nucleus, endoplasmic reticulum and Golgi apparatus, together with vesicles, act together.
9. Explain the function of the mitochondria.
10. Discuss the function of chloroplasts and explain which cells contain them and why.
11. Explain the importance of ribosomes and differentiate between eukaryotic and prokaryotic types.
12. List and describe the three main fibers of the cytoskeleton.
13. List some general features of fungal anatomy.
14. Differentiate among the terms *heterotrophic*, *saprobe*, and *parasite*.
15. Connect the concepts of fungal hyphae and a mycelium.
16. Describe two ways in which fungal spores arise.
17. List two detrimental and two beneficial activities of fungi (from the viewpoint of humans).
18. Use protozoan characteristics to explain why they are informally placed into a single group.
19. List three means of locomotion by protozoa.
20. Explain why a cyst stage might be useful.
21. Give an example of a disease caused by each of the four types of protozoa
22. List the two major groups of helminths and then the two subgroups of one of these groups.
23. Describe a typical helminth lifestyle.

Viruses

1. Describe the significance of viruses being recognized as "filterable".
2. Construct arguments on both sides of the "Are viruses living?" debate.
3. Identify better terms for viruses than "alive" or "dead".

4. Discuss the size of viruses relative to other microorganisms.
5. Describe the function and structure(s) of viral capsids.
6. Distinguish between enveloped and naked viruses.
7. Explain the importance of viral surface proteins, or spikes.
8. Diagram the possible configurations of nucleic acid viruses may possess
9. Explain why some find it difficult to assign species names to viruses.
10. Demonstrate how family and genus names in viruses are written
11. Diagram the 5-step life cycle of animal viruses.
12. Explain what cytopathic effects are.
13. Discuss both persistent and transforming infections.
14. Provide a thorough description of lysogenic and lytic bacteriophage infections.
15. List the three principal purposes of cultivating viruses.
16. Describe three ways in which viruses are cultivated.
17. Analyze the relative importance of viruses in human infection and disease
18. Name at least three non-cellular infectious agents besides viruses
19. Discuss the primary reason that antiviral drugs are more difficult to design than antibacterial drugs

Nutrition, Ecology and Growth

1. List the essential nutrients of a bacterial cell.
2. Differentiate between macronutrients and micronutrients.
3. Construct four different terms that describe an organism's sources of carbon and energy.
4. Define saprobe and parasite.
5. Discuss diffusion and osmosis.
6. Identify the effects on a cell of isotonic, hypotonic, and hypertonic conditions.
7. Name two types of passive transport and three types of active transport
8. Name five types of bacteria based on their temperature preferences.
9. Explain how different organisms deal with oxygen
10. Name three other physical factors that microbes must contend with.
11. List and describe the five types of associations microbes can have with their hosts.
12. Discuss characteristics of biofilms that differentiate them from planktonic bacteria
13. Describe the major way that bacteria divide; name another way used by fewer bacteria.
14. Define doubling time and how it relates to exponential growth.
15. Compare and contrast the four phases of growth in a bacterial growth curve.
16. Identify three methods besides a growth curve to count bacteria

Metabolism

1. Describe the relationship among metabolism, catabolism and anabolism.
2. Fully define the structure and function of enzymes.
3. Differentiate between an apoenzyme and a holoenzyme.
4. Differentiate between *endoenzyme* and *exoenzyme*, and between *constitutive* and *regulated* enzymes.
5. Diagram some different patterns of metabolism.
6. Describe how enzymes are controlled.
7. Name the chemical in which energy is stored in cells
8. Create a general diagram of a redox reaction?

9. Identify electron carriers used by cells
10. Name three basic catabolic pathways and give an estimate of how much ATP each of them yields.
11. Write a summary statement describing glycolysis.
12. Describe the Krebs cycle.
13. Discuss the significance of the electron transport system.
14. Point out how anaerobic respiration differs from aerobic respiration.
15. Provide a summary of fermentation.
16. Describe how non-carbohydrate compounds are catabolized.
17. Provide an overview of the anabolic stages of metabolism.
18. Define *amphibolism*
19. Summarize the process of photosynthesis in simple language.
20. Discuss the relationship between light-dependent and light-independent reactions.
21. Explain where the Calvin cycle fits into photosynthesis.

