CE 521 Environmental Biotechnology

Instructional Objectives

Fundamentals of Microbiology

The Microbial World:

1. Be able to list the distinguishing characteristics of the two main groups of Protista.
2. Be able to describe the composition and function of the cytoplasmic membrane, outer membrane, cell wall, and glycocalyx
3. Be able to describe the various mean s of cell motility.
4. Be able to describe the function of pili, storage products, gas vacuoles, and endospores.
5. Be able to define the structure and function of DNA, RNA, and plasmids.
6. Be able to describe the processes of replication, transcription, and translation and name the three types of RNA.
7. Be able to list and describe the four means of genetic recombinations among microorganisms.
8. Be able to describe the process of genetic engineering and probe technology and provide examples for their use.
9. Be able to give the distinguishing characteristics of bacteria, fungi, algae, protozoa, and viruses.
10. Be able to give the approximate size, three basic shapes, and unusual types of bacteria.
11. Be able to define the general classifications and structure of fungi, algae, and protozoa.
12. Be able to describe the steps in virus replication, detection, enumeration, and classification.

Microbial Metabolism and Growth:

13. Be able to describe the function and classes of enzymes.
14. Be able to state the Michaelis-Menten equation and define the terms.
15. Be able to describe the effect of competitive, noncompetitive, and uncompetitive inhibition on enzyme kinetics.
16. Be able to describe the role of ATP in microbial metabolism and the three methods of ATP generation.
17. Be able to describe the functions of catabolic, anabolic, amphibolic, and anapleurotic reactions in metabolism.
18. Be able to outline the EMP (glycolysis) pathway, providing the names of intermediates and side reaction products. Be able to state the starting and end-products of the TCA cycle.
19. Be able to describe the steps involved in the electron transport system and describe how ATP is produced.
20. Be able to describe key elements of fermentation, anabolism, and photosynthesis.
21. Be able to classify microorganisms on the basis of metabolism.
22. Be able to characterize microbial growth in batch and continuous culture.
23. Be able to define and detail the measurement of the specific growth rate, specific substrate utilization rate, cell yield, and cell density.
24. Be able to provide a checklist of microbial growth requirements.

Role of Microorganisms in Biogeochemcial Cycles

25. Be able to diagram and describe the role of microorganisms in the nitrogen cycle.
26. Be able to describe the microbiology, kinetics, and factors affecting nitrification and denitrification.
27. Be able to detail the impact of nitrogen discharges from wastewater treatment plants.
28. Be able to diagram the phosphorus and sulfur cycles.
29. Be able to describe the role of microorganisms in biological phosphorus removal.
30. Be able to explain the impact of sulfur and sulfur compounds on environmental systems.

Public Health Microbiology

Pathogens and Parasites in Domestic Wastewater

31. Be able to describe the epidemiological aspects of pathogens in water and wastewater.
32. Be able to define and explain the following terms: infectious agent, reservoir, mode of transmission, portal of entry, and host susceptibility.
33. Be able to list and describe the common bacterial, viral, and protozoal parasites in water and wastewater.
34. Be able to describe the diseases and symptoms caused by the different bacterial, viral, and protozoal parasites in water and wastewater.
35. Be able to describe the life cycle of helminths that cause *schistosomiasis* and *ascariasis.*

Indicator Microorganisms

36. Be able to list the criteria for an ideal indicator organism.
37. Be able to describe the characteristics of bacteria that are classified as total coliforms, fecal coliforms, and fecal streptococci.
38. Be able to name the bacteria that are used as indicators in anaerobic environments.
39. Be able to describe the use of bacteriophages as indicator organisms.
40. Be able to explain the use of heterotrophic plate count.
41. Be able to describe the traditional and rapid methods for coliform enumeration in environmental samples.

Water and Wastewater Disinfection

42. Be able to describe the factors affecting disinfection.
43. Given appropriate data, be able to calculate the number of microorganisms remaining after disinfection for a specific decay constant.
44. Be able to explain the relationship between concentration and contact time.
45. Be able to define and describe the following terms: free chlorine THM, THMFP, chloramination, breakpoint chlorination.
46. Be able to propose alternatives to chlorine for disinfection and state the advantages and disadvantages of each.

Water and Wastewater Treatment Microbiology

Introduction to Wastewater Treatment

47. Be able to state the primary objectives of wastewater treatment.
48. Be able to characterize the main constituents in wastewater and give typical concentrations.
49. Be able to describe the significance and analytical procedures for carbonaceous and nitrogenous BOD, COD, and TOC.
50. Be able to describe the four stages in wastewater treatment and give examples of each.

Activated Sludge

51. Be able to describe the components that comprise an activated sludge system. Be able to define and explain the terms aeration tank, secondary clarifier, MLSS, MLVSS, F/M, HRT, and SRT.
52. Be able to describe modifications to the conventional activated sludge process.
53. Be able to the desired characteristics and typical populations of activated sludge microorganisms.
54. Be able to discuss the attributes of microorganisms that allow good settleability. Be able to define and explain the term SVI.
55. Be able to describe the configurations of activated sludge systems to achieve nutrient removal.
56. Be able to describe the effect of activated sludge on pathogens.

Sludge Bulking and Foaming

57. Be able to explain the common causes for filamentous bulking in activated sludge systems.
58. Be able to list prevalent filamentous organisms and the conditions that lead to their proliferation.
59. Be able to describe the kinetic selection theory and the use of selectors to control bulking.
60. Be able to explain the causes and control of foaming in activated sludge systems and the organisms commonly responsible.

Stabilization Ponds

61. Be able to list the advantages and disadvantages of waste stabilization ponds.
62. Be able to describe the processes occurring in each of the three zones in a waste stabilization pond.
63. Be able to characterize the performance of oxidation ponds with respect to pathogen removal.

Biofilms and Attached Growth Processes

64. Be able to provide a process description of a trickling filter and a rotating biological contactor.
65. Be able to provide a list of organisms typically found in biofilms typical of those in trickling filters and RBCs.
66. Be able to list the advantages and disadvantages of attached growth processes such as trickling filters and RBCs.
67. Be able to diagram the potentially rate limiting phenomena in biofilm systems.

Sludge Microbiology

68. Be able to list the pathogens typically found in wastewater sludge and biosolids.
69. Be able to describe the sludge processing and treatment systems typically used in wastewater treatment.
70. Be able to explain the important process parameters during sludge treatment that impact pathogen destruction.

Anaerobic Digestion of Wastewater and Sludge

71. Be able to describe the interrelationship between the various microorganisms in anaerobic systems.

72. Be able to describe the different process configurations in anaerobic treatment systems, including the configurations recently developed at Iowa State University.
73. Be able to list and discuss the factors that affect anaerobic systems.

Microbiological Aspects of Drinking Water Treatment

74. Be able to describe the main processes involved in water treatment and explain the fate of pathogens.
75. Be able to describe the concerns about biofilm growth in distribution systems.
76. Be able to give an account of conditions that enable growth of pathogens and indicator organisms in water distribution systems.
77. Be able to define and explain the terms AOC, DOC, and BDOC.
78. Be able to list the advantages and potential concerns with point of use devices for water treatment.

Pollution Control Biotechnology

79. Be able to describe the use of genetically engineered microorganisms, enzymes, and enrichment cultures for pollution control.
80. Be able to describe the immobilization of cells and their use in wastewater treatment and in biosensors.
81. Be able to list the possible uses and limitations of recombinant DNA technology for waste treatment.

Public Health Aspects of Wastewater and Sludge Disposal and Wastewater Reuse

82. Be able to diagram and discuss the physical, chemical, and biological processes occurring during land treatment of wastewater and sludge.
83. Be able to discuss the transport and fate of pathogens applied to soils.
84. Be able to explain the effect of septic tank effluent on soils and groundwater.
85. Be able to list and discuss the conventional techniques for bioremediation.
86. Be able to discuss the implications of marine disposal of wastewater and sludge and the factors that affect the survival of pathogens in seawater.
87. Be able to list and discuss the factors that affect survival of pathogens in sediments.
88. Be able to discuss the exposure to autochthonous microorganisms.
89. Be able to list and explain the applications for and concerns with reuse of reclaimed wastewater.
90. Be able to draw a diagram of wastewater and water treatment processes that might be employed in a water reuse project.