

2025 USC Invitational Tournament

Microbe Mission B Test Packet



Welcome to Microbe Mission B! **Please wait until instructed to start the test!**

- **Please do not write on this test packet!**
- The test has a total of 4 sections of a mix of multiple choice and short answer questions for a total of 54 questions, and you will have 50 minutes to complete it!
- You are allowed two Class II calculators and one 8.5x11" cheat sheet per team
- You may remove the staple, but you must rearrange the test packet in the correct order
- All multiple choice questions are worth 1 point while short answers have specified point values
- Select all that apply questions will have 2-4 answers and are all or nothing
- Tiebreakers Order of Priority: 49, 50, 22, 11, 39, 16, 20, 44, 32, 3
- Good luck and have fun!

DO NOT WRITE ON THIS PACKET!

Section 1: Microscopes, Staining, and Morphology

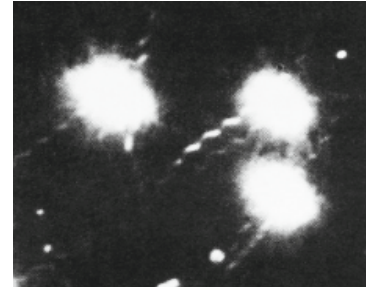
1. Which microscopy technique produced the image below?

- A) Bright Field
- B) Dark Field
- C) Phase Contrast
- D) Scanning Electron
- E) Transmission Electron



2. Which microscopy technique produced the image on the right?

- A) Bright Field
- B) Dark Field
- C) Phase Contrast
- D) Scanning Electron
- E) Transmission Electron

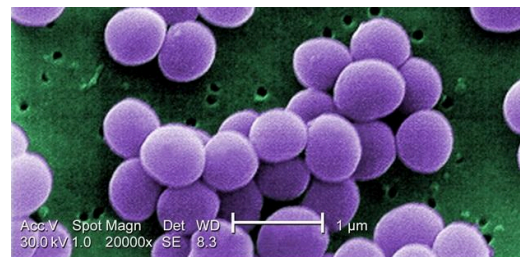


3. Comparing the microscopy techniques from the previous two questions, what are notable differences between the techniques?

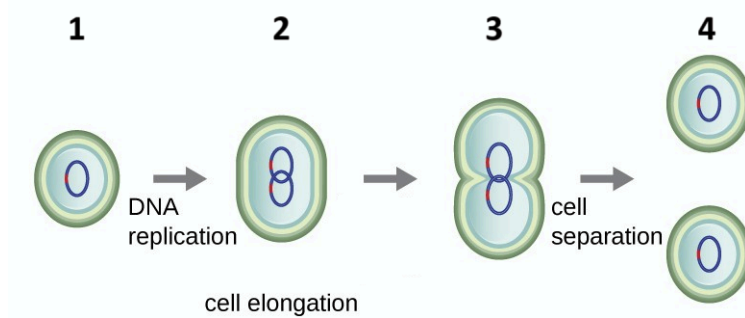
- A) Question 1's technique creates a bright halo surrounding the cell, while Question 2's technique passes polarized light through a prism, generating two distinct beams of light, which are recombined after passing through cells to create a 3D image
- B) Question 1's technique allows for live cell viewing, while Question 2's technique requires the cells to be fixed
- C) Question 1's technique funnels electrons into cells to make out organelles, while Question 2's technique funnels light through the specimens on a dark background
- D) Question 1's technique requires the coating of the cell with an electrical-coating metal like gold, while Question 2's technique utilizes fluorescent staining
- E) Question 1's allows for live visualization of intracellular organelles while Question 2's allows for visualization of small features, such as flagella, through contrast

4. Select all that apply: which of the following descriptions best describes the bacteria on the right?

- A) Bacillus
- B) Cocci
- C) Vibrio
- D) Staphylococcus
- E) Streptococcus



Use the following image of binary fission to answer the following questions.



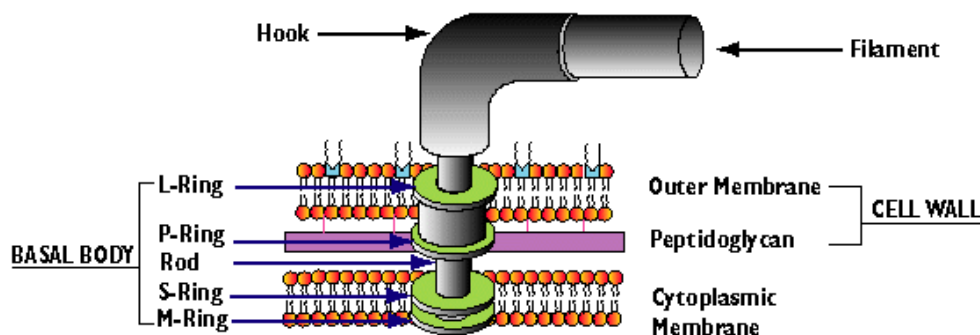
5. What is the purpose of binary fission?
 - A) Development of multicellular organisms from prokaryotes
 - B) Endosymbiotic dissolution
 - C) Lysis of bacterial cells into two
 - D) Metabolism of nucleic acids and proteins
 - E) Reproduction of bacteria into two identical daughter cells

6. If a bacteria has a dysfunctional DnaA, what step of binary fission (as numbered in the image) would it be paused on?
 - A) Step 1
 - B) Step 2
 - C) Step 3
 - D) Step 4
 - E) Binary fission would still be functional

7. What step of binary fission (as numbered in the image) is the division septum fully formed by the FtsZ complex?
 - A) Step 1
 - B) Step 2
 - C) Step 3
 - D) Step 4
 - E) Binary fission does not form a division septum

8. What step of binary fission (as numbered in the image) does the mitotic spindle separate chromosomes?
 - A) Step 1
 - B) Step 2
 - C) Step 3
 - D) Step 4
 - E) Binary fission does not utilize a mitotic spindle

Use the image of an embedded organelle in a gram negative bacterial envelope to answer the following questions.



9. What is the embedded organelle depicted in the image?
 - A) Eyespot
 - B) Fimbria
 - C) Flagella
 - D) Pilus
 - E) Spirochochete
10. What is the function of this embedded organelle?
 - A) Horizontal Gene Transfer
 - B) Infectivity
 - C) Transmembrane Nutrient Shuttling
 - D) Motility
 - E) Replication
11. Select all that apply: what components would not be present in a gram positive bacteria?
 - A) Filament
 - B) Hook
 - C) L ring
 - D) Outer Membrane
 - E) Peptidoglycan
12. What component in the image would be significantly thicker in gram positive bacteria?
 - A) Cytoplasmic Membrane
 - B) L ring
 - C) Outer Membrane
 - D) Peptidoglycan
 - E) P ring

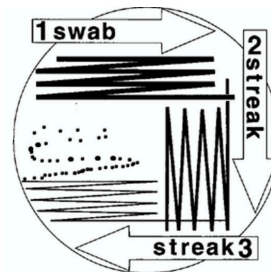
Section 2: Spoiled Milk

You find that your milk in the refrigerator is spoiled due to bacteria. In hopes of identifying the bacterial culprit you perform several tests to identify its properties. All questions in this section refer to this scenario.

13. Based solely on the bacteria's preference for low temperatures, what term best describes it?
- A) Acidophile
 - B) Alkaliphile
 - C) Halophile
 - D) Psychrophile
 - E) Thermophile
14. What adaptations would you expect this bacteria to have?
- A) Proteins with less alpha helices
 - B) Proteins with a larger proportion of beta sheets
 - C) Higher unsaturated fatty acid chain proportion in membrane for fluidity
 - D) Higher long fatty acid chain proportion in membrane for rigidity
 - E) Na⁺ driven ATP production as opposed to H⁺
15. During a gram stain, gram positive bacteria stain ____ and gram negative bacteria stain ____.
- A) pink; pink
 - B) pink; purple
 - C) purple; pink
 - D) purple; purple
 - E) colorless; pink
16. During a gram stain, you accidentally skip the iodine treatment step. Under this incorrect procedure, you would expect gram positive bacteria to stain ____ and gram negative bacteria to stain ____.
- A) pink; pink
 - B) pink; purple
 - C) purple; pink
 - D) purple; purple
 - E) colorless; pink
17. You are unsure about the nutritional conditions needed to culture this bacteria, but you hope to grow some bacteria to plate. What type of medium should you use to culture the bacteria?
- A) Complex Media
 - B) Defined Media
 - C) Differential Media
 - D) Selective Media
 - E) Water

18. You use the streak method and an inoculation loop to spread the bacteria on a plate (depicted on the right). Between each use, you flame the loop. What is the purpose of this streak and flame method?

- A) Creates neat patterns on the plate
- B) Prewarm the bacteria to increase growth
- C) Sterilize the loop to isolate single colonies
- D) To evenly spread the bacteria
- E) Flaming is incorrect because it kills bacteria between use



19. After isolating and culturing a single colony, you replate it on a type of MacConkey agar that has beef extract, lactose, a pH indicator that turns red in acidic pHs, and crystal violet that inhibits gram positive bacteria growth. The agar turns red and colonies grow. What is the bacteria's metabolic strategy?

- A) Chemoautotroph and Lactic Acid Fermentation
- B) Chemoheterotroph and Lactic Acid Fermentation
- C) Photoautotroph and Photosynthesis
- D) Photoheterotroph and Lactic Acid Fermentation
- E) Gram negative and Photosynthesis

20. Select all that apply: The MacConkey agar described is an example of what type(s) of media?

- A) Complex Media
- B) Defined Media
- C) Differential Media
- D) Selective Media
- E) Solid Media

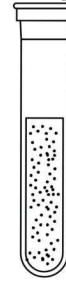
21. Before plating the bacteria, you perform four serial dilutions of 1:10. After plating 0.05 ml you end up with 50 colonies. Calculate the colony forming units (CFUs) per ml.

- A) 10,000,000 CFUs/ml
- B) 1,000,000 CFUs/ml
- C) 500,000 CFUs/ml
- D) 10,000 CFUs/ml
- E) 1,000 CFUs/ml

22. Before plating the bacteria, you perform four serial dilutions of 1:10. After plating 0.05 ml you end up with 50 colonies. Calculate the number of colony forming units in 4 ml of media.

- A) 40,000,000 CFUs/ml
- B) 4,000,000 CFUs/ml
- C) 2,500,000 CFUs/ml
- D) 400,000 CFUs/ml
- E) 25,000 CFUs/ml

23. Using your knowledge of the bacteria's metabolic strategy and the image on the right, determine the oxygen needs of this bacteria. (The image on the right displays the bacteria in a tube culture exposed to oxygen; consider the position and density of the bacteria in the culture tube)



- A) Obligate aerobic (requires oxygen; lack of oxygen is lethal)
 - B) Facultative aerobic (oxygen improves growth)
 - C) Microaerophilic (low levels of oxygen are needed for growth)
 - D) Aerotolerant anaerobic (oxygen has no effect on growth)
 - E) Obligate anaerobe (oxygen is harmful to growth)
24. As you culture the bacteria in a tube, you notice four phases of growth. What are the phases in order?
- A) Lag phase → Stationary phase → Exponential phase → Death phase
 - B) Lag phase → Exponential phase → Stationary phase → Death phase
 - C) Stationary phase → Exponential phase → Lag phase → Death phase
 - D) Stationary phase → Lag phase → Exponential phase → Death phase
 - E) Exponential phase → Death phase → Lag phase → Death phase
25. Upon the addition of maltose (a second sugar) into the initial culture, you notice a second exponential phase. What is this phenomenon called?
- A) Binary fission
 - B) Cryptic growth
 - C) Diauxic growth
 - D) Non-uniform growth
 - E) Synchronous growth
26. What is the purpose of 16S amplicon sequencing?
- A) Identify the species of fungi present in a sample
 - B) Isolation of bacterial clones
 - C) Determine what viral DNA/RNA is present in a sample
 - D) Profile microbial communities in terms of diversity, composition, and relative abundance
 - E) Proteomics technique to identify protein diversity
27. If you were to perform 16S amplicon sequencing on the bacteria in the spoiled milk, how would you expect the alpha diversity to differ between the milk sample and a single isolated colony culture?
- A) Alpha diversity of the milk sample will be higher
 - B) Alpha diversity of the single isolated colony culture will be higher
 - C) Alpha diversity of both samples will be equal
 - D) Alpha diversity is not obtainable from 16S amplicon sequencing
 - E) Not enough information

Section 3: Field Work (Metabolism, Evolution, and Ecology)

28. A bacteria produces bacteriocin to kill neighboring bacteria to increase the nutrients available for itself.

What best describes this relationship?

- A) Competition
- B) Commensalism
- C) Mutualism
- D) Parasitism
- E) Predation

29. A rhizosphere bacteria converts ammonia to nitrite. A second rhizosphere bacteria converts nitrite to nitrate. What best describes this relationship?

- A) Competition
- B) Commensalism
- C) Mutualism
- D) Parasitism
- E) Predation

30. A mycobacterium tuberculosis bacterium inhabits and replicates inside macrophage cells. What best describes this relationship?

- A) Competition
- B) Commensalism
- C) Mutualism
- D) Parasitism
- E) Predation

31. In the endosymbiotic theory of organelle evolution, a proto-eukaryote engulfed a proto-mitochondria. In this relationship, the proto-eukaryote provided protection while the proto-mitochondria provided energy. What best describes this relationship?

- A) Competition
- B) Commensalism
- C) Mutualism
- D) Parasitism
- E) Predation

32. Select all that apply: bacteria that live at the bottom of the Mariana trench, the deepest oceanic trench on Earth, can be categorized as what type of extremophiles:
- A) Acidophile
 - B) Barophile/Piezophile
 - C) Halotolerant
 - D) Mesophile
 - E) Thermophile
33. What adaptations would you expect from bacteria that reside in acidic mine drainage?
- A) Decreased DNA/protein repair
 - B) Inefficient proton pump
 - C) Lack of cytoplasmic buffer that sequesters protons
 - D) Low proton permeability in the cytoplasmic membrane
 - E) Na^+ gradient to drive cellular processes
34. The metabolism of cyanobacteria with chlorophyll that produce oxygen can be categorized as
- A) Anoxygenic fermentation
 - B) Anoxygenic photosynthesis
 - C) Oxygenic fermentation
 - D) Oxygenic photosynthesis
 - E) Nitrogen fixation
35. To fix nitrogen, bacteria use nitrogen gas to form what compound?
- A) Ammonia
 - B) Carbon Dioxide
 - C) Nitrite
 - D) Nitrate
 - E) Oxygen
36. A heterotrophic bacteria that utilizes glycolysis, the citric acid cycle, and electron transport chain pathways with a final O_2 electron acceptor is best categorized as a:
- A) Aerobic Chemoorganotroph
 - B) Anaerobic Chemoorganotroph
 - C) Chemolithotroph
 - D) Oxygenic Phototroph
 - E) Anoxygenic Phototroph

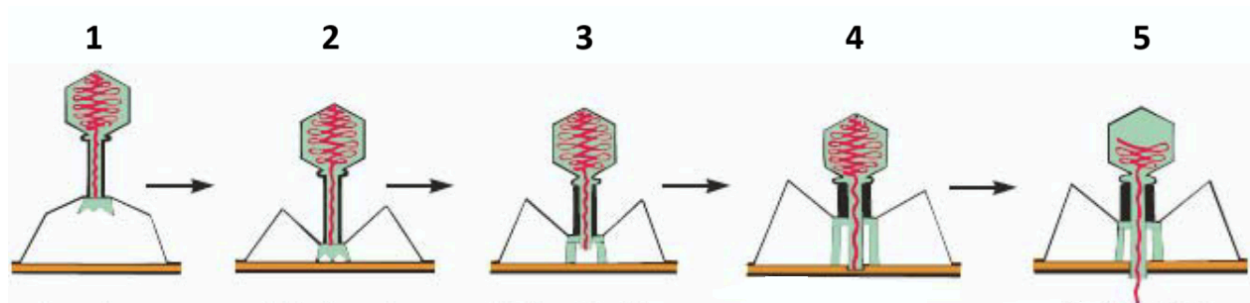
In a sample, you notice that bacteria have acquired plasmids carrying antibiotic resistance genes via horizontal gene transfer. Use this scenario to answer the following questions on this page.

37. Which of the following is not a property of horizontal gene transfer?
- A) Always moves genes between direct descendants
 - B) Beneficial genes are kept over time
 - C) Contributes to pathogen evolution
 - D) DNA can be integrated into the recipient genomes
 - E) Not constrained between a single species
38. Select all that apply: you confirm that there is no evidence of virus in your bacterial sample. Which methods of horizontal gene transfer are not responsible for the acquired antibiotic resistance?
- A) Conjugation
 - B) Transformation
 - C) Generalized Transduction
 - D) Specialized Transduction
 - E) None of the above
39. Select all that apply: you identify the presence of specialized pili that are involved in the uptake of genetic material. Which methods of horizontal gene transfer can use pili?
- A) Conjugation
 - B) Transformation
 - C) Generalized Transduction
 - D) Specialized Transduction
 - E) All of the above
40. Your bacteria lack the competence system. Which horizontal transfer method requires competence?
- A) Conjugation
 - B) Transformation
 - C) Generalized Transduction
 - D) Specialized Transduction
 - E) All of the above
41. Using the results of the previous questions and the presence of F Plasmid, which of the following horizontal gene transfer methods are responsible for your bacteria's acquired antibiotic resistance?
- A) Conjugation
 - B) Transformation
 - C) Generalized Transduction
 - D) Specialized Transduction
 - E) None of the above

42. In transformation, what protein facilitates recombination of DNA strands into the host genome?
- A) Pilus
 - B) ssDNA Binding Proteins
 - C) Competence system
 - D) Endonuclease
 - E) RecA
43. Lytic viruses contribute most to what method of horizontal gene transfer?
- A) Conjugation
 - B) Transformation
 - C) Generalized Transduction
 - D) Specialized Transduction
 - E) None of the above
44. In conjugation, what must happen to DNA before rolling circle DNA replication is started?
- A) DNA must be ligated
 - B) DNA must be nicked
 - C) DNA must be recombined
 - D) DNA must be transcribed
 - E) DNA must be winded up

Section 4: Viruses

The following image depicts a part of the life cycle of bacteriophages



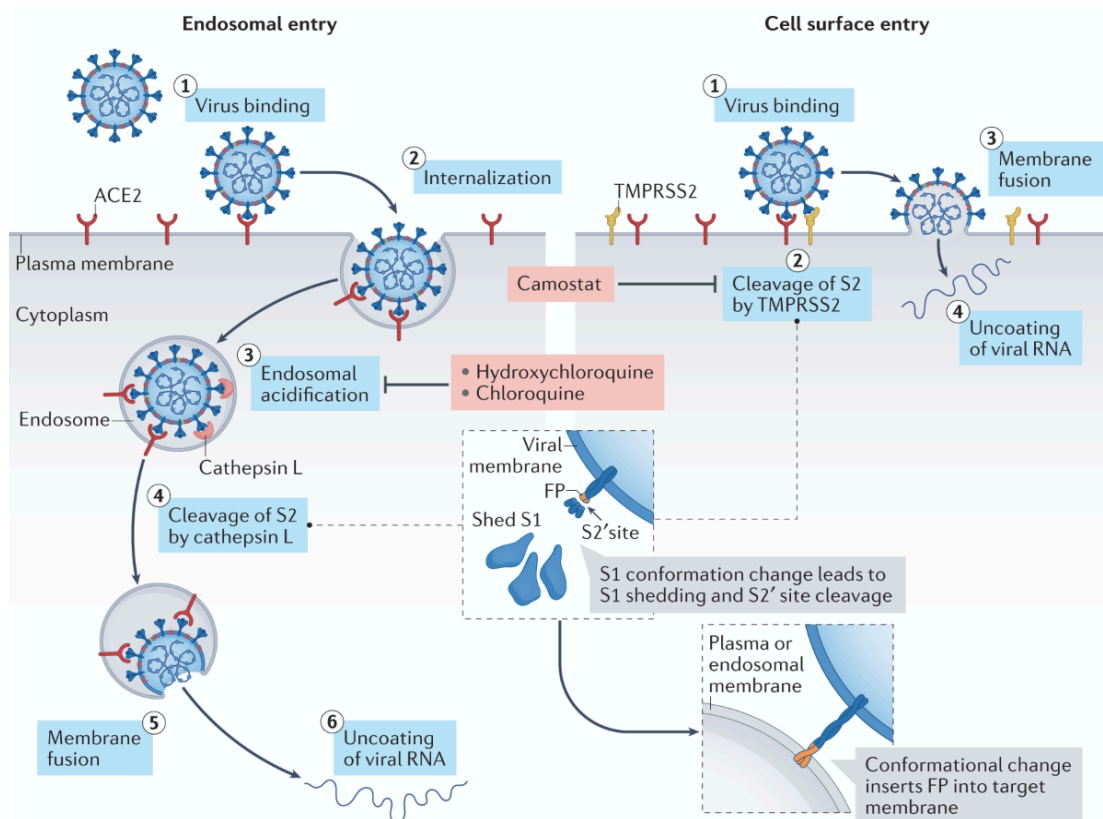
45. What are the steps of the bacteriophage life cycle depicted in order?
 - A) Attachment, tail contraction, landing, penetration, and DNA injection
 - B) Attachment, tail contraction, penetration, DNA injection, and landing
 - C) Landing, attachment, tail contraction, penetration, and DNA injection
 - D) Landing, attachment, penetration, tail contraction, and DNA injection
 - E) Landing, tail contraction, attachment, penetration, and DNA injection

46. During step 2, what feature of the bacteriophage makes contact to grip the cell surface?
 - A) Collar
 - B) Core
 - C) Sheath
 - D) Tail pin
 - E) Tail fiber

47. The head of the phage is made of proteins arranged in an icosahedral shape. What is the name of this protein shell that surrounds the nucleic acid?
 - A) Capsid
 - B) Integrase
 - C) Lysozyme
 - D) Neuraminidase
 - E) Spike

48. What is one difference between the life cycle of eukaryotic viruses differ from bacteriophages?
 - A) Bacteriophages inject DNA while eukaryotic viruses inject RNA
 - B) Bacteriophages enter host cells through fusion while eukaryotic viruses do not
 - C) Bacteriophages do not have capsomeres while eukaryotic viruses do
 - D) Eukaryotic viruses can enter the host cell whole while bacteriophages do not
 - E) Eukaryotic viruses have helical symmetry while bacteriophages have icosahedral symmetry

The image below illustrates two major SARS-CoV-2 pathways used to enter host eukaryotic cells: the endosomal pathway and cell surface pathway. In the endosomal pathway, the virus enters the cell by endocytosis after its spike protein binds angiotensin converting enzyme 2 (ACE2). In the cell surface pathway, spike protein binds ACE2 similarly, but the S2 subunit of the spike protein is cleaved by the host cell's transmembrane protease serine 2 (TMPRSS2). Cleavage of S2 allows S2 to facilitate the fusion of the viral membrane to the host cell membrane. Use this model to answer the following questions.



49. Neuron cells do not express TMPRSS2 but express ACE2. However, neurons are capable of being infected by SARS-CoV-2. Explain how this is possible. [3 points]
50. You want to investigate a SARS-CoV-2 variant with mutations on its spike protein that has a heightened ability to infect cells. Suggest two hypotheses as to how mutations to the spike protein may increase virulence of SARS-CoV-2. [3 points]
51. A patient has a dysfunctional ACE2 protein that is unable to be expressed on the surface of cells. Will SARS-CoV-2 be able to infect them? Explain. [2 points]
52. SARS-CoV-2 viral particles spread from the throat to the saliva before any symptoms appear. Explain why this lack of symptoms might be beneficial for its transmissibility. [2 points]
53. SARS-CoV-2 is an enveloped plus single stranded RNA (+ssRNA) virus. Does SARS-CoV-2 +ssRNA require any transcription before translation by ribosomes? Why or why not? [2 points]
54. Does SARS-CoV-2 integrate into the host genome? Does it have a lytic or lysogenic life cycle? [1 point]