Directions:

- **Write your name in the correct space on the mark-sense sheet and the exam booklet.** Both the exam booklet and the mark-sense sheet must be turned in at the end of the period.

- **Indicate the version letter (A, B, C, or D) in the “Key ID” box in the upper left corner of the mark-sense sheet.**

- Each question has only one correct answer. When a group of choices is used for more than one question, a choice may be used more than once.

- You may write in the exam booklet, but only the mark-sense sheet will be graded. No other paper, scratch paper, etc., may be used.

- Students must turn in the exam before leaving the room for any reason. A student may not continue working on the exam after having left the room.

Multiple Choice. 50 questions, 2 pt each.

1. Which of the following species have strains that are capable of undergoing the process of conjugation?

   (a) *Streptococcus pneumoniae*
   (b) *Escherichia coli*
   (c) *Bacillus subtilis*
   (d) None of the above.

2. Which of the following methods would be used to make *Escherichia coli* cells competent for transformation?

   (a) Treatment with CaCl$_2$
   (b) Growth at elevated temperature
   (c) Protoplasting
   (d) Polymerase chain reaction (PCR)
   (e) None. *Escherichia coli* is naturally competent.
The following information pertains to questions 3 – 5.
A “Winogradsky column” is an experiment used to demonstrate the bacteria of the sulfur cycle. At the bottom of a long glass cylinder, the scientist places a mixture of calcium sulfate and soil from a salt marsh. The soil-sulfate mixture is covered with sea water. The soil-sulfate mixture at the bottom is characterized by high sulfate ($\text{SO}_4^{2-}$) concentration and anaerobic conditions. The liquid at the surface of the column is aerobic, and has a high concentration of hydrogen sulfide ($\text{H}_2\text{S}$).

In an experiment, a microbiologist has set up two Winogradsky columns. One column (Column A) was grown in continuous light, while the other column (Column B) was kept in the dark. She found the following results:

- She isolated two types of bacteria that were found at the bottoms of both Column A and Column B.
- She isolated two types of bacteria from the surface of both Column A and Column B. These bacteria were non-pigmented (uncolored).
- From the surface of column A, she isolated two types of pigmented bacteria, a purple one and a green one. These bacteria were not found in Column B.

The following choices are used for questions 3 – 5.

(a) *Thiobacillus* and *Beggia toa*
(b) *Chlorobium* and *Chromatium*
(c) *Bacillus* and *Pseudomonas*
(d) *Nitrobacter* and *Nitrosomonas*
(e) *Desulfovibrio* and *Desulfuromonas*

3. What were the bacteria that she isolated from the bottoms of Column A and Column B?

4. What were the nonpigmented bacteria that she isolated from the surfaces of Column A and Column B?

5. What were the pigmented bacteria that she isolated from the surface of Column A (not found in Column B)?

6. Glucose is converted into phosphogluconate in the initial step of each of the following pathways EXCEPT

(a) the phosphoketolase pathway.
(b) the Embden-Meyerhoff-Parnas pathway.
(c) the Entner-Doudoroff pathway.
(d) the hexose monophosphate pathway.
7. The Entner-Douderoff pathway of glycolysis is characteristic of
   (a) *Pseudomonas* and related genera
   (b) *Clostridium acetobutylicum*
   (c) *Bifidobacterium* and *Leuconostoc*
   (d) *Acetobacter*
   (e) *Nitrobacter* and *Nitrosomonas*

8. The major purpose of fermentation in bacteria is
   (a) the synthesis of organic acids to regulate the pH of the organism’s environment.
   (b) to provide a means for bacteria to identify each other by the production of different fermentation end products.
   (c) to produce large quantities of ATP from pyruvic acid, since very little ATP is produced during glycolysis.
   (d) to oxidize NADH into NAD.
   (e) to regenerate ADP for the process of glycolysis.

9. Which of the following compounds is detected by the Voges-Proskauer test?
   (a) lactic acid
   (b) acetylmethylcarbinol
   (c) acetic acid
   (d) butyraldehyde
   (e) propionic acid

10. The final electron acceptor of the respiratory electron transport chain during respiration is always
    (a) oxygen.
    (b) an inorganic molecule.
    (c) NADH.
    (d) located in the matrix of the mitochondrion.
    (e) responsible for absorbing a photon of light energy.

11. During respiration, which of the following processes is most directly responsible for the synthesis of the greatest amount of ATP?
    (a) the conversion of glucose into pyruvic acid
    (b) the conversion of α-acetolactic acid into acetylmethylcarbinol
    (c) the conversion of pyruvic acid into acetyl CoA and CO₂
    (d) the tricarboxylic acid cycle
    (e) the respiratory electron transport chain
12. In a certain enzymatic pathway, electrons are transferred from phaeophytin to coenzyme Q, then to plastoquinone, and then to the cytochrome b6-f complex. In which pathway does this occur?
   (a) aerobic respiration  (d) anoxygenic photosynthesis
   (b) anaerobic respiration  (e) chemolithotrophy
   (c) oxygenic photosynthesis

The following choices are used for questions 13 - 17.

