

Appendix C: Answers to Even-Numbered End-of-Chapter Questions

Chapter 1

Step A: Self-Test

2. A; 4. C; 6. A; 8. C; 10. B; 12. B; 14. A; 16. B

Step B: Review

18. F (van Helmont); 20. T; 22. F (Snow);
24. T; 26. T

Step C: Applications

28. One method would be to mix the substance in an agar growth medium. Then, streak the bacterial cells on the agar surface. Over the next few days, see if the bacterial cells grow on the agar. No bacterial colonies would indicate the substance killed the cells while growth that is slower than in a control plate (the substance not added to agar) would indicate it retards bacterial growth.
30. Chance certainly favored the prepared mind of Semmelweis in his recognition of the need for hand washing; Snow is recognizing the source for the London cholera outbreak; and Fleming in realizing that a mold might hold the cure for treating bacterial diseases.

Step D: Questions for Thought and Discussion

32. The control group does not receive the treatment to which the experimental group is exposed. Comparisons then can be made between the two groups as to whether the treatment had any affect. You can discover the controls for the Redi-Needham-Spallanzani experiments on spontaneous generation. Controls for Pasteur's experiments to refute the doctrine are identified in the MicroInquiry 1 exercise.
34. Microbiology could be explained in many ways. Perhaps the most direct is that microbiology involves the study of microorganisms and viruses. The microorganisms include two groups of prokaryotes, the *Bacteria* and *Archaea*. Eukaryotic microorganisms include the fungi and protista. You could continue on add particular areas of microbiology study, emphasizing that most microorganisms do not cause disease but rather have beneficial roles.
36. This is a difficult choice. Leeuwenhoek was the first person to see "bacteria," but he had

no idea of their significance. However, Pasteur and Koch laid the foundations for bacteriology and microbiology in general. So, I would vote for the latter two.

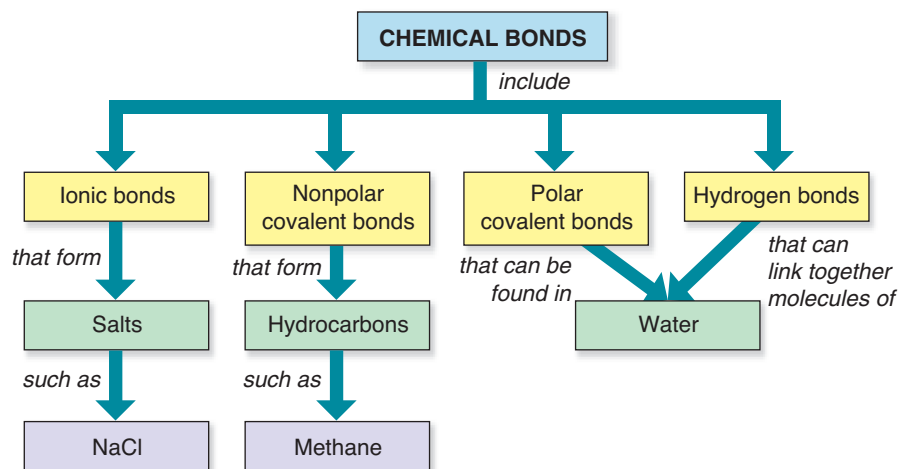
Chapter 2

Step A: Self-Test

2. C; 4. B; 6. B; 8. C; 10. D; 12. B; 14. A

Step B: Review

16.



18. (i) Hydroxyl group
(ii) No functional groups
(iii) 1 hydroxyl group
(iv) Hydroxyl groups
(v) Amino, carboxyl, and hydroxyl groups

Step C: Applications

20. First, determine the pH of the two buffers using the pH papers. Then, add a drop of an acid to the buffered broth. The pH will not drop. Then, add a drop to the buffered broth. The pH will drop.

Step D: Questions for Thought and Discussion

22. Organic molecules invariably contain carbon atoms, and carbon atoms form four covalent bonds with other atoms. Soon these evolve a Tinker-toy-like arrangement of atoms that is quite a large molecule, especially if multiple carbon atoms are present.
24. Different arguments can be presented for destroying different groups of chemical

substances. For example, destroying proteins would eliminate enzyme and chemical structures; carbohydrate destruction would remove vital energy sources for life and the ability to form a cell wall; and lipid destruction would cause leakage through the cell membrane and consequent death. Eliminating the nucleic acids would disrupt the chromosome and genes, thereby preventing protein synthesis.

26. Proteins are denatured by heat, thereby losing their tertiary structure and assuming a nonfunctional form that would be nontoxic.

Chapter 3

Step A: Self-Test

2. C; 4. D; 6. B; 8. D; 10. C; 12. B

Step B: Review

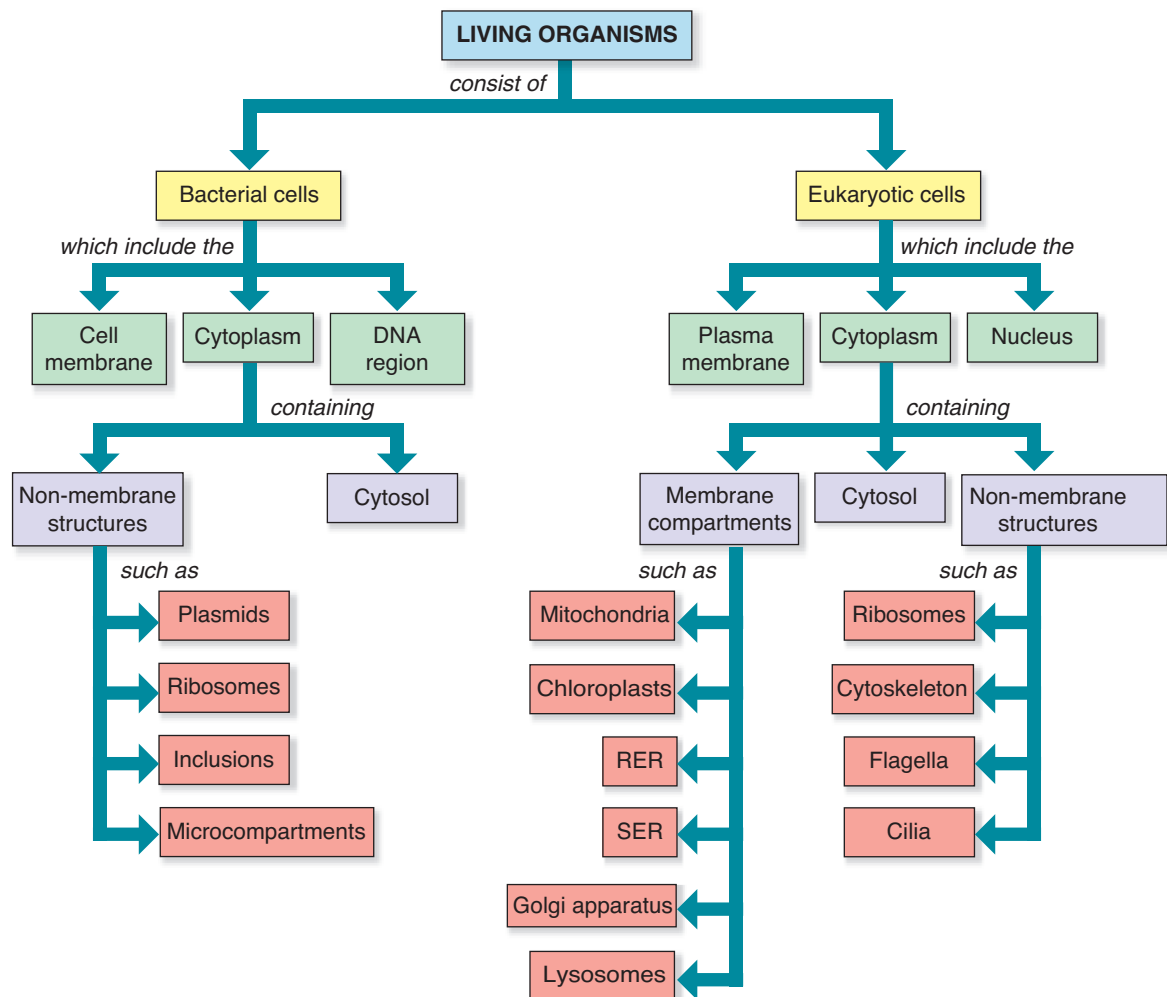
- 14.

16. A; 18. O; 20. K; 22. I; 24. P

Step C: Applications

26. Methylene blue can be used in place of safranin. The result will be purple gram-positive cells and blue (rather than red) gram-negative cells.
28. Drawing (A): (a) flagellum; (b) ribosomes; (c) Mitochondrion; (d) Nucleus (chromosomes; DNA; nucleoplasm); (e) Cilia; (f) Smooth endoplasmic reticulum; (g). Rough endoplasmic reticulum; (h) Actin filaments; (i) Plasma membrane; (j) Cytoplasm; (k) Golgi apparatus.

Drawing (B): (l) Ribosome; (m) Cell membrane; (n) Cell wall; (o) Nucleolus (DNA; bacterial chromosome); (p) Cytoplasm (cytosol).



Step D: Questions for Thought and Discussion

30. The correct form is “The famous bacterium *E. coli*.”
32. Because of their small size, bacterial cells have a large surface-to-volume ratio, making the transport (diffusion) of materials a relatively quick process. Eukaryotic cells are much larger and have a smaller surface-to-volume ratio. This would mean diffusion and transport would be much slower—and probably lethal—to the cell. By compartmentalizing functions (organelles), cell metabolism becomes more efficient.
34. This is a common mistake. Actually, the species is a conceptual entity whose name is *Homo sapiens*. Several species (e.g., *Homo erectus*, *Homo habilis*, etc.) are organized into the genus *Homo*. The binomial name thus consists of the genus name and the species modifier (not the species). If you still cannot understand this concept, ask what a *sapiens* is; then ask what a *Homo sapiens* is.
36. The stem *methano-* refers to “methane-loving” and *-halophilus* refers to “salt-loving.”

20. Plasmid; 22. Pili; 24. Capsule; 26. Cell wall; 28. Plasmids; 30. Cytosol

Step C: Applications

32. Being a gram-negative bacterium, it will have an outer membrane containing lipopolysaccharide (LPS). Providing an antibiotic may kill the pathogen but in the process free LPS material into the body which can act as a toxin.

Step D: Questions for Thought and Discussion

34. Ideally, if the story is about the genus *Bacillus*, it will be capitalized and it will be italicized or underlined. If it is referring to a shape, “bacillus” will be lower case. However, newspaper articles and mass-market magazines often omit the italics or underlining. The genus is still capitalized though.
36. It has always been “assumed” that prokaryotic cells lack these structures. It has only been through the development of new and very precise microscopic techniques and molecular/genetic studies that such structures and proteins have been identified and their roles elucidated.

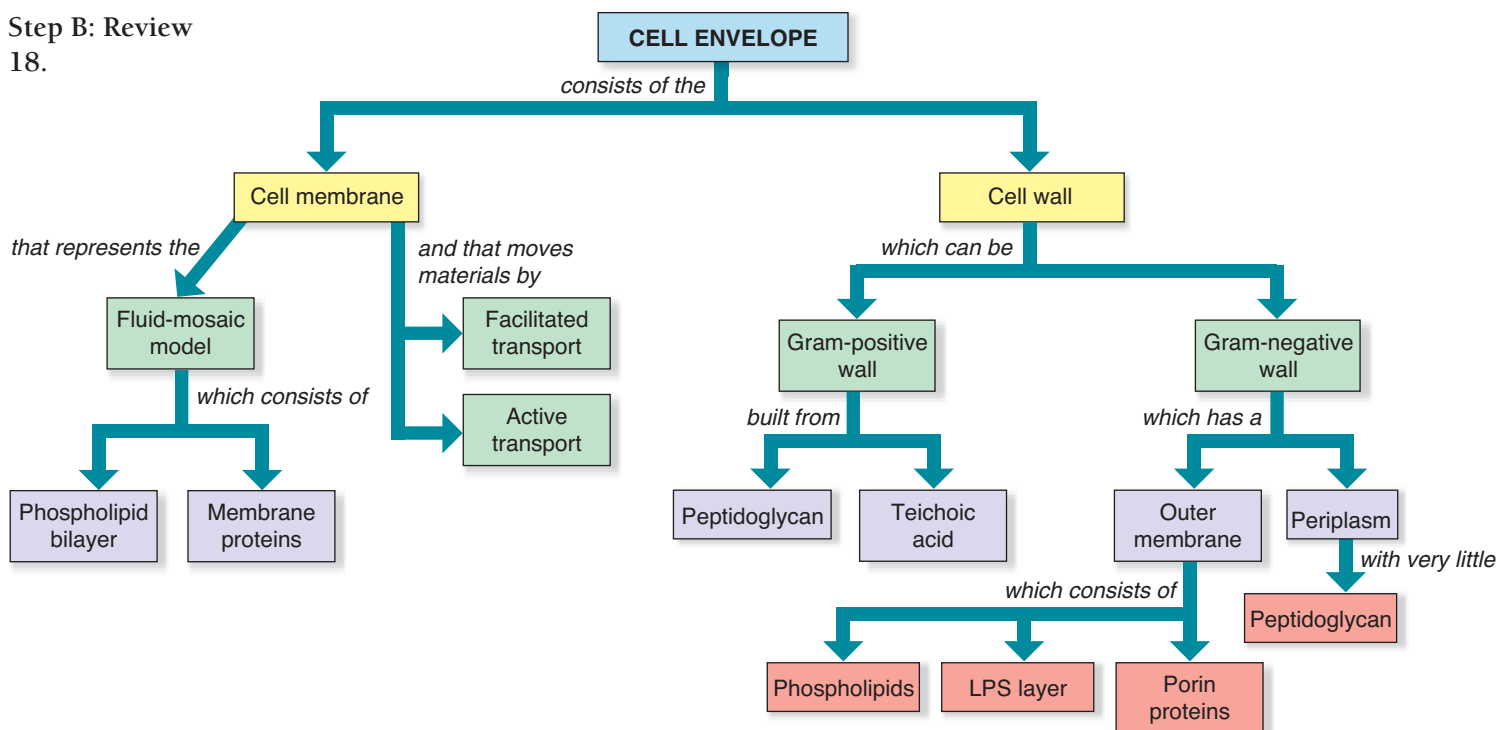
Chapter 4

Step A: Self-Test

2. A; 4. D; 6. D; 8. B; 10. A; 12. D; 14. D; 16. D

Step B: Review

18.



Chapter 5**Step A: Self Test**

2. D; 4. A; 6. A; 8. B

Step B: Review

10. a. 3; b. 3; c. 1.

12. F (gram-positive); 14. T; 16. T; 18. F (less than 5); 20. T; 22. F (swell)—note, these cells have a cell wall, so they may not burst.

Step C: Applications

24. Stuffing is made with various ingredients that have probably come in contact with bacterial cells, including bread cubes and spices, and it is often mixed by hand. The bacterial content is therefore high. It takes a long time for a turkey's internal organs to cool to refrigerator temperature, and bacterial cells have the opportunity to grow profusely before the cold affects them. Therefore, it's best to make the stuffing, refrigerate it to cool quickly, and stuff the turkey in the morning.

Step D: Questions for Thought and Discussion

26. Nitrogen is a relatively inert gas that will not support the energy-producing or synthesis metabolism of bacterial cells (Chapter 5). Without bacterial growth, decay will not take place.
28. Among the *Titanic*-digesting bacterial species, one might expect to find halophiles in the saltwater, psychrophiles in the cold water, metal-digesters, anaerobes in the mud and debris where is little oxygen, autotrophs where there is no organic matter to digest, and numerous other types.

Chapter 6**Step A: Self-Test**

2. A; 4. C; 6. C; 8. B; 10. A; 12. C; 14. A

Step B: Review

16. metabolism/synthesis/catabolism; 18. glycolysis/energy/ATP; 20. electrons/cytochromes/energy/ATP; 22. amino/amino/deamination; 24. inorganic compounds/carbohydrates/*Nitrosomonas*

Step C: Applications

26. *E. coli* can only carry out cellular respiration, and one of the products would be CO₂ gas. On the other hand, the cyanobacteria not only carry out cellular respiration, they also do photosynthesis, which will use up CO₂ gas produced from cellular respiration.
28. Apparently this company is interested in producing citric acid because citric acid will accumulate in the absence of the enzyme citrase. Chapter 27 explores this industrial process in more detail and includes some uses for citric acid, including beverages and clot prevention.

Step D: Questions for Thought and Discussion

30. ATP could not be absorbed into the cytoplasm of a bacterial cell. More importantly, ATP cannot be stored as ATP; it will be quickly broken down.
32. Stopping glycolysis would mean that the pyruvate fuel for the citric acid cycle would cease being made from carbohydrate. However, pyruvate could be produced from amino acids by deamination of certain amino acids, and fatty acids might convert to acetyl-CoA for entry to the cycle.

Chapter 7**Step A: Self-Test**

2. A; 4. B; 6. B; 8. C; 10. A; 12. B; 14. D; 16. C; 18. A

Step B: Review—Physical Methods

20. MEMBRANE; 22. DENATURATION;
24. SPORE; 26. ULTRAVIOLET; 28. OSMOSIS;
30. TUBERCULOSIS

Review—Chemical Methods

32. D; 34. C; 36. A; 38. H; 40. J; 42. I; 44. D

Step C: Applications

46. Bringing water to a boil and then cooling it will effectively destroy most microorganisms, but up to 30 minutes may be required if large concentrations of hepatitis viruses, protozoa cysts, or other heat-resistant forms are present. Over 2 hours may be necessary for the destruction of anthrax spores, but the possibility of their presence is extremely remote. In the great majority of cases, the recommendation that water be boiled is merely a precaution by health officials, and the implication is that bringing water to a rolling boil is sufficient. Indeed, milk pasteurization is conducted at 71.6°C for 15 seconds, and this is deemed suitable for the destruction of pathogens in the milk.
48. In selecting a laboratory disinfectant or sanitizing agent, it would be advisable to ask whether the agent was bactericidal or bacteriostatic under the desired conditions. Inquiry should also be made about its toxicity, solubility in water, shelf life, use in diluted form, penetrating ability, corrosiveness, temperature and pH of use, and cost. Many other avenues of inquiry are noted in the chapter.
50. This is an interesting dilemma. Washing followed by disinfection would be most appropriate, since the washing would

mechanically remove microorganisms and the disinfectant would continue and complete the process on the residue.

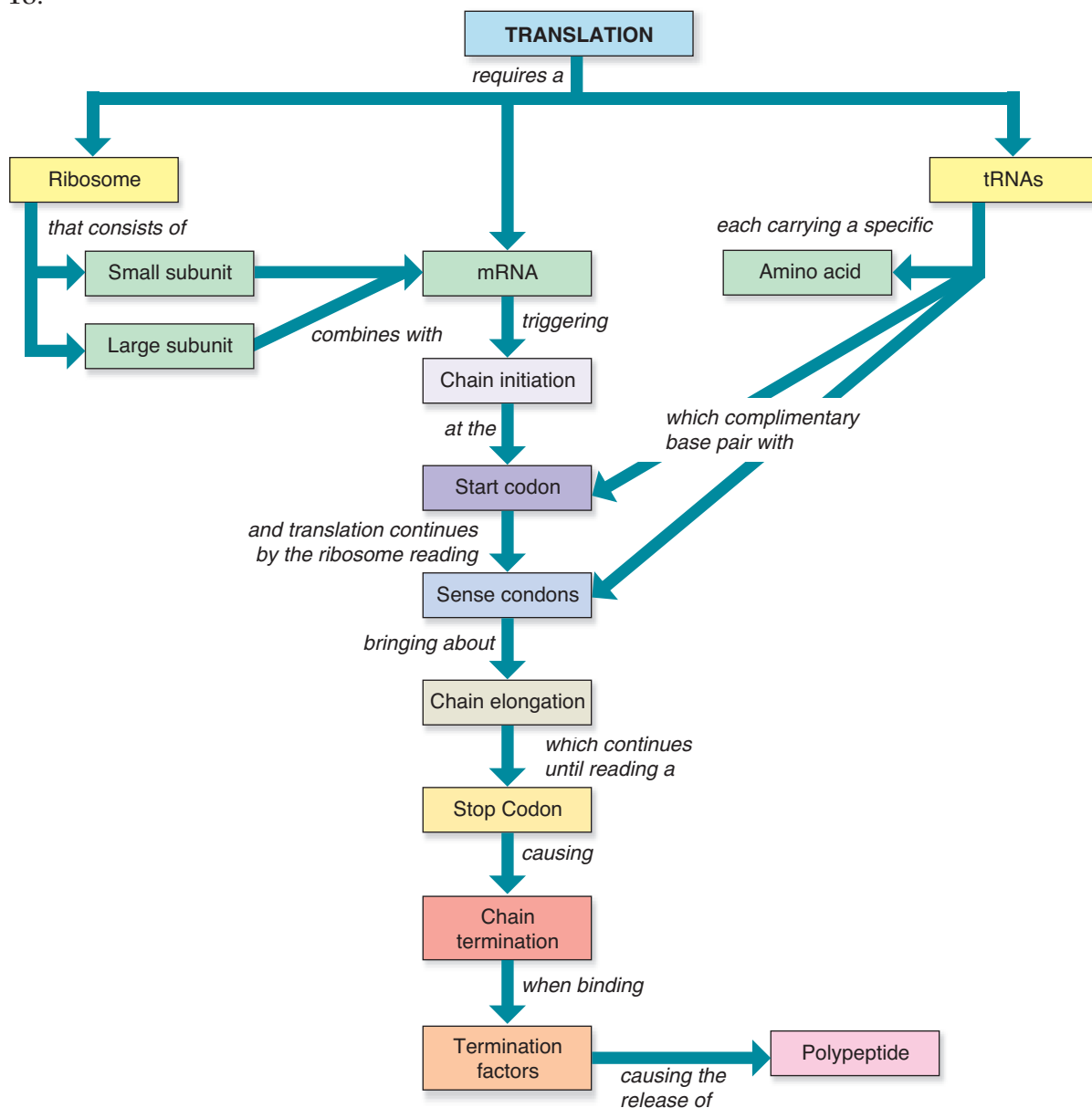
Step D: Questions for Thought and Discussion

52. A suspicious person might inquire what will happen within 30 days. Will spontaneous generation take place? Is it possible that the contents were sterilized at the manufacturing plant, but that the porous container is now permitting airborne microorganisms to enter? If so, then the product was once sterilized but is now contaminated, and evidence of contamination will appear by the expiration date.
54. Pasteurization merely implies the destruction of pathogenic microorganisms from milk or other liquid. The process does not affect bacterial endospores and it may be tolerated by protozoal or worm cysts. Therefore, a pasteurized product cannot be considered sterilized. By contrast, a sterilized product contains no life form of any type (including viruses) and is considered both pasteurized and sterilized.
56. One effective way of treating the thermometer would be to wash it well in hot soapy water, rinse it thoroughly, and immerse it in a tray of ethyl alcohol or rubbing alcohol for a minimum of 10 minutes. Admittedly, this would require an interval of time before taking the next child's temperature, but the wait might be worth it, especially if the second child was not already sick.

Chapter 8**Step A: Self-Test**

2. D; 4. C; 6. A; 8. B; 10. A; 12. D; 14. B; 16. D

Step B: Review
18.



20. (a) DNA because it contains Ts; (b) met-cys-tyr-gln-asn-phe-asn-ala = silent because the fourth codon still codes for gln; (c) met-cys-tyr-gln = nonsense because the insertion generated a stop codon (UAA).

Step C: Applications

22. The lack of colonies near the center of the plate is probably due to the very high concentration of mutagen. Here the mutagen is so strong it caused so many mutations that they were lethal to any cells that were pres-

ent. Farther out, where the mutagen is more diluted (less concentrated), fewer mutations would occur and some bacterial cells would survive.

24. You could take the plate with benzene-metabolizing colonies and replica plate it onto a similar synthetic medium plate containing the ³²P material. Any colonies sensitive to the radioactive material will not grow (negative selection). These can be identified by looking back at the master plate with benzene-metabolizing colonies.

Step D: Questions for Thought and Discussion

26. One would have to believe that double-stranded DNA viruses would be better at DNA repair because if a mutation occurs in one strand, the complementary strand is a template for mismatch repair. Single-stranded RNA viruses would lack this ability.

Chapter 9**Step A: Self-Test**

2. D; 4. B; 6. D; 8. D; 10. C; 12. D

Step B: Review

14. PLASMIDS; 16. COMPETENCE;
18. ENDONUCLEASE; 20. LIGASE; 22. CON-
JUGATION; 24. GENOME

Step C: Applications

26. Perhaps the organism was one that had existed previously but as a harmless species. A recombination process may have permitted it to assume a parasitic mode and thus cause disease. Another possibility is the acquisition of genes through HGT that allowed it to produce toxic substances, which lead to tissue destruction.
28. (a) *Legionella pneumophila* is the causative agent of Legionnaires' disease in humans that kills many people every year.
(b) By knowing the bacterial species' DNA sequence, perhaps sites sensitive to antibiotics can be identified or from which a vaccine can be produced.

Step D: Questions for Thought and Discussion

30. It might have been an adaptive advantage because some fragments might contain genes of use to the recipient cell. Such genes could be for antibiotic resistance or the ability of breakdown a nutrient source.
32. Reproduction leads to "more" cells through binary fission, budding, or mitosis, while recombination leads to "different" cells through the recombining of genes and genomes.

Chapter 10**Step A: Self-Test**

2. A; 4. B; 6. A; 8. C; 10. A; 12. D

Step B: Review

14. Tuberculosis; 16. Legionellosis (Legionnaires' disease); 18. miliary; 20. Pneumococcus; 22. cell wall; 24. *Mycobacterium*

Step C: Applications

26. The key to diagnosis in this case was the dropping red blood cell count. Apparently the patient was producing antibodies that at cold temperatures (i.e., in February) react with and clump red blood cells, thereby causing them to disintegrate, thus the dropping cell count. Another insight was the resistance to penicillin, a notable characteristic of mycoplasmas. The final diagnosis was primary atypical pneumonia caused by *Mycoplasma pneumoniae*.
28. It would be wise to target nursing homes and long-term care facilities. Impress upon them the numbers of older adults who die each year from a vaccine-preventable disease. Tell them it is a one-time immunization and they can receive it when they get their flu vaccination.

Step D: Questions for Thought and Discussion

30. This question assumes that a pathogen is in an advantageous condition, a situation with which you might take issue. Perhaps the virus places the bacillus in a difficult position because pathogenicity is not always desirable, especially after the host dies. On the other hand, the virus permits active growth in the tissues, a situation not possible without the toxin.

Chapter 11**Step A: Self-Test**

2. A; 4. C; 6. D; 8a. C; 8b. B; 8c. A; 8d. B;
8e. A; 10. A

Step B: Review

12. dysentery; 14. symptoms; 16. *Streptococcus mutans*; 18. serotypes; 20. intoxicated

Step C: Applications

22. Mushrooms are cultivated in dark, humid caves on trays of fresh manure and other organic matter. Clostridial spores probably enter the manure from the animal's intestine

and cling to the mushrooms as they grow tall. When the mushrooms are bottled, anaerobic conditions can be established following a failed sterilization procedure with steam. Now the toxin is produced, and assuming the mushrooms are not boiled, the toxin will pass to consumers.

24. The disease was brucellosis. All recovered and returned to work. The health department also made several recommendations to prevent further outbreaks, including the use of rubber gloves, face shields, and negative air pressure on the floor.

Step D: Questions for Thought and Discussion

26. The bacterial species survive the acidity of the arthropod stomach. They are then transmitted to distant locales, where they can be transmitted to humans after the arthropod feeds on food, or possibly by arthropod bite.
28. Virtually all the organisms mentioned in this chapter could cause “stomach flu.”

Chapter 12

Step A: Self-Test

2. D; 4. C; 6. C; 8. A; 10. C

Step B: Review

12. F; 14. B; 16. A; 18. H; 20. E; 22. H; 24. A

Step C: Applications

26. The bipolar staining characteristic of the plague bacillus makes it appear as a safety pin, and the technician apparently thought diplococci were present. In addition, the plague bacillus is a gram-negative rod, which indicates that the Gram stain technique was performed poorly. The erroneous conclusions appeared to have dire consequences.
28. Good-quality boots, preferably hip length, would be a wise suggestion.
30. The festering boils on humans and cattle are probably those of anthrax. Anthrax may be caused by airborne spores settling on the skin. It is fair to say that people were familiar with the disease, since anthrax has been a concern in veterinary medicine for centuries. The French originally called it *char-*

boneuse, a reference to the black-encrusted boils that form.