Genetics

1. Define the terms genome and gene.
2. Differentiate between genotype and phenotype.
3. Draw a picture of a length of DNA, including all important chemical groups.
4. Explain how DNA replication takes place.
5. Use Okazaki fragments to explain about leading and lagging strands.
6. Relate the new and old versions of the "central dogma".
7. Identify important differences between RNA and DNA.
8. Draw a picture of the process of transcription.
9. List the three types of RNA directly involved in translation.
10. Define "codon" and "anticodon"
11. Identify on which molecules the promoter, the start codon, and the A and P sites appear.
12. Indicate how eukaryotic transcription and translation differ from these processes in prokaryotes.
13. List one or two important advantages to arranging genes in an operon.
14. Differentiate between repressible and inducible operons.
15. Name some antibiotic targets of the transcription and translation machinery.
16. Define the term "mutation" and discuss its importance.
17. Differentiate among frameshift, nonsense, silent and missense mutations
18. Define recombinant.
19. Describe three forms of horizontal gene transfer used in bacteria

Genetic Engineering

1. Provide examples of practical applications of genetic manipulation
2. Explain the importance of restriction endonucleases to genetic engineering.
3. Describe how gel electrophoresis helps in the analysis of DNA.
4. Discuss Southern blots and how gene probes figure in them.
5. Outline the process of DNA sequencing.
6. List the steps in the polymerase chain reaction
7. Describe how you can clone a gene into a bacterium.
8. Define *recombinant*

9. Provide several examples of recombinant products that have contributed to human health
10. Define *recombinant*.
11. Compare and contrast recombinant bacteria, plants and animals
12. Differentiate between somatic and germline gene therapy.
13. Describe at least two gene silencing strategies
14. Outline the general steps in DNA profiling.
15. Discuss the significance of single nucleotide polymorphisms (SNPs).
16. Describe the utility of DNA microarray analysis

Control of Microbes

1. Distinguish among the terms sterilization, disinfection, antiseptics and decontamination.
2. Identify the microorganisms that are most resistant and least resistant to control measures.
3. Define “-static” and “-cidal”.
4. Name four categories of cellular targets for physical and chemical agents
5. Name six methods of physical control of microorganisms.
6. Discuss both moist and dry heat methods and identify multiple examples of both.
7. Define thermal death time and thermal death point.
8. Explain four different methods of moist heat control.
9. Explain two methods of dry heat control.
10. Identify advantages and disadvantages of cold and desiccation.
11. Differentiate between the two types of radiation control methods.
12. Explain how filtration functions as a control method.
13. Identify some common uses of osmotic pressure as a control method.
14. Name the desirable characteristics of chemical control agents.
15. Discuss several different halogen agents and their uses.
16. List advantages and disadvantages to phenolic compounds.
17. Explain the mode of action of alcohols.
18. Pinpoint the most appropriate applications of hydrogen peroxide agents.
19. Define surfactant and explain its mode of action.
20. Identify some heavy metal control agents and their most common applications.
21. Discuss the advantages and disadvantages of aldehyde agents.
22. Identify applications for ethylene oxide sterilization

Chemotherapeutic agents

1. State the two main goals of antimicrobial treatment.
2. Identify the sources for most currently used antimicrobials
3. Explain the concept of selective toxicity.
4. List the five major targets of antimicrobial agents.
5. Identify which categories of drugs are most selectively toxic and why.
6. Explain how drugs that inhibit protein synthesis can be selective.
7. Define *metabolic analog* and discuss its relevance to antimicrobial action.
8. Distinguish between broad-spectrum and narrow-spectrum antimicrobials and explain the significance of the distinction.
9. Trace the evolution of penicillin antimicrobials, and identify which microbes they are effective against.