(a) Nitrite (NO\(_2^-\)) \rightarrow\text{Nitrogen (N}_2\text{)}
(b) Water (H\(_2\text{O}\)) \rightarrow\text{Oxygen (O}_2\text{)}
(c) Sulfate (SO\(_4^{2-}\)) \rightarrow\text{Hydrogen sulfide (H}_2\text{S)}
(d) Hydrogen sulfide (H\(_2\text{S}\)) \rightarrow\text{Elemental sulfur (S}_0\text{)}
(e) Nitrite (NO\(_2^-\)) \rightarrow\text{Nitrate (NO}_3^{2-}\text{)}

13. This reaction represents the final step in the anaerobic respiration of certain species of \textit{Pseudomonas} and \textit{Bacillus}.

14. This reaction represents the step in which light energy removes electrons from the electron donor during photosynthesis in \textit{Chlorobium}.

15. This reaction represents the step in which light energy removes electrons from the electron donor during photosynthesis in the cyanobacteria as well as in chloroplasts.

16. This reaction represents the step in which a reduced electron donor is oxidized in the chemolithotrophic metabolism of \textit{Nitrobacter}.

17. This reaction represents the step in which a reduced inorganic electron donor is oxidized in the chemolithotrophic metabolism of \textit{Thiobacillus} and \textit{Beggiatoa}.

18. A system of classification in which organisms are grouped according to genetic similarity and evolutionary relatedness is a
   (a) parthogenic system  (d) phlostogonistic system
   (b) phenetic system  (e) heuristic system
   (c) phylogenetic system
The following choices are used for questions 19 – 20.

(a) Green sulfur bacteria  (d) Purple nonsulfur bacteria
(b) Purple sulfur bacteria  (e) None of the above.
(c) Green nonsulfur bacteria

19. *Chloroflexus* is an example of this group.

20. *Rhodobacter* is an example of this group.

The following choices are used for questions 21 – 26.

(a) H$_2$S or S$_o$
(b) H$_2$ or an organic compound
(c) H$_2$O
(d) NH$_4^+$
(e) NO$_2^-$

21. This is the electron donor for anoxygenic photosynthesis in the green and purple nonsulfur bacteria.

22. This is the electron donor for anoxygenic photosynthesis in the green and purple sulfur bacteria.

23. This is the electron donor for chemolithotrophic metabolism in *Nitrosomonas*.

24. This is the electron donor for chemolithotrophic metabolism in *Nitrobacter*.

25. This is the electron donor for chemolithotrophic metabolism in *Thiobacillus*.

26. This is the electron donor for oxygenic photosynthesis in cyanobacteria.

27. Which of the following methods would be used to make *Bacillus stearothermophilus* cells competent for transformation?

(a) Treatment with CaCl$_2$
(b) Growth at elevated temperature
(c) Protoplasting
(d) Polymerase chain reaction (PCR)
(e) None. *Bacillus stearothermophilus* is naturally competent.
The following information pertains to questions 28 – 30.
Consider the following chemical structures (labeled I, II, and III).

28. List the structures in the order of most reduced carbon to least reduced carbon.
   (a) I, II, III
   (b) III, II, I
   (c) III, I, II
   (d) II, I, III
   (e) I, III, II

29. In which of the structures does the carbon have the greatest potential chemical energy (if reacted with oxygen)?
   (a) I
   (b) II
   (c) III

30. Which diagram is the structure of an alcohol?
   (a) I
   (b) II
   (c) III

31. The identification of an unknown bacterial species is based primarily on
   (a) whether or not the unknown species can sexually mate (and produce viable offspring) with known species called type strains.
   (b) the location from where the unknown species was isolated (eg, respiratory tract, colon, soil, water, etc.).
   (c) a comparison of the properties (colony morphology, cell properties, gram staining, biochemical characteristics, etc.) of the unknown species with known species called type strains.
32. Read the following sentence.

All Bacillus are bacilli, but not all bacilli are Bacillus.

What does this mean?

(a) All rod-shaped bacteria belong to the genus Bacillus, but not all members of the genus Bacillus are rod-shaped bacteria.
(b) All members of the genus Bacillus are rod-shaped bacteria, but not all rod-shaped bacteria are members of the genus Bacillus.
(c) All spherical-shaped bacteria belong to the genus Bacillus, but not all members of the genus Bacillus are spherical-shaped bacteria.
(d) All members of the genus Bacillus are spherical-shaped bacteria, but not all spherical-shaped bacteria are members of the genus Bacillus.
(e) “Bacillus” is a species name, and “bacilli” is a genus name.

33. Look at the names of each of the bacteria listed below.

I. Bacillus megaterium
II. Group A streptococcus
III. tuberculosis
IV. Diphtheria bacillus
V. Staphylococcus epidermidis

Which of the names is (are) written according to the formal rules of systematic binomial nomenclature?

(a) II and IV only  (d) I and V only
(b) I, III, and V only  (e) I, IV, and V only
(c) I, III, IV, and V only

34. Which of the following methods would be used to make Acinetobacter calcoaceticus cells competent for transformation?

(a) Treatment with CaCl₂
(b) Growth at elevated temperature
(c) Protoplasting
(d) Polymerase chain reaction (PCR)
(e) None. Acinetobacter calcoaceticus is naturally competent.
The following choices are used for questions 35 – 38.

(a) Propionibacterium  
(b) Clostridium  
(c) Enterobacter  
(d) Escherichia  
(e) