Prescott's Microbiology 11th edition Willey Solutions Manual

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1 The Evolution of Microorganisms and Microbiology

CHAPTER OVERVIEW

This chapter introduces the field of microbiology and discusses the importance of microorganisms not only as causative agents of disease but also as important contributors to food production, antibiotic manufacture, vaccine development, and environmental management. It presents a brief history of the science of microbiology and an overview of the microbial world. The origin of life and microbial evolution is put in the context of microbial phylogenies.

LEARNING OUTCOMES

After reading this chapter, students should be able to:

- define the term *microbiology*
- explain Carl Woese's contributions in establishing the three-domain system for classifying cellular life
- determine the type of microbe (bacterium, fungus, etc.) when given a description of a newly discovered one
- provide an example of the importance to humans of each of the major types of microbes
- propose a timeline of the origin and history of microbial life and integrate supporting evidence into it
- design a set of experiments that could be used to place a newly discovered cellular microbe on a phylogenetic tree based on small subunit (SSU) rRNA sequences
- compare and contrast the definitions of plant and animal species, microbial species, and microbial strains
- evaluate the importance of the contributions to microbiology made by Hooke, Leewenhoek, Pasteur, Koch, Cohn, Beijerinck, von Behring, Kitasato, Metchnikoff, and Winogradsky
- outline a set of experiments that might be used to decide if a particular microbe is the causative agent of a disease
- predict the difficulties that might arise when using Koch's postulates to determine if a microbe causes a disease unique to humans
- construct a concept map, table, or drawing that illustrates the diverse nature of microbiology and how it has improved human conditions
- discuss the belief held by many microbiologists that microbiology is experiencing its second golden age

GUIDELINES FOR ANSWERING THE COMPREHENSION CHECK QUESTIONS

As the name of this section implies, these questions range from first-order retrieval of information from the preceding text to application of the content to open ended questions or scenarios. As such, the answers are either easily obtained from the text or may have many different answers that can be considered valid. For this reason, we do not include these questions in the instructor's manual.

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GUIDELINES FOR ANSWERING THE MICRO INQUIRY QUESTIONS

Figure 1.1 ***How would you alter this concept map so that it also distinguishes the cellular organisms from each other?***
Modify this hierarchical concept map by adding a dichotomy between prokaryotes and eukaryotes under the *cellular* classification. Bacteria (eubacteria) and archaea would be under prokaryotes and fungi and protists under eukaryotes.

Figure 1.2 ***How many of the taxa listed in the figure include microbes?***
All of them.

Figure 1.6 ***Why are the probionts pictured above not considered cellular life?***
All cells contain DNA, RNA, and proteins and can self replicate.

Figure 1.8 ***Why does the branch length indicate amount of evolutionary change but not the time it took for that change to occur?***
The lines on a phylogenetic tree indicate a measure of relatedness because they represent genetic sequence divergence. They are not a measure of time because it is not known how much time was needed for organisms to diverge because divergence is influenced by multiple factors.

Figure 1.14 ***Why is the fourth postulate necessary?***
The fourth postulate is necessary to complete the loop of causation. If a suspected pathogen was introduced to a susceptible host but could not be re-isolated following the onset of disease, this may imply that the organism itself is not the direct cause of the disease and would warrant a search for other co-isolated organisms.

GUIDELINES FOR ANSWERING THE ACTIVE LEARNING QUESTIONS

1. Why aren't viruses, viroids, satellites, and prions included in the three-domain system?
Only cellular organisms are in taxonomic systems, because only they are descended from each other with vertical gene transmission. Viruses do not reproduce, they are assembled (like machines). Viroids and satellites are RNA, not organisms. Prions are proteins, not organisms.

2. Would microbiology have developed more slowly if Fanny Hesse had not suggested the use of agar? Give your reasoning.
This is opinion, so various answers are possible. Just look for logical and factual support of their argument. Relevant issues include the intrinsic resistance of agar to degradation as compared to gelatin and the necessity of solid media to obtain pure cultures by physical separation, which is much more difficult in liquid media (dilution to extinction).

3. Some individuals can be infected by a pathogen yet not develop disease. In fact, some become chronic carriers of the pathogen. How does this observation affect Koch's postulates? How might the postulates be modified to account for the existence of chronic carriers?
In the carrier state, a host carries the pathogen without clinical symptoms. For example, approximately 20% of college students carry *Staphylococcus aureus* in their nasal passages, with no ill effects. However, it can cause disease (damage to the host) if they become immunocompromised. They can also transmit the

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bacteria to others. Technically, this does not relate to Koch's postulates because they are designed to isolate the causative agent of a disease, and the carrier state is not disease. Koch's postulates may be modified to include modern sequencing technology to investigate resistance from microbial communities or include inoculation to an immune-deficient host to assess disease causation in the absence of immune resistance mechanisms. The bottom line is that while Koch's postulates certainly do not apply in every case and they have limitations, they were of tremendous historical importance in demonstrating experimentally the germ theory of disease, which was a tremendous advance in modern medicine.

4. Support this statement: "Vaccinations against various childhood diseases have contributed to the entry of women, particularly mothers, into the full-time workplace."
-Children spent less time being sick, thus mothers spend less time away from work.
-Because childhood mortality has been lowered and thus more children survive to adulthood, this may contribute to fewer children on average to each family, thus less childcare burden on the mother.
-A number of sites including National Opinion Research Center (NORC) have compiled statistics comparing vaccination with employment statistics.

5. For many years, the oldest stromatolites with compelling evidence of ancient life on Earth were found in Western Australia. The microbial communities that built the sedimentary structures were dated at roughly 3.5 billion years old. However, in 2016 stromatolites in Greenland were reported to be 3.7 billion years old. Interestingly, the complexity and morphology of the Greenland stromatolites is similar to that of those in Australia. Why is it of interest to document the oldest evidence of life on Earth? What might this suggest about the evolution of life during the intervening 200 million years? What is the significance, if any, of the geographic distribution of these stromatolites?

Read the original paper: Nutman, A.P., et al. 2016. Rapid emergence of life shown by discovery of 3,700-million-year-old microbial structures. *Nature.* 537: 535–539. doi:10.1038/nature19355.

This answer is opinion, so various answers are possible. Documenting the oldest evidence of life on Earth provides insight into the origins of life. The similarities in microbial communities suggest that life diversity was already complex 3.7 billion years ago and that these microbial communities were evolutionarily preserved over the course of 200 million years. While the similarity between microbial communities on such geographically distinct locations could suggest that microbial life developed synchronously and independently, it is more likely that at one point in history these distant landmasses were connected or in close proximity.

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