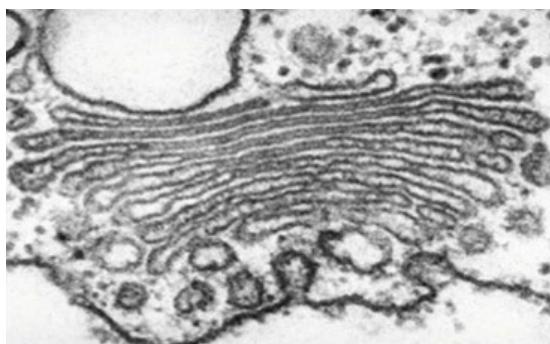


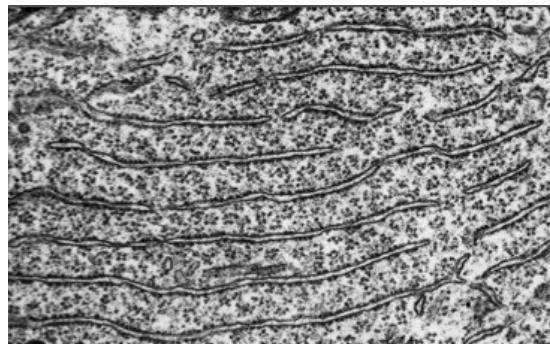


**2023-24 ARCHIMEDEAN SATELLITE INVITATIONAL**  
**MICROBE MISSION - KEY**

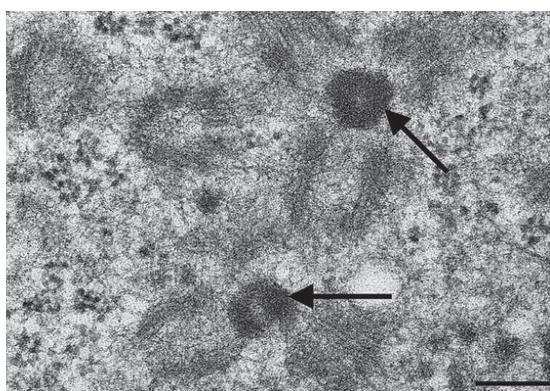
The following images will be used for questions 1-6:



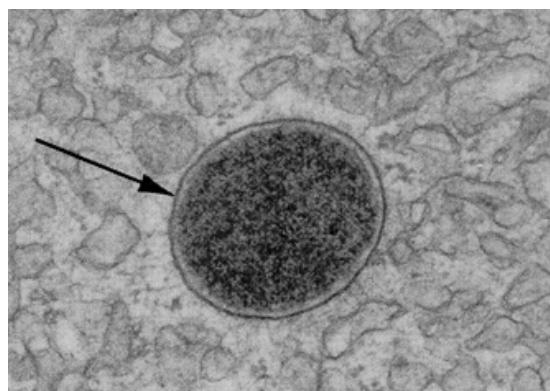
A



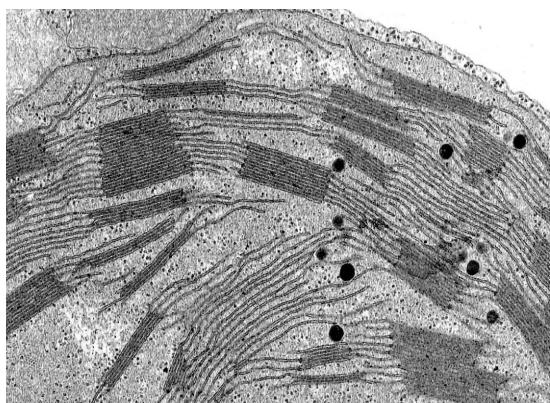
B



C



D



E

1. Which micrograph displays the organelle that is responsible for breaking down waste and bacteria?
  - A. A
  - B. B
  - C. C
  - D. D**

- E. E
2. Which micrograph displays the organelle that is responsible for processing and preparing proteins for transport?
- A. A
- B. B
- C. C
- D. D
- E. E
3. Which micrograph displays the organelle that is responsible for production of ATP and O<sub>2</sub>?
- A. A
- B. B
- C. C
- D. D
- E. E
4. Which micrograph displays the organelle that is responsible for organizing organelles?
- A. A
- B. B
- C. C
- D. D
- E. E
5. Which micrograph displays the organelle that is responsible for protein synthesis, folding, and modification?
- A. A
- B. B
- C. C
- D. D
- E. E
6. Which organelles are included in the endomembrane system? Select all that apply.
- A. A
- B. B
- C. C
- D. D
- E. E

F. All of the above

Read the following case report:

A 30-year-old pre-school teacher comes into the doctor's office. She reports that she has been having extreme fatigue and nausea. Additionally, she has been having frequent diarrhea, loose stools, and has experienced bloating and rapid weight loss. She remembers having previously eaten 12 containers of yogurt before her symptoms began (they were buy-one-get-one free, she couldn't resist), having met with a friend visiting from abroad, and having a few children with similar symptoms in her class.

Based on your knowledge and the information provided, answer the following questions:

7. What disorder does the patient have?

**giardia**

8. What microbe causes this disorder?

**giardia duodenalis**

9. What may have caused the patient to contract this disorder?

**working at the pre-school puts the teacher in contact with students who may have been sick with giardia; the friend visiting from abroad may have also exposed her to the disease; one of the containers of yogurt she ate could have been handled by someone with the disorder.**

10. Write and number the steps of performing a gram stain.

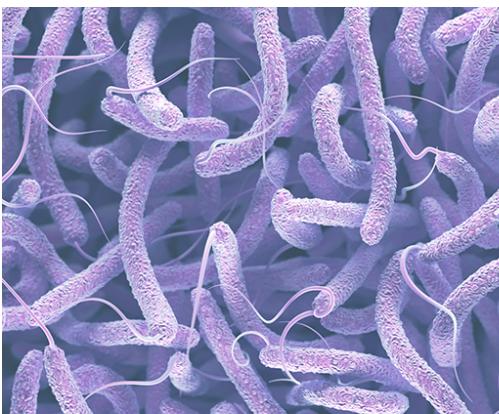
- 1. apply a primary stain (crystal violet) and rinse with water.**
- 2. add a mordant (gram's iodine) and incubate.**
- 3. rapid decolorization with ethanol, acetone or a mixture of both and rinse with water.**
- 4. counterstain with safranin and rinse with water.**

11. What will be the difference between the gram negative and gram positive bacteria after the procedure?

**if the bacteria stays purple, they are gram-positive. if the bacteria turns pink or red, they are gram-negative.**

Questions 12-16 will provide images of different microbes. For each, name the microbe and the disease it causes.

12.



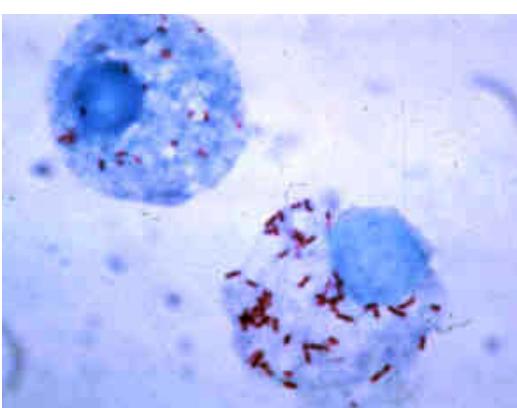
**vibrio cholerae; cholera**

13.



**mycobacterium tuberculosis; tuberculosis**

14.



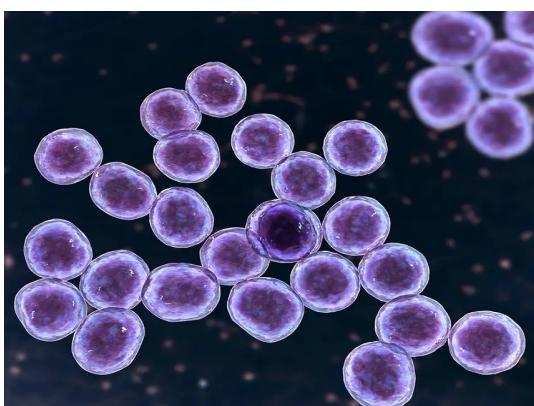
**rickettsia rickettsii; rocky mountain spotted fever**

15.



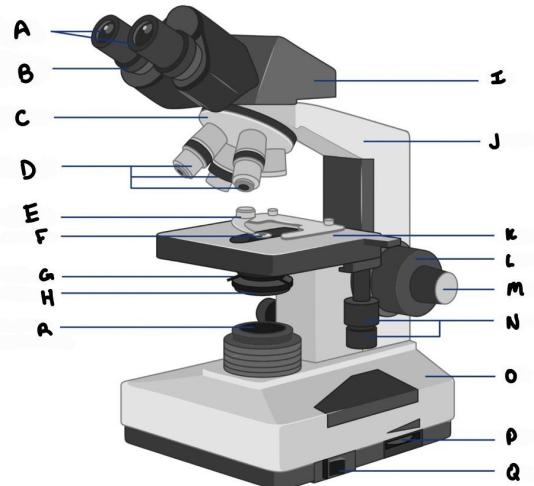
**alternaria solani; early blight**

16.



**staphylococcus aureus; staph infection**

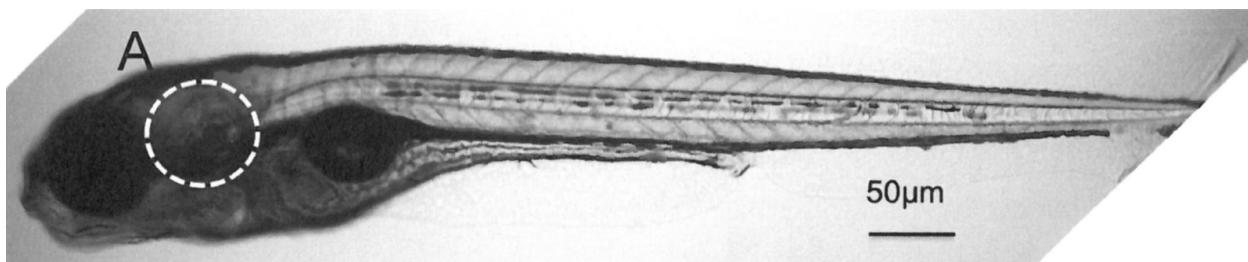
Use the following diagram for questions 17-24:



17. Label parts A, B, and C  
**ocular lens (eye piece); diopter adjustment; nose piece**
18. Label parts D, E, and F  
**objective lens; stage clip; aperture**
19. Label parts G, H, and I  
**diaphragm; condenser; head**
20. Label parts J, K, and L  
**arm (carrying handle); mechanical stage; course adjustment**
21. Label parts M, N, and O  
**fine adjustment; stage controls; base**
22. Label parts P, Q, and R  
**brightness adjustment; light switch; illuminator (light source)**
23. Which type of microscope is most suitable for observing various microbes in pond water?  
**compound light**
24. Which type of microscope is most suitable for examining the surface of a virus?  
**scanning electron**
25. What is a downside to using a transmission electron microscope to observe organisms?  
**the organism will not be living, the images are in black and white, the images are 2D, it is expensive to use, etc.**
26. Explain the life cycle of *alternaria solani*, making sure to number each step.  
**1. mycelium and conidia overwinter in infected plant debris or on volunteers and/or weedy hosts.  
2. collar rot of seedling  
3. conidiophores and conidia produced from mature lesions  
4. conidia dispersal by wind and rain splash  
5. conidia germinate in presence of free moisture  
6. lesions on leaf, stems, and fruit**
27. Define the following terms:  
a. Acidophile: **an organism that thrives under highly acidic conditions (pH < 3).**