10. Explain the significance of beta-lactamases, and where they are found.
11. List other beta-lactam classes of antibiotics and two examples.
12. List some cell wall antibiotics that are not in beta-lactam category.
13. Identify two older and two newer antimicrobials that act by inhibiting protein synthesis.
14. Explain how drugs targeting folic acid synthesis work.
15. Identify the cellular target of quinolones and name two examples.
16. Name two drugs that target the cellular membrane.
17. Discuss how treatment of biofilm infections differs than that of non-biofilm infections.
18. Name the four main categories of antifungal agents and provide one example of each.
19. Name four anti-protozoal drugs and three anti-helminthic drugs.
20. List the three major modes of actions of anti-viral drugs.
21. Discuss three possible ways that microbes acquire antimicrobial resistance.
22. List five cellular or structural mechanisms that microbes use to resist antimicrobials.
23. Discuss at least four novel antimicrobial strategies that are under investigation.
24. Distinguish between drug toxicity and allergic reactions to drugs.
25. Explain what a superinfection is and how it occurs.
26. Describe two methods for testing antimicrobial susceptibility.
27. Define therapeutic index and identify whether a high or a low index is preferable.

Pathology

1. Differentiate between colonization, infection and disease.
2. Enumerate the sites where normal biota is found in humans.
3. Discuss how the Human Microbiome project will change our understanding of normal biota.
4. Point out how microbial antagonism can be helpful to the human host.
5. Differentiate between pathogenicity and virulence.
6. Define opportunism.
7. List the steps a microbe has to take to get to the point where it can cause disease.
8. List several portals of entry.
9. Define infectious dose.
10. Describe three ways microbes cause tissue damage.
11. Differentiate between endotoxins and exotoxins.
12. Provide a definition of virulence factors.
13. Discuss the topic of reservoirs thoroughly.
14. List seven different modes of transmission of infectious agents.
15. Define nosocomial infection and list the three most common types.
16. List Koch's postulates, and when they might not be appropriate in establishing causation.
17. Differentiate the science of epidemiology from traditional medical practice.
18. Define incidence and prevalence.
19. Discuss point-source, common-source and propagated epidemics and predict the shape of the epidemic curves associated with each.

Innate Immunity

1. Summarize what the three lines of defense are.

2. Identify three components of the first line of defense
3. Define *marker*, and discuss its importance in the second and third lines of defense?
4. Name four body compartments that participate in immunity?
5. List the components of the reticuloendothelial system?
6. Fully describe the structure and function of the lymphatic system?
7. Differentiate between whole blood and plasma?
8. Name six kinds of blood cells that function in nonspecific immunity, and the most important function of each?
9. Name two kinds of lymphocytes involved in specific immunity?
10. List the four major categories of nonspecific immunity?
11. Outline the steps in inflammation?
12. Outline the steps in phagocytosis?
Discuss the mechanism of fever and what it accomplishes?
13. Name four types of antimicrobial proteins?

Acquired Immunity

1. Describe how the third line of defense is different than the other two.
2. List the 4 stages of a specific immune response.
3. Discuss four major immune functions of cell markers.
4. Describe the major histocompatibility complex in two sentences.
5. Contrast the way T cells recognize antigen with the way B cells do.
6. Summarize the maturation process of both B cells and T cells.
7. Explain how our bodies are equipped with lymphocytes capable of responding to nearly any antigen imaginable.
8. Outline the processes of clonal selection and expansion.
9. Describe the B-cell receptor and the T-cell receptor.
10. Compare the terms *antigen*, *immunogen*, and *epitope*.
11. List characteristics of antigens that optimize their immunogenicity.
12. List the types of cells that can act as antigen-presenting cells
13. Diagram the steps in the B cell response.
14. Make a detailed drawing of an antibody molecule.
15. Explain the various end results of antibody binding to an antigen.
16. List the five types of antibodies and important facts about each.
17. Describe the memory response
18. List the three major types of cells T cells will differentiate into after stimulation.
19. Describe the main functions of these three types of T cells.
20. Explain how TC cells kill other cells
21. List and define the four different descriptors of specific immune states.
22. Discuss the qualities of an effective vaccine.
23. Name the two major categories of vaccines and then the subcategories under each.

24. Discuss the pros and cons of killed (or inactivated) vs. attenuated vaccines.
25. Describe the principle behind DNA vaccines.
26. Explain the principle of herd immunity

Infectious Diseases

Skin and Eyes

1. Describe the important anatomical features of the skin.
2. List the natural defenses present in the skin.
3. List the types of normal biota presently known to occupy the skin.
4. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for each of the diseases of the upper respiratory tract. These are: acne, impetigo, cellulitis, Staphylococcal scalded skin syndrome, gas gangrene, vesicular/pustular rash diseases, maculopapular rash diseases, wartlike eruptions, large pustular skin lesions, and cutaneous mycoses.
5. Discuss the spectrum of skin and tissue diseases caused by *Staphylococcus aureus* and *Streptococcus pyogenes*.
6. Provide an update of the status of MRSA infections in the United States.
7. Discuss the relative dangers of rubella and rubeola viruses in different populations.
8. Describe the important anatomical features of the eye.
9. List the natural defenses present in the eye.
10. List the types of normal biota presently known to occupy the eye.
11. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for each of the diseases of the eye. These are: conjunctivitis, trachoma, keratitis and river blindness.

Nervous System

1. Describe the important anatomical features of the nervous system.
2. List the natural defenses present in the nervous system
3. Talk about the normal biota of the nervous system and the background behind it.
4. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for meningitis and also for neonatal meningitis.
5. Identify the most common and also the most deadly of the multiple possible causes of meningitis.
6. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for diseases most directly involving the brain. These are: meningoencephalitis, encephalitis, and subacute encephalitis.
7. Identify which viruses that can cause encephalitis you should be on the lookout for in your geographical area.
8. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for other diseases in the nervous system. These are: rabies, poliomyelitis, tetanus, botulism and African sleeping sickness.
9. Explain the difference between the oral polio vaccine and the inactivated polio vaccine and under which circumstances each is appropriate.

Cardiovascular/Lymphatic Systems

1. Describe the important anatomical features of the cardiovascular system.
2. List the natural defenses present in the cardiovascular system.
3. Discuss the "what" and the "why" of the normal biota of the cardiovascular system.

4. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for the two forms of endocarditis.
5. Discuss what series of events may lead to septicemia and how it should be prevented and treated.
6. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for cardiovascular system infections that have only one infectious cause. These are plague, tularemia, Lyme disease and infectious mononucleosis.
7. Discuss factors that distinguish hemorrhagic and nonhemorrhagic fever diseases.
8. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for hemorrhagic fever diseases.
9. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for nonhemorrhagic fever diseases.
10. Discuss all aspects of malaria, with special emphasis on epidemiology.
11. Describe what makes anthrax a good agent for bioterrorism and list the important signs to look for in presenting patients.
12. Discuss how the epidemiology of HIV infection in the United States has changed over time and why.
13. Discuss the epidemiology of HIV infection in the developing world.

Respiratory System

1. Discuss how the epidemiology of HIV infection in the United States has changed over time and why.
2. Discuss the epidemiology of HIV infection in the developing world.
3. List the types of normal biota presently known to occupy the respiratory tract.
4. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for each of the diseases of the upper respiratory tract (rhinitis, sinusitis, otitis media, pharyngitis, and diphtheria).
5. Identify which disease is often caused by a mixture of microorganisms.
6. Identify two bacteria that can cause dangerous pharyngitis cases.
7. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for each of the diseases infecting both the upper and lower respiratory tract (pertussis, RSV disease, and influenza).
8. Compare and contrast antigenic drift and antigenic shift in influenza viruses
9. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for each of the diseases infecting the lower respiratory tract (tuberculosis, community-acquired pneumonia, and nosocomial pneumonia).
10. Discuss the problems associated with MDRTB and XDRTB.
11. Demonstrate an in-depth understanding of the epidemiology of tuberculosis infection.
12. Describe the importance of the recent phenomenon of cold viruses causing pneumonia.
13. List the distinguishing characteristics of nosocomial vs. community-acquired pneumonia.

Digestive System

1. Draw or describe the anatomical features of the gastrointestinal tract.
2. List the natural defenses present in the gastrointestinal tract
3. List the types of normal biota presently known to occupy the gastrointestinal tract.
4. Describe how our view has changed of normal biota present in the stomach.
5. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for each of the kinds of oral diseases.
6. Discuss current theories about the connection between oral bacteria and cardiovascular disease.

7. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for mumps, gastritis and gastric ulcers.
8. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for acute and chronic diarrhea, and also for acute diarrhea with vomiting.
9. Differentiate among the main types of hepatitis and discuss each causative agent, mode of transmission, diagnostic techniques, prevention and treatment of each.
10. Describe some distinguishing characteristics and commonalities seen in helminthic infections.
11. List four helminths that cause primarily intestinal symptoms, and identify which life cycle they follow and one unique fact about each one.
12. List four helminths that cause intestinal symptoms that may be accompanied by migratory symptoms, and identify which life cycle they follow and one unique fact about each one.
13. List the modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for each of the helminth infections resulting in liver and intestinal symptoms. These are infections caused by *Opisthorchis sinensis*, *Clonorchis sinensis*, and *Fasciola hepatica*.
14. Describe the type of disease caused by *Trichinella* species.
15. Diagram the life cycle of *Schistosoma mansoni* and *Schistosoma japonicum*, discuss how it differs from the life cycle of t

Urinary/Reproductive Systems

1. Draw or describe the anatomical features of the genitourinary tracts of both genders.
2. List the natural defenses present in the genitourinary tracts.
3. List the types of normal biota presently known to occupy the genitourinary tracts of both genders
4. List the possible causative agents, modes of transmission, virulence factors, diagnostic techniques and prevention/treatment for each type of urinary tract infection (including leptospirosis and schistosomiasis).
5. Distinguish between vaginitis and vaginosis.
6. Discuss prostatitis.
7. List the possible causative agents, modes of transmission, virulence factors, and prevention/treatment for gonorrhea and Chlamydia.
8. Name three diseases that result in genital ulcers and discuss their important features.
9. Differentiate between the two diseases causing warts in the reproductive tract.
10. Provide some detail about the first "cancer vaccine" and how it works.
11. Identify the most important risk group for Group B *Streptococcus* infection and why.

Environmental Microbiology

1. Define microbial ecology.
2. Summarize why our view of the abundance of microbes on earth has changed in recent years.
3. Discuss the terms *ecosystem* and *community* in relation to one another.
4. Differentiate between habitat and niche.
5. Draw an example of an energy pyramid, labeling producers and consumers.
6. Define bioremediation.
7. List five important elements of biogeochemical cycles.
8. Diagram a carbon cycle.
9. Point out where methanogens influence the carbon cycle.
10. List the four reactions involved in the nitrogen cycle.
11. Describe the process of nitrogen fixation, and provide some examples of organisms that perform it.

12. Give brief summaries of the sulfur and phosphorus cycles.
13. Outline the basic process used to perform metagenomic analysis of the environment.
14. List two important partnerships that occur in the soil.
15. Diagram the hydrologic cycle.
16. Discuss what metagenomic sampling of oceans has revealed.
17. Name the regions, top to bottom, of large bodies of standing water.
18. Define *eutrophication* and discuss its consequences.

Industrial Microbiology

1. Define biotechnology.
2. Compose a sentence about the history of applied microbiology.
3. Outline the steps in water purification.
4. Differentiate water purification from sewage treatment.
5. Describe the primary and secondary phases of sewage treatment.
6. List 5 important pathogens of drinking water.
7. Explain why indicator bacteria are used as surrogates for pathogenic bacteria in examination of water safety.
8. Discuss the relevance of fecal coliforms.
9. Name five foods and/or beverages that benefit from microbial fermentation.
10. What microbial actions lead to leavening in bread.
11. Write the equation for turning yeast and sugar into alcoholic beverages.
12. Discuss why microorganisms themselves might be useful as food products.
13. Provide some background about HACCP procedures.
14. Report 10-year trends in foodborne illness.
15. Outline basic principles of using temperature to preserve food.
16. List mechanisms other than temperature that are used to preserve food.
17. State the general aim(s) of industrial microbiology.
18. Distinguish between primary and secondary metabolites. 25.16
19. List the four steps of industrial product production from microbes.
20. List 5 different types of substances produced from industrial microbiology, and their applications.