Step D: Questions for Thought and Discussion

32. Endemic typhus is caused by rickettsiae transmitted by the fleas of rodents. When the rat poison was used, the rats died and the fleas quickly left the dead animal bodies, only to infest the nearby human bodies.
34. Read MicroFocus 19.5.
36. When leaves and debris pile at the curbside, soilborne arthropods flourish, including ticks that commonly occur on grass and leaves. A child’s chance playing in the leaves may bring him/her in contact with the ticks, and any of the three diseases indicated may follow.

Chapter 13

Step A: Self-Test

2. C; 4. A; 6. A; 8. C; 10. B; 12. B; 14. D; 16. C; 18. C

Step B: Review

20. nongonococcal urethritis; 22. Southeast; 24. Donovan; 26. *hominis*; 28. *Escherichia coli*; 30. chain of transmission

Step C: Applications

32. The disease was leprosy (Hansen disease).
34. At our college, we have had the hollow tubes removed because the practical benefit does not seem to outweigh the danger of contracting conjunctivitis (pinkeye), particularly when so many different students use the microscope. Disinfection is a useful alternative to removal, but this is not always possible.
36. The woman probably had syphilis. Congenital syphilis often leads to miscarriage after the fourth month. The symptoms in the newborn, including Hutchinson’s triad, also point to syphilis.

Step D: Questions for Thought and Discussion

38. Impetigo is a skin disease often caused by staphylococci and occurring most commonly among children. Children tend to have more contact with one another during the summer months than during any

other time of the year, and the skin is often unclothed at this time.

40. Historic writings, public images and pictures, and stories about leprosy have all added to the social stigma accompanying the disease.

Chapter 14

Step A: Self-Test

2. C; 4. D; 6. A; 8. B; 10. C; 12. A; 14. D; 16. B

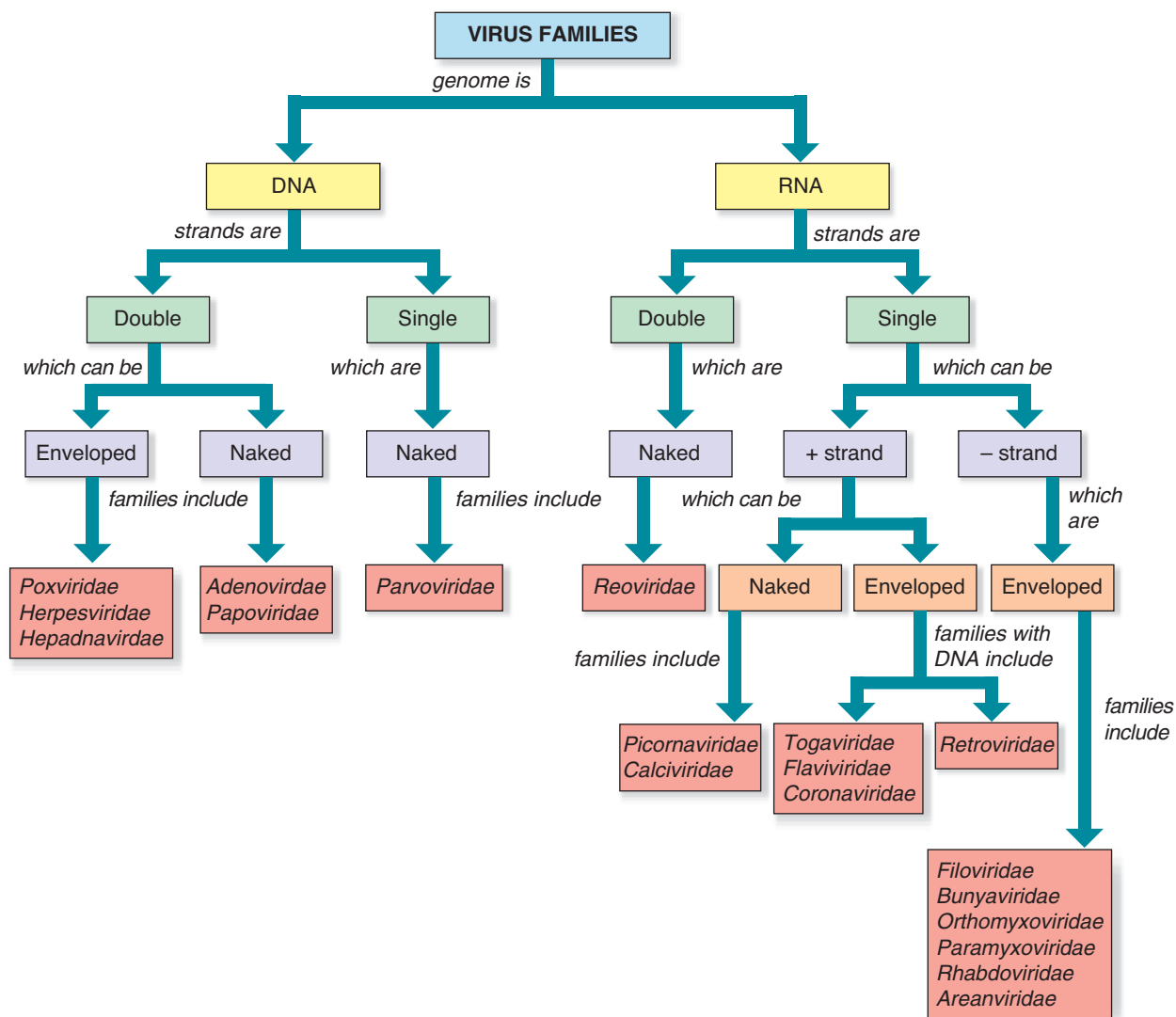
Step B: Review

- 18.

20. BACTERIOPHAGE; 22. ONCOGENE;
24. ICOSAHEDRAL; 26. VIRION; 28. PRIONS

Step C: Applications

30. Not every phage can infect every type of bacterial species. Also, in the human, the phage would have to pass through the stomach, where the acidity would more than likely destroy most, if not, all the phage.
32. The defective viruses could possibly make vectors for carrying genes to cure genetic diseases. If the spike proteins could be



change to recognize different cell types, then these defective viruses could target different types of cells. For example, the defective viruses could be engineered to carry a toxin that on attaching to and penetration of the cancer cells, would release the toxins, killing the cancer cells.

Step D: Questions for Thought and Discussion

34. Oncogenes appear to function in the production of substances that are involved in the metabolism of body cells (“Jekyll”). When these substances are overproduced, however, they may transform the cell into a tumor cell (“Hyde”).
36. Reproduction has a connotation in biology that implies the generation of new individuals by asexual or sexual processes. Although new individuals are generated in viral replication, the process is neither asexual nor sexual, but a completely separate process seen nowhere else in biology.
38. Viroids and prions are of special interest because they appear to lack protein and nucleic acid, respectively. Even at the level of viruses, both components seem to be necessary. Viruses do or do not conform to other living things, depending on how one defines living things. Discussions like these are fruitful because they challenge the perception of what is a living thing.

Chapter 15

Step A: Self-Test

2. C; 4. C; 6. A; 8. C; 10. A; 12. D; 14. B

Step B: Review

16. contact/blisters/emotional stress; 18. Reye/testes/orchitis; 20. influenza/vaccine/bacteria; 22. coronavirus/enveloped/person-to-person; 24. icosahedral/HSV-2/thin/weeks/stress

Step C: Applications

26. Here is what transpired: Twice-daily reports were collected from delegations on whether any members had measles symptoms. All visitors to medical stations were observed for measles symptoms. Letters were sent to all participants, volunteers, and staff advis-

ing them of the situation and the control measures, signs, and symptoms. Daily telephone calls were made to all local hospital emergency rooms. State health departments of the competition participants were notified of the outbreak. Can you think of anything the epidemiologists missed? (P.S. No additional cases occurred.)

28. The virus causing the man’s shingles is the chickenpox virus. If he were to come in contact with children, he might initiate an epidemic. The advice is therefore justified. Indeed, in some hospitals, shingles patients are placed in isolation for the duration of their illness.

Step D: Questions for Thought and Discussion

30. The incident helps prove that the agents of disease are transmissible. Pasteur and his supporters were right on target.

Chapter 16

Step A: Self-Test

2. C; 4. B; 6. D; 8. D; 10. C

Step B: Review

12. F (no symptoms); 14. F (rabies); 16. T; 18. T; 20. T; 22. T; 24. T

Step C: Applications

26. The Sicilian barbers in the study used traditional razors that are nondisposable and unsterilized. They probably shaved themselves with the razors after shaving their patrons and transmitted hepatitis C viruses in bits of blood remaining on the razor. No doubt they also contributed to a high incidence of hepatitis C in their patrons.
28. This anomaly is probably the result of the cross-reactivity of the antibodies for yellow fever and dengue fever. The viruses are very similar, so the antibodies produced against one virus yield protection against the other virus.

Step D: Questions for Thought and Discussion

30. Those in favor say that if a person receives a positive test for hepatitis C, he or she has a right to know the results. Moreover, the person can vary the diet or make lifestyle

changes to enhance the health of the liver. Those who oppose divulging the results indicate that thus far, there is no treatment for hepatitis C and not enough is known about it; therefore, alarming the individual is not warranted.

32. Chickens are used because the birds are susceptible to viral encephalitis. Furthermore, it is easy to detect the virus in their tissues, and they are inexpensive. Susceptibility to viral encephalitis is high because the park is built on swampland where mosquitoes thrive and harbor the virus. Tourists might be advised to use lots of insecticide, wear long sleeves, stay indoors at night, and make note of unusual fevers or headaches. Park officials should be advised to temporarily close all water parks and golf courses in the event of an outbreak.

Chapter 17

Step A: Self-Test

2. C; 4. A; 6. B; 8. B; 10. A; 12. D; 14. A; 16. D

Step B: Review

18. K; 20. G; 22. P; 24. F; 26. I; 28. B; 30. L

Step C: Applications

32. The tests and information point to *Histoplasma capsulatum* and histoplasmosis.

Step D: Questions for Thought and Discussion

34. *Cryptococcus neoformans* is known for its ability to grow in pigeon droppings. The organisms then are airborne by wind gusts and inhaled into the lungs, where respiratory disease may develop. The action of the residents would therefore appear to be justified, at least microbiologically.
36. The mold would be found in warm, humid climates, which is exactly what the environment would be in the compost piles within the facility. *Aspergillus* can cause lung infections forming aspergillomas.

Chapter 18

Step A: Self-Test

2A. A; 2B. D; 2C. C; 2D. A; 4A. B; 4B. C; 4C. B; 6. D; 8. C

Step B: Review

10. A; 12. A; 14. A, B, C; 16. A; 18. B; 20. A; 22. C; 24. C

Step C: Applications

26. To avoid toxoplasmosis, you might give your friend two helpful pieces of advice: have the hamburger well-done, and send the cats to someone else's house until the baby is born. Toxoplasmosis is a significant threat to a pregnant woman.
28. I would consider the situation dangerous because *Trichinella spiralis* is still quite prevalent in pork; the preventive measures are minimal, and the possibility of contracting trichinellosis remains real. One day it may be possible to screen pork for trichinellosis.

Step D: Questions for Thought and Discussion

30. As the borders of Rome expanded, Romans ventured into far-off lands where mosquitoes thrived and where the malaria parasite was prevalent. Infected Romans probably brought the disease back to Rome, and the mosquito populations of the aqueducts and pools propagated the parasite and spread the disease.
32. On a global scale, diseases as these “impede national and individual development, make fertile land inhospitable, impair intellectual and physical growth, and exact a huge cost in treatment and control programs.” Solutions are straightforward: Develop new drugs, vaccines, diagnostic tests, and control methods. Can you suggest any novel approaches?
34. The concept of studying parasitology to appreciate the web of life is intriguing and worthy of note. Hundreds of thousands of individuals are infected with multicellular parasites. The relationship is benign in huge numbers of cases but parasitical in many others, as this chapter shows. Perhaps a geographical summary of the parasites might help us appreciate the global perspective for parasites.

Chapter 19

Step A: Self-Test

2. D; 4. A; 6. B; 8. D; 10. D; 12. A; 14. B

Step B: Review

16. T; 18. F (liver and others); 20. F (mechanical); 22. F (antitoxins); 24. T; 26. F (direct); 28. F (incubation); 30. F (signs)

Step C: Applications

32. At the emergency room, your friend was given a “tetanus shot,” a preparation of tetanus toxoid to induce his immune system to produce tetanus antitoxins. These antitoxins would protect him against tetanus toxins, since tetanus spores had probably entered the wound from the soil.
34. You could make a case either way. You could envisage an epidemic disease as the greater threat because of its explosiveness, but a case also could be made for an endemic disease since it often is hidden from detection and strikes without warning.

Step D: Questions for Thought and Discussion

36. Cholera bacilli are susceptible to stomach acid, so the bacilli may never have reached von Pettenkofer’s intestine to cause disease. It is also conceivable that von Pettenkofer’s anxiety caused his stomach to put out a higher-than-normal amount of acid, which would further reduce the bacterial population. Perhaps the laboratory isolate was less infectious than one directly from a diseased patient.
38. If a virus kills its victims quickly, there is no way it will be around long enough to spread to new hosts. Of course, this theory assumes that the virus does not exist anywhere in nature where it can be contracted easily, and that it relies on human-to-human transfer to remain in existence. In this particular case, the more virulent the virus, the less likely it is to be a slate-wiper (i.e., a disease that kills huge numbers of victims).

Chapter 20**Step A: Self-Test**

2. D; 4. D; 6. A; 8. B; 10. A

Step B: Review

12. J; 14. F; 16. B; 18. G; 20. H; 22. O; 24. P

Step C: Applications

26. The pain is due to nerve damage at the cut site while the warmth is due to the increase in blood flow resulting from capillary dilation and fluid accumulation.
28. Swollen glands refer to swollen lymph nodes. You tell her it is her body’s response to the pathogen and the “fight” is occurring in the lymph nodes.

Step D: Questions for Thought and Discussion

30. There are chemical signals that stimulate phagocytosis, the defensins, interferons, inflammatory signals, signals triggering fever, signals involved with complement activation, and chemical interactions with the toll-like receptors.

Chapter 21**Step A: Self-Test**

2. C; 4. A; 6. C; 8. C; 10. B; 12. C

Step B: Review

14. T; 16. F (immunoglobulin); 18. T; 20. T; 22. F (two); 24. F (macrophages); 26. T; 28. F (four); 30. F (heavy chains); 32. F (IgG); 34. F (IgD)

Step C: Applications

36. When antigenic determinants arrive in the lymphoid tissue, they must seek out receptor sites on one of perhaps a million different cells. Only after that interaction has taken place will the immune system be stimulated. The analogy would appear correct.
38. The inability of nanorobots to be recognized as foreign by the immune system would be important and critical if they are to be effective disease fighters. In addition, how will nanorobots detect and eliminate disease; and what happens to the nanorobots once the disease has been eliminated?

Step D: Questions for Thought and Discussion

40. In short, T cells carry receptor proteins that resemble antibodies. However, B cells do carry IgD and antibodies on their surface.

Chapter 22**Step A: Self-Test**

2. B; 4. D; 6. D; 8. B; 10. D; 12. A

Step B: Review

14. active/passive; 16. diphtheria/pertussis/tetanus; 18. hyperimmune/antiserum; 20. transplacental passage/breast feeding; 22. diphtheria/tetanus; 24. neutralization/agglutination

Step C: Applications

26. IgM is not used in gamma globulin preparations possibly because the expense of obtaining it is prohibitive and storage can be a problem.
28. The one with the higher titer may have had a clinical infection, a subclinical infection, a mumps vaccination, a blood transfusion containing mumps antibodies, or an injection of antiserum. Any other possibilities?
30. The MMR vaccine is an attenuated vaccine; the antigens (viruses) are not killed, so there is a miniscule risk that the child could get one of the diseases from the vaccine.

Step D: Questions for Thought and Discussion

32. It would seem to be a good idea, but it will take lots of money to implement. And the willingness for the American taxpayer to part with the funds will depend in part on how serious the threat of disease is perceived to be. You should continue the debate from here.
34. Children between the ages of 5 and 15 generally eat well and are adequately clothed. Their cells are actively metabolizing, and their tissues are growing rapidly. Their immune systems are fully functional. They enjoy exercise for physical fitness and are relatively free of cares for mental fitness. At first signs of disease, they are given home or hospital care.

Chapter 23**Step A: Self-Test**

2. A; 4. C; 6. D; 8. B; 10. D; 12. D; 14. B

Step B: Review

16. DIGEORGE; 18. CYTOTOXICITY; 20. ANTIGEN; 22. BASOPHILS; 24. RASH

Step C: Applications

26. No, the officer should be stopped. His blood cells contain B antigens, which will agglutinate with b antibodies in the recipient's serum. The transfusion reaction will probably kill the recipient.
28. The condition is hay fever.

Step D: Questions for Thought and Discussion

30. She is suffering an allergic reaction. Insufficient sensitization had taken place after the previous injections but now, after the fifth injection, she was fully sensitized and basophils and mast cells began to degranulate. Most allergists recommend that a patient spend several minutes in the office after injections to be available in case an allergic reaction takes place.
32. It is interesting to question whether the immune system is actually protecting the body during immune disorders. Allergies can be interpreted as protective mechanisms for ridding the body of antigens, and the theory can be extended to other types of hypersensitivity, as well as to transplants and tumors. Autoimmune diseases stand in stark contrast because the body appears to be attacking itself. An oxymoron is two terms that do not fit together (the dictionary definition is "two mutually exclusive juxtaposed words"). "Immune disorder" appears to be an oxymoron because *immune* means "free of" and a disorder is a problem. Therefore, how can you have a problem that you don't have?

Chapter 24**Step A: Self-Test**

2. B; 4. D; 6. D; 8. D; 10. C; 12. A; 14. A; 16. D; 18. A; 20. D

Step B: Review—Antimicrobial Drugs

22. F (bacterial cells); 24. F (tetracycline); 26. T; 28. T; 30. F (neomycin)

Step B: Review—Identification

32. Membrane; 34. DNA; 36. Cell wall; 38. Cell wall; 40. Cell wall

Step C: Applications

42. The arrival of antibiotics and modern medical practices in Nepal typifies how medical advances can disrupt the lives of a population. With more mouths to feed, forests had to be cleared, and great pressure was placed in preparing the land for crops. Living space soon became a premium, and natural resources, such as water supplies, were tapped to their limit. Greater populations also meant greater sanitation problems and, consequently, more opportunity for the spread of disease. Discussions such as these help us understand the negative aspects of medical advances.

Step D: Questions for Thought and Discussion

44. Observations as that in China illustrate how people were enjoying the effects of antibiotics without realizing it. In this case, the mold in the soybean curd was probably the source of the antibiotic.
46. It would seem likely that many genera of microorganisms could produce antibiotics, yet only five genera have been pinpointed in this chapter. Perhaps this has to do with the soil habitat in which these genera normally exist. It is probable that many other genera of microorganisms produce antibiotics, but the chemicals are generally too toxic for use in the body.
48. The antibiotic issue is one that can be argued for hours. Perhaps this might be a good question for a debate panel. Side effects, the emergence of antibiotic-resistant bacteria, the effect on human population growth, and human dependence on antibiotics would stimulate the anti-antibiotic side. The misery and death from disease, rising food costs, job impact in the pharmaceutical industry, and generally better quality of life might be discussed by the pro-antibiotic side.

Chapter 25**Step A: Self-Test**

2. D; 4. A; 6. B; 8. A; 10. A; 12. B; 14. C; 16. C

Step B: Review

18. *SALMONELLA*; 20. *SERRATIA*; 22. *STREPTOCOCCUS*; 24. *ACETOBACTER*; 26. *CLAVICEPS*; 28. *PSEUDOMONAS*; 30. *ASPERGILLUS*

Step C: Applications

32. The correct sequence would be to prepare the salad before the chicken. *Salmonella* serotypes may be present in the chicken, and cross-contamination to the salad may take place. Cooking eliminated *Salmonella* in chicken, but salad is eaten raw and is potentially dangerous.
34. Precautions to take when gathering apples include not picking apples off the ground, just off the tree. Also, move far into the orchard away from any animals grazing nearby because their feces may have contaminated the soil. Moreover, wash and brush the apples before pressing them and briefly boil the cider before drinking it, or use a preservative to prepare the cider for storage.

Step D: Questions for Thought and Discussion

36. Blue cheese is made with *Penicillium roquefortii*. On very rare occasions, eating food with penicillin in it can cause reactions (hives, itches) for penicillin-sensitive individuals.
38. The liver would probably be the better choice because it will spoil more rapidly than the steak. Liver is an organ meat, with a looser tissue consistency and richer blood supply than muscle tissue. Contamination is therefore more probable in the liver.
40. Individuals who pick fruits and vegetables in the fields should be vaccinated against any diseases they could transmit. Toilet facilities should be made available to them, and they should be discouraged from working if they are ill. The water used to wash the produce should be purified. You should recommend other such regulations.

Chapter 26**Step A: Self-Test**

2. B; 4. B; 6. A; 8. D; 10. D

Step B: Review

12. B; 14. A, B; 16. A, B; 18. A; 20. A, C;
22. A, C; 24. B, C

Step C: Applications

26. The methane was generated during the decomposition of sewage by bacterial species in the septic tank. This tragedy highlights the danger of dealing with actively decaying sewage, and it should be of interest to those who work near landfill operations.
28. Choosing a cesspool or septic tank presents an interesting dilemma because a strong case can be made for either choice. Among the considerations is the expense and ease of installation, the desirability of regular cleaning out, the type of waste to be deposited, and local ordinances.

Step D: Questions for Thought and Discussion

30. Connecting storm and sanitary sewers was a poor one because it resulted in a huge body of storm runoff polluting sanitary waste, and vice versa. Separation would make handling the waste considerably easier. However, there are arguments for connecting the systems, the most obvious being the economic benefit.
32. The following may be offered: (a) Soil runoff may contaminate the water, despite the absence of large animals or humans, and small animals such as beavers or others may be sources; (b) microorganisms survive in ice and snow, either of which may be contaminated with animal excrement; (c) water may pick up contaminants during its journey out of the soil or over rocks; also, it may have run into the ground farther up the hill; (d) rapidly moving water may dilute contaminants more efficiently than still water, but it presents no assurance of being germ-free.
34. The carbon, sulfur, and nitrogen cycles provide irrefutable evidence of the roles that microorganisms play in enhancing the quality of life. It is instructive to try to imagine a

world where no microorganisms are available to recycle these elements.

Chapter 27**Step A: Self-Test**

2. A; 4. D; 6. A; 8. D; 10. B

Step B: Review

12. B; 14. G; 16. E; 18. C; 20. H; 22. M; 24. F

Step C: Applications

26. More carbohydrate breakdown means less residual carbohydrate and therefore fewer calories. The product is “lite” beer.
28. Despite extensive reassurances, many microbiologists remain skeptical about the widespread use of *Bacillus thuringiensis*. What would happen, for example, if the organism mutated or underwent recombination to a pathogenic form? Ecologically speaking, is it possible that the insecticide is killing off insects that provide natural controls to other insects? These thoughts should provide a basis for a discussion.

Step D: Questions for Thought and Discussion

30. By the time you reach Chapter 27, you should have a firm understanding of how microorganisms contribute to the quality of life. Examples abound in this chapter. Combined with examples from Chapters 25 and 26, they are a formidable list that should help you see the positive roles of microorganisms in our lives.
32. This is an intriguing question similar to that proposed for lactobacilli and streptococci in yogurt (Chapter 25). You might speculate about what factors might be necessary to establish pathogenicity in the yeast. The question also illustrates how we consume microorganisms regularly without a thought of dangerous consequences.
34. The list of microbial products should be formidable and should include food, drink, and numerous industrial products.

Appendix D: Answers to Textbook Case and MicroInquiry Questions

Textbook Cases

Textbook Case 2

- 2A. Contaminated fresh eggs can be sources of *Salmonella*.
- 2B. Warm water; left at 60°F for 8 to 10 hours in salad bar.
- 2C. Use egg substitute; keep dressing colder.
- 2D. Lipids attached to carbohydrate (polysaccharide).
- 2E. Elderly individuals most likely had a lowered immune system function, making them more susceptible to the toxin.

Textbook Case 3

- 3A. Gram-positive spheres would appear blue-purple in color.
- 3B. The reliability is good after culturing the organism and reexamination of the CFS smear.
- 3C. Ninety-five % alcohol (ethanol) is usually used; too short a decolorization could have given the false gram-positive result.

Textbook Case 4

- 4A. Presumably, a hemodialysis patient was infected with *E. cloacae* and the machine was not properly cleaned and sterilized after patient use.
- 4B. Apparently, the correlation between infection and the hemodialysis machine was not evident. These five patients may be reported their illness to their own physicians, who treated the infections independently.
- 4C. Make sure the machine is (1) working properly, including the drain valves and (2) is decontaminated to prevent possible infection subsequent dialysis patients.

Textbook Case 5

- 5A. Cooking the chicken would kill all *C. jejuni* cells.
- 5B. Raw chicken contained *C. jejuni*, which contaminated the other salad ingredients cut on the same contaminated countertop.

- 5C. Patrons became ill from *C. jejuni* that contaminated the salad ingredients, such as the fresh lettuce.

Textbook Case 9

- 9A. The patient had diabetes, peripheral vascular disease, and chronic renal failure. His medical condition certainly made him susceptible to *S. aureus*.
- 9B. More than likely there was a HGT event that transferred the *vanA* gene from *Enterococcus* to *Staphylococcus* as a result of the hemodialysis treatment. The original foot ulcer infection in 2001 may have been the source of VRE.
- 9C. The nares were tested to see if the VRSA was picked up airborne transmission. It appears it was not, meaning there is less likelihood of others being infected.
- 9D. The patient needed to be put on an antimicrobial drug very different from vancomycin and to which the organism was probably sensitive.
- 9E. The hemodialysis equipment needs to be carefully cleaned and sterilized as this is probably the source of the *S. aureus* infection.

Textbook Case 10

- 10A. Since most cases were in Bogalusa, one can be fairly certain that the outbreak has not spread and originated in the city. The controls were individuals who visited the same locations but did not become ill.
- 10B. Previous outbreaks of Legionnaires' disease had involved cooling towers.
- 10C. Many controls had visited these locations without becoming ill.
- 10D. The public, the media, hospitals, clinics, and physician offices. The findings should be reported through newspapers, radio, and television.
- 10E. (i) More females shop at grocery stores. (ii) All cases were in older adults whose immune systems were likely weakened due to age. Grocery employees must have been younger individuals with fully

active immune systems to fight off the bacterial species.

Textbook Case 11

- 11A. An infection of variable severity with diarrhea and cramps lasting less than seven days.
- 11B. Lunch foods, apple cider.
- 11C. Hemorrhagic colitis.
- 11D. “Drop” apples could be contaminated with soil-dwelling bacterial species or species from animal feces.
- 11E. Don’t use “drop” apples for cider; pasteurize apple juice before selling.

Textbook Case 12

- 12A. ERF has a relatively high mortality rate. Also, initially the illness might have been due to lice-borne relapsing fever, which has an even higher mortality rate.
- 12B. An infection involving up to 13 relapses of fever and chills over several days.
- 12C. Perhaps those five patients have lower, unidentified numbers of spirochetes—or the blood samples were not analyzed!
- 12D. All were bitten by ticks during cleaning.
- 12E. Bites by infected ticks from rodents.

Textbook Case 13

- 13A. Yes, condoms can lower the risk.
- 13B. No, they are very general symptoms.
- 13C. Progression of PID and salpingitis.
- 13D. It is the structure within which the developmental cycle of *Chlamydia* occurs; see figure 13.6D.
- 13E. Scarring can block the fallopian tubes and result in infertility or an ectopic pregnancy.

Textbook Case 15

- 15A. They did not want the true extent of the disease to be known.
- 15B. Quarantine and isolation prevent the mixing of infected individuals with uninfected, susceptible individuals.
- 15C. Close contact spreads the virus from patient to health care provider.
- 15D. Better hand hygiene and the use of surgical masks to prevent exposure to and spread of the SARS virus.

- 15E. SARS represents a viral disease that jumped species from an animal reservoir to humans.

Textbook Case 16

- 16A. Hepatitis A often is spread by an infected restaurant worker.
- 16B. Immunoglobulin injections involve the use of antibodies that bind to and cross link hepatitis A viruses, blocking viral attachment and cell penetration.
- 16C. Deaths from hepatitis A are rare.
- 16D. The establishment of an infection requires exposure to a specific infectious dose.
- 16E. Contaminated water, exposure to hepatitis A virus in feces, or contamination during the processing of the green onions for shipment.

Textbook Case 17

- 17A. Arthrospores produced by the fungus in the soil.
- 17B. A flu-like illness characterized by one or more of the following:
 - Fever, cough, headache, rash, and muscle aches;
 - Pneumonia or other pulmonary lesion, diagnosed by chest X-ray.
- 17C. A serosurvey would give an idea of the extent of the outbreak.
- 17D. It simply shows that the fungal organism can occur over a more extended area than previously thought.
- 17E. Prevention would include avoiding dusty environments in “potentially” endemic regions. If dust exposure is inevitable, wearing a mask that will prevent the passage of arthrospores into the upper respiratory system would be advised.

Textbook Case 18

- 18A. No, because not enough time may have passed to detect the infectious organism.
- 18B. The follow-up was done to confirm the diagnosis.
- 18C. Infection probably came from swimming in the freshwater river.

- 18D. The disease is very rare, meaning there were few amoebae present. More than likely, it was a rare infection.
- 18E. Do not swim in freshwater rivers.

MicroInquiry Questions

MicroInquiry 2

- 2a. Sulfur.
- 2b. Phosphorus.
- 2c. No, because these elements are found in proteins and DNA.
- 2d. ^{35}S .
- 2e. ^{32}P .
- 2f. It supported Avery's work because ^{32}P was detected in the pellet (bacterial cells).

MicroInquiry 5

- 5e. The results show in which tubes acid was produced. Therefore, tubes 4, 7, and 9 are *S. aureus*.

MicroInquiry 7

- 7a. **A** = 90% kill every 4 minutes, so in 24 minutes there theoretically would be one cell remaining alive. Another 4 minutes should kill the last cell, so 28 minutes would be required. Likewise, **B** = 70 minutes and **C** = 126 minutes, both one time interval beyond the point where one cell remains alive.
- 7b. **A** = 4 min.; **B** = 10 min.; **C** = 18 min.
- 7c. 70°C.
- 7d. 108 minutes.

MicroInquiry 8

When tryptophan is absent from the growth medium, the repressor protein of the *trp* operon fails to bind to the operator (**Figure A**). The RNA polymerase is free to transcribe the five genes coding for tryptophan synthesis. When tryptophan is added to the growth medium, the cells preferentially use what is available rather than expend energy to make their own amino acids. So, in the cell tryptophan binds to the repressor protein, which can now bind to the operator and block transcription by the RNA polymerase (**Figure B**). In this example, tryptophan is said to be a corepressor because

it is needed to repress or “turn off” gene transcription.

MicroInquiry 9

- 9a. Bacterial colonies on the agar plate that are not blue contain the insulin gene.
- 9b. Bacterial cells without a plasmid would not grow on the plate because only the plasmid confers resistance to ampicillin. Therefore, bacterial cells without a plasmid will be killed by the antibiotic added to the agar growth medium.

MicroInquiry 10

Case 1

- 10.1a. Often a tubercle is visible in a chest X-ray.
- 10.1b. Identification of *M. tuberculosis* by acid-fast staining from sputum usually is sufficient for a diagnosis of TB because these bacterial cells are not normally found in respiratory secretions.
- 10.1c. Skin becomes thick with a raised red welts developing within 48 to 72 hours.
- 10.1d. A tuberculin skin test does not necessarily mean the person has tuberculosis. It simply indicates the person has been exposed to *Mycobacterium tuberculosis*, been immunized recently, or had a previous tuberculin skin test.
- 10.1e. Tuberculosis; *Mycobacterium tuberculosis*.
- 10.1f. Most likely from his former roommate.
- 10.1g. Tuberculosis is more virulent in HIV-infected patients because their immune system is compromised from fighting the HIV infection.
- 10.1h. The patient was on INH for an extended period because of his HIV infection. With a lowered immune system, the patient's immune system will not mount a strong response to the TB infection. Drugs, such as INH, are the best hope for control and recovery.

Case 2

- 10.2a. *Corynebacterium diphtheriae*.
- 10.2b. Dead tissue accumulates with mucus, white blood cells, and fibrous material (pseudomembrane) in the throat. Respi-

ratory blockage can result, which can lead to death.

- 10.2c. Having the proper vaccinations, in this case the DTaP vaccine.
- 10.2d. Treatment requires both antibiotics to kill the bacterial cells and antitoxins to neutralize the diphtheria toxins.

Case 3

- 10.3a. *Streptococcus pneumoniae*.
- 10.3b. The patient's underlying medical condition (heavy smoker and alcoholic) place him at high risk for the disease.
- 10.3c. Vaccination with the pneumococcal 23-valent vaccine.
- 10.3d. Polysaccharide capsule and toxin production.
- 10.3e. Alpha-hemolytic.

MicroInquiry 12

Case 1

- 12.1a. Headache, rash on thighs, fever, hiking near Seattle.
- 12.1b. Lyme disease; *Borrelia burgdorferi*.
- 12.1c. Tick bite.
- 12.1d. Without treatment, infection can lead to an early disseminated stage characterized by meningitis, facial palsy, and peripheral nerve disorders. Joint and muscle pain also can occur.
- 12.1e. Wear protective clothing and avoid tick-infested areas. If bitten by a tick, remove whole tick and wash the skin wound with soap and water, and apply antiseptic.

Case 2

- 12.2a. *Clostridium tetani*; tetanus.
- 12.2b. Sedatives and muscle relaxants; penicillin and tetanus antitoxin.
- 12.2c. No, because symptoms develop rapidly and the patient could die waiting for lab results.
- 12.2d. If the spores entered via a foot wound, they will germinate and growth will produce dead tissue.
- 12.2e. See 12.2d.

Case 3

- 12.3a. *Rickettsia rickettsii* and *Ehrlichia chaffeensis*.
- 12.3b. *R. rickettsii*. A pink rash on palms and feet; tick bite; geography (South Carolina).
- 12.3c. Lyme disease, relapsing fever, tularemia, and ehrlichiosis.
- 12.3d. Weil-Felix test.
- 12.3e. *E. chaffeensis* does not usually cause a rash and it is associated with a lowered WBC count, not a raised count.

Case 4

- 12.4a. Gas gangrene; *Clostridium perfringens*.
- 12.4b. Anaerobic conditions, as the bacterium is an anaerobe.
- 12.4c. Debridement.
- 12.4d. Use of a hyperbaric chamber, which introduces oxygen gas into necrotic tissues. Oxygen gas will kill *C. perfringens* cells.

MicroInquiry 13

Case 1

- 13.1a. *E. coli*, *Proteus mirabilis*, *Enterobacter faecalis*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*.
- 13.1b. Due to anatomical differences. The female urethra is relatively short, proximity of urethra to anus.
- 13.1c. Infections of the urethra, bladder, and possibly the kidneys.
- 13.1d. Avoiding tight-fitting clothes and urinating as soon after intercourse as possible.
- 13.1e. Biofilms are a key factor. Bacteria are protected from immune attack by a slimy coating. The coating also makes antibiotic therapy difficult since the drug does not penetrate the biofilm.

Case 2

- 13.2a. *Chlamydia trachomatis* and *Neisseria gonorrhoeae*. Chlamydia.
- 13.2b. *C. trachomatis* is an obligate pathogen and only grows in tissue culture. The reproductive cycle is described in the chapter.

- 13.2c. Laboratory tests include the use of fluorescent antibodies on a cervical swab or an immunoassay test.
- 13.2d. A *C. trachomatis* infection can be spread to others through sexual intercourse.
- 13.2e. Recovery from a gonorrhea infection does not generate life-long immunity because of the weak immune response to the bacterium.

Case 3

- 13.3a. *Pasteurella multocida*.
- 13.3b. Cat bite, swollen and painful wrist, tenderness at the site, small puncture wound, and small abscess. Gram-negative rods.
- 13.3c. The pharynx.
- 13.3d. Limiting contact with the animal and washing the site thoroughly.

Case 4

- 13.4a. Gonorrhea; *Neisseria gonorrhoeae*.
- 13.4b. Gonorrhea can be spread by sexual intercourse. Complications in females include salpingitis and pelvic inflammatory disease.
- 13.4c. HIV, syphilis, and chlamydial infections, because they all are sexually transmitted diseases.
- 13.4d. Although these are additional signs of gonorrhea in males, the infection has not affected these tissues.
- 13.4e. Ceftriaxone, or cefixime.

MicroInquiry 14

- 14.1a. 10 hours. During this time, the viral nucleic acid is being replicated and new capsid parts are being synthesized.
- 14.1b. 15 hours. During this time, the viral nucleic acid is being replicated, new capsid parts are being synthesized, and nucleic acid and capsids are being assembled into new virions (maturation stage).
- 14.1c. 10^8 virions are released from 10^5 cells in culture. Therefore, the burst size is 10^3 virions per infected cell.
- 14.1d. The decline reflects the loss of phages as they are slowly taken into host cells.

MicroInquiry 16

Case 1

- 16.1a. Hepatitis C; hepatitis C virus.
- 16.1b. History of oral drug abuse suggests he overdosed on an over the counter drug that lead to the symptoms of nausea, vomiting, fever, headache, and abdominal pain. The slight jaundice and upper right quadrant discomfort, along with negative HBsAg and serum antibodies to HAV, suggest hepatitis C.
- 16.1c. This is indicative of liver damage, which would be the infection site for the virus.
- 16.1d. Being a drug user, contaminated needles are the probable source.
- 16.1e. Most likely hepatitis B and HIV, both of which can be transmitted by contaminated needles.

Case 2

- 16.2a. Infectious mononucleosis; Epstein-Barr virus.
- 16.2b. Some of the symptoms (sore throat, fever) could have been due to a strep infection.
- 16.2c. The elevated B lymphocyte count is because the Epstein-Barr virus infects B lymphocytes and the immune system is attempting to replace the damaged cells.
- 16.2d. Heart defects, paralysis of the face, and rupture of the spleen.
- 16.2e. Burkitt's lymphoma. The malarial parasite may stimulate tumor development.

Case 3

- 16.3a. Hepatitis A and E.
- 16.3b. Hepatitis A because of the jaundice, short incubation period, initial symptoms, and travel history.
- 16.3c. A transmission route could be from contaminated water or food eaten at local restaurants.
- 16.3d. Hepatitis A antibodies in serum.
- 16.3e. Administering hepatitis A immune globulin.

Case 4

- 16.4a. Dengue fever.
- 16.4b. Clues included, fever, backache, headache, bone and joint pain, and eye pain.

Her trip to Bangladesh (where Dengue is prevalent) and mosquito bites also were clues.

- 16.4c. Four strains of the virus are known.
- 16.4d. She has a viral disease for which antibiotics are useless.
- 16.4e. Returning to Southeast Asia puts her at risk of being infected by another strain of dengue virus, which could lead to a severe or deadly illness called dengue hemorrhagic fever.

MicroInquiry 17

- 17.1. Fungi are more closely related to the animals because they share many more characteristics with the animals than they do with the plants.
- 17.2. See figure 18.2 and connect the fungi with Figure 17.10.

MicroInquiry 19

- 19.1a. Approximately 110,000 cases in 1993 and 45,000 cases in 2003.
- 19.1b. Prevalence: 1993 = 0.09%; 2003 = 0.13%.
- 19.2a. Continuous common source epidemic. Plateau indicates person-to-person transmission.
- 19.2b. Possibly three plateaus, suggesting spread within different communities or groups of individuals.
- 19.3a. Reported cases are clustered in the Northeast states and upper Midwest. Fewer cases in Eastern and Pacific states.
- 19.4a. Highest number of cases in infants less than 1 year old, with higher incidence in 10–14 and 15–19 age groups.
- 19.4b. Vaccinations would eliminate the high numbers of infant cases, and booster shots would reduce the cases in all age groups.

MicroInquiry 22

- 22.1a. ELISA is a serological test for the presence of antibodies or antigens in serum. In your case, Pat, the hepatitis C kit will assay for the presence or absence of hepatitis C antibodies in the blood sample you sent.

22.1b. To make sure all the reagents are functioning properly, positive and negative controls are run along with your blood sample. A positive control contains antibodies specific to hepatitis C antigen so a positive color reaction will be produced. A negative control lacks hepatitis C antibodies, so no color reaction will develop.

- 22.1c. If your blood sample tests positive, it means you are seropositive. That is, your blood contains anti-HCV antibodies.
- 22.1d. A seronegative result would mean you are “probably” not infected with HCV. However, you still should be retested in six months because sometimes it can take that long for the immune system to produce enough antibodies to be detected by ELISA.
- 22.1e. Do another HCV test in six months. Even if that one is positive, lab errors or some other infection may mimic an HCV antigen. If that ELISA test proves positive, another type of test, called a Western blot, is run that detects the actual presence of HCV in your blood. If all tests come back positive, then I am afraid you are infected with the microbe because when ELISA is used with the Western blot, the results are more than 99.9% accurate.

MicroInquiry 24

- 24.1a. Self-explanatory.
- 24.1b. The drug appears most effective against *S. aureus* as seen by the large rings where growth was inhibited. The drug looks promising against *S. aureus*.
- 24.1c. The drug looks good at 10 µg but not at 100 µg. Need to do intermediate concentration tests.
- 24.1d. The control was to make sure there wasn't something in the solution used to dissolve the drug that could cause an adverse cellular effect. Drug testing should continue.
- 24.2a. A concentration somewhere between 100 mg and 1,000 mg was toxic to the animals. Need to test intermediate

concentrations to narrow down the toxicity range.

24.2b. Self-explanatory.

24.3. There are pros and cons to this decision. For example, without a control group, it might not be possible to accurately evaluate the efficacy of the drug. On the other hand, if early drug trials show obvious benefit, the control group could be given the drug. Discuss with classmates.

MicroInquiry 25

25.1. Your refrigerator should be kept at 5° C (41° F). Although this temperature will not kill most microbes, it will slow their growth, making it less likely you might spread or could get sick from food stored there.

25.2. Freezing also does not kill all microbes. So, foods like frozen chicken should not be set on the counter to defrost. You risk illness as bacteria grow rapidly at room temperature. **Microwaving the food following package directions or thawing it in the refrigerator will keep any microbes from growing.** Incidentally, that kitchen sponge you used to clean up spilled food juices should be rinsed and sanitized by microwaving it for 20 seconds.

25.3. Raw foods can be contaminated with several disease-causing microbes that can cling to a cutting board. So, **clean that board with soap and hot water and then sanitize it with a mild bleach solution** (or put it in the dishwasher).

25.4. **Wash your hands with soap and warm water for about 20 seconds** so you don't deposit harmful bacteria on other surfaces. Also, keep tabby away from kitchen counters and where food is being prepared. Pets carry and spread diseases to foods.

25.5. Your sink drain and garbage disposal can harbor several species of viruses and bacteria. Some sinks can contain more bacteria than in a flushed toilet. So, **every week you should sanitize your drain: pour a solution of 1 teaspoon**

of chlorine bleach in 1 quart of water down the drain.

25.6. In the oven, the high temperatures used in cooking kill microbes. However, **cooled leftovers should be refrigerated within two hours after cooking.** Once refrigerated, they are safe to eat for three to five days.

25.7. Did you clean your kitchen counters after preparing raw food? **Hot, soapy water and dilute chlorine bleach are recommended.** Hot water and soap alone do not get rid of all possible bacteria.

25.8. Meats should be cooked until there is no red seen and the juices run clear. **Well-done meats that reach 160°F kill foodborne microbes.** Meats and other improperly cooked foods can retain food-borne microbes.

25.9. Most kitchen sponges contain some bacteria that can make people sick. In one study, 20% of sponges and dishrags collected from many of the 1,000 kitchens tested in five American cities contained *Salmonella* bacteria, which can cause food poisoning, typhoid fever, and gastrointestinal diseases. **So, microwave that damp kitchen sponge for 20 seconds and wash dishrags.** Also, change to a new sponge often or use a germ-resistant sponge.

25.10. Now that dinner is over, what to do with the dishes? Don't soak them for several hours because the soaking water becomes "nutrient broth" for bacteria. **Either wash them in the dishwasher and air-dry them, or wash them within two hours in hot, soapy water and let them air-dry.**

MicroInquiry 26

26.1. Provides a richer growth medium, ensuring the growth of coliforms, if present.

26.2. Do not want to introduce any contaminating bacteria. It is unlikely that pipettes would contain coliforms.

26.3. Sample 4 appears to contain high numbers of coliforms. For this sample, the

presumptive test read 5–4–5, indicating an MPN of 430 per 100 ml (confidence limits of 150–1,100 organisms).

- 26.4. Double-check on the presumptive test results.
- 26.5. Sample 4 and possibly sample 6 (MPN 14).
- 26.6. Close off the area of the lake where sample 4 was collected until further testing indicates the water again is safe. Also, investigate the cause for the high coliform numbers.

MicroInquiry 27

- 27.1a. Identify or genetically engineer bacterial species that can break down the thick crude into lighter forms.
- 27.1b. There are bacterial species that are known to produce enzymes that break down sulfur compounds into water-soluble products while other bacterial species can remove heavy metal contaminants. Since each oil field is slightly different in terms of the heavy crude, different “bacterial cocktails” may be needed. In some cases, this probably would require genetic modifications to give the microbes the precise genes to deal with crude-oil digestion. However, if the right mix of bacterial species can be assembled, the result could be a lighter, cleaner crude for refining.
- 27.2. Chemolithotrophic (“rock-eating”) bacterial species represent groups that

survive by using inorganic compounds (minerals) in rocks as their source of nutrients and energy. Bacterial species associated with iron pyrite break the minerals into acidic solutions of iron that then can be used to dissolve out usable forms of copper. Also, using natural bacterial species or genetically engineered ones, it may become possible to convert low-grade ores into a sustainable yield of metals for the future.

- 27.3. Contaminated soil was excavated and only mineral nutrients had to be added for growth since indigenous microorganisms already existed in the soil. Such biostimulation was performed from December 1989 through September 1991, and approximately 16,000 tons of soil were treated. Through bioremediation, PAH concentrations were reduced by 70%.
- 27.4. From January 1992 through November 1993, approximately 300,000 tons of sediment and subsoil from the lagoon were treated using the indigenous microorganisms that were biostimulated with added oxygen and growth nutrients. The bioremediation process achieved the specified soil cleanup goals for the contaminants within 11 months of treatment. For example, benzene levels were reduced from 608.0 mg/kg to 4.4 mg/kg.