- b. Piezophile: **an organism with optimal growth under high hydrostatic pressure (at or below 10 MPa).**
  - c. Xerophile: **an organism with the ability to grow in extremely dry conditions or in the presence of very low water activity.**
  - d. Polyextremophile: **an organism that can survive in two or more extreme environmental conditions.**
  - e. Psychrophile: **an organism with the ability to grow and reproduce under low temperatures ( $-20^{\circ}\text{C}$  to  $10^{\circ}\text{C}$ ).**
  - f. Microaerophile: **an organism that requires environments containing lower levels of oxygen than the atmosphere for optimal growth (2-10%).**
28. Compare adherent vs. suspension culturing.  
**in adherent cell culture, cells are grown while attached to a substrate as monolayers.**  
**in suspension cell culture, cells are free floating in the culture medium.**
29. What is one industrial application/use of Lactobacillus? Be sure to explain how it is used in its application.  
**answers vary depending on application chosen. (e.g. production of cheese; can be used as a starter culture to quickly produce acid by converting lactose into lactic acid and make curd).**

Questions 30 and 31 use the image and the information provided below



Shown here in 'A' a zebrafish larva, a common model for bacterial infections. The area circled in white is the otic vesicle, or the zebrafish ear. Assume that the zebrafish ear is a perfect sphere with a volume of  $1 \times 10^5$  cubic microns.

30. If a zebrafish researcher wanted to fill the zebrafish otic vesicle completely with *Streptococcus pneumoniae*, how many bacteria should be injected into the ear, assuming that a single *S. pneumoniae* bacterium is 2 micron in diameter? Give your answer in scientific notation.

**2.3x10<sup>4</sup> < x < 2.5x10<sup>4</sup> bacteria**

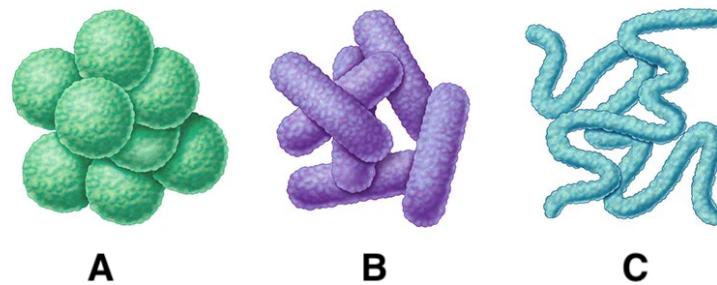
31. If you have a culture tube with *S. pneumoniae* at a concentration of  $1 \times 10^8$  bacteria/mL, how many mL would you need to inject into the fish's ear? Give your answer in scientific notation. Given this number, should you dilute or concentrate your bacterial stock to make it easier to work with?

**2.3x10<sup>-4</sup> mL; dilute**

32. What are the 2 main glycoproteins on the influenza virion?

**hemagglutinin (HA) and neuraminidase (NA)**

33. Name the three variations of bacteria pictured:



- A. cocci**
- B. bacilli**
- C. spirochetes**

34. What are the diagnostic pathological features of Creutzfeld-Jakob disease?

**Multiple florid plaques in hematoxylin and eosin sections; numerous small cluster plaques in prion protein-stained sections; and amorphous pericellular and perivascular prion protein accumulation in the cerebral and cerebellar cortex.**

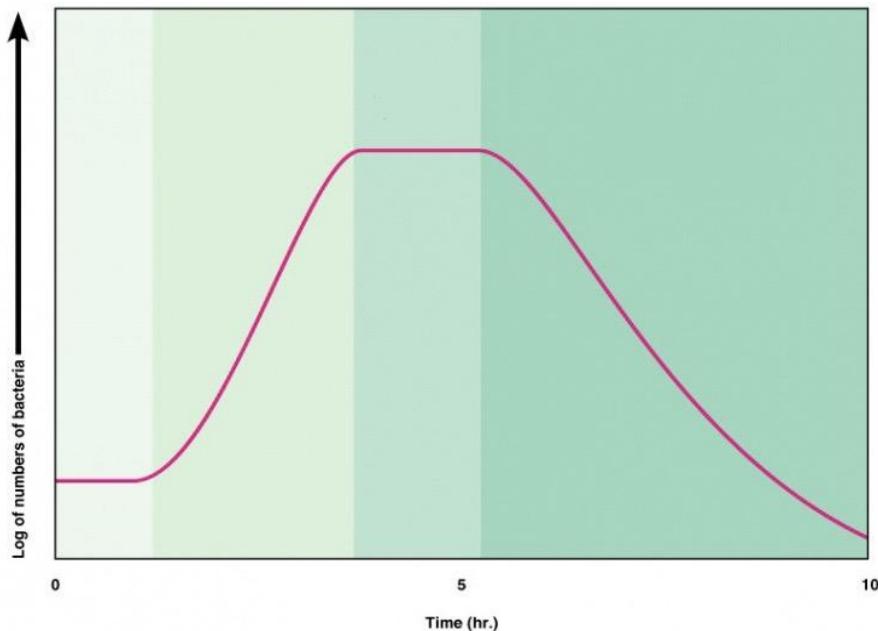
35. Provide a step-by-step (numbering each step) description of how an individual may contract Bovine Spongiform Encephalopathy.

- 1. a cow becomes infected with the abnormal prion indirectly through a contaminated environmental source (e.g. soil, food, or water) or through direct contact.**
- 2. other cows become infected through feed containing parts from an infected cow.**
- 3. the newly infected cow is used for food.**
- 4. a human comes in contact with these beef products from the infected cow and consumes them.**
- 5. the spinal cord and brain degenerate over time as the prions transmitted continue to infect the body.**

36. Which of the following places the listed tapeworms in the correct order of increasing length?

- A. Whipworm, Roundworm, Hookworm, Tapeworm
- B. Whipworm, Tapeworm, Hookworm, Roundworm
- C. Roundworm, Hookworm, Tapeworm, Whipworm
- D. Roundworm, Whipworm, Hookworm, Tapeworm**

The diagram below corresponds to questions 37-41:



37. From left to right, list the proper terminologies for each colored section of the graph, separating each response with a comma.

**lag phase, log/exponential growth phase, stationary phase, death/logarithmic decline phase**

38. What is happening in the first phase of the diagram and why does the graph appear the way it does?

**the bacteria are adapting to their growth conditions, increasing in size, synthesizing proteins, enzymes, and rna, and repairing damage. the graph appears flat because they have not yet begun dividing.**

39. What is happening in the second phase of the diagram and why does the graph appear the way it does?

**cells are dividing by binary fission and the doubling of each generation causes the exponential growth seen.**

40. What is happening in the third phase of the diagram and why does the graph appear the way it does?

**the rate of bacterial growth is equal to the rate of cell death, meaning that the number of bacterial cells stops increasing. This is why we begin to see the graph leveling out.**

41. What is happening in the last phase of the diagram and why does the graph appear the way it does?

**waste slowly begins to build up and nutrient rich media is depleted, causing the cells to stop their metabolic functions and begin dying, causing a downward trend in bacterial growth.**

42. List and describe the steps of lytic and lysogenic virus replication.

**lytic replication:**

- 1. attachment: the virus attaches to the host by binding to receptors on the host's surface.**
- 2. penetration: the virus injects its DNA into the host cell by puncturing a hole in the cell membrane.**
- 3. biosynthesis: the virus replicates its DNA and produces proteins.**
- 4. maturation: the virus assembles around the phage genomes.**
- 5. release: the mature virus bursts out of the host cell.**

**lysogenic replication:**

- 1. the phage infects a cell.**
- 2. the phage dna becomes incorporated into the host genome.**
- 3. the cell divides and prophage dna is passed on to daughter cells.**
- 4. under stressful conditions, the prophage dna is excised from the bacterial chromosome and enters the lytic cycle.**
- 5. phage dna replicates and phage proteins are made.**

- 6. new phage particles are assembled.**
- 7. the cell lyses, releasing the newly made phages.**

43. For which of the following organisms would antibiotics be effective ?
- A. Influenza B
  - B. *Staphylococcus aureus***
  - C. Varicella-zoster
  - D. Nematode
44. Which organism is the primary cause of food poisoning from canned foods?
- A. Varicella
  - B. *Clostridium botulinum***
  - C. Vibrio Cholerae
  - D. Alternaria Solani
45. What bacterial stage of development is believed to be responsible for bacteria being able to resist harsh environmental conditions?
- Sporulation**
46. Which of the following is not true about viruses?
- A. Antibiotics are ineffective against them
  - B. They can only contain RNA**
  - C. Viruses release virions during cell lysis and budding
  - D. Are obligate intracellular parasites
47. What part of the influenza virus does the flu vaccine recognize?
- A. DNA
  - B. Capsid
  - C. Surface protein**
  - D. Peptidoglycan
48. List three examples of microbial usage in food production.
- examples may include: beer, kimchi, soy sauce, cheese production, ...**
49. Why can algal blooms be dangerous for aquatic environments?
- deoxygenation, blocking out sunlight, toxins, etc.**
50. Which microbial process is responsible for the conversion of sugar into alcohol and carbon dioxide?

**A. Fermentation**

- B. Photosynthesis
- C. Respiration
- D. Mitosis

51. What is the term for a protective structure formed by bacteria that allows them to survive harsh environmental conditions?

**A. Capsule**

- B. Nucleus
- C. Chloroplast
- D. Endoplasmic reticulum

52. Which of the following diseases is caused by a virus?

- A. Tuberculosis

- B. Cholera

**C. Influenza**

- D. Lyme disease

53. In microbiology, what is the significance of a plasmid?

- A. It is a component of the bacterial cell wall

**B. It carries genes that may provide advantages, such as antibiotic resistance**

- C. It is involved in photosynthesis

- D. It is a structure for locomotion in bacteria

54. Which of the following is an example of a Gram-negative bacterium?

- A. Staphylococcus aureus

**B. Escherichia coli (E. coli)**

- C. Streptococcus pneumoniae

- D. Bacillus subtilis

55. What is the process by which bacteria exchange genetic material through direct cell-to-cell contact?

**A. Conjugation**

- B. Transformation

- C. Transduction

- D. Replication

56. In microbial ecology, what is the term for a relationship between two organisms where one benefits, and the other is neither helped nor harmed?

- A. Mutualism

**B. Commensalism**

- C. Parasitism
- D. Amensalism

57. Which enzyme is responsible for the synthesis of complementary DNA (cDNA) from RNA templates in reverse transcription?

- A. DNA polymerase
- B. RNA polymerase

**C. Reverse transcriptase**

- D. Ligase

58. Which of the following is an example of an obligate anaerobe?

- A. Escherichia coli
- B. Streptococcus pyogenes

**C. Clostridium botulinum**

- D. Pseudomonas aeruginosa

59. What is the significance of quorum sensing in microbial communities?

- A. Regulation of gene expression based on population density**
- B. Energy production through photosynthesis
- C. Antibiotic resistance
- D. Cellular respiration

60. Which microbial process is responsible for the fixation of atmospheric nitrogen into a usable form?

- A. Denitrification
- B. Nitrification

**C. Nitrogen Fixation**

- D. Nitrogenation

61. What is the difference between vertical and horizontal gene transfer?

**vertical gene transfer occurs from parent to offspring in a hierarchical manner, while horizontal gene transfer involves the exchange of genetic material between organisms, potentially unrelated in a familial sense.**

62. Which microbial process involves the exchange of genetic material through the uptake of free DNA from the environment by a bacterial cell?

- A. Transduction

**B. Transformation**

- C. Conjugation

- D. Transposition
63. Which microbial structure is involved in the attachment of bacteria to surfaces and the formation of biofilms
- A. Flagellum
  - B. Pilus**
  - C. Capsule
  - D. Ribosomes
64. What is the primary role of bacteriophages in the context of microbial ecosystems?
- A. Nitrogen fixation
  - B. Predation on bacteria**
  - C. Decomposition of organic molecules
  - D. Plant symbiosis
65. What is the primary advantage of sexual reproduction over asexual reproduction in microbial populations?  
**increasing genetic diversity or a more resilient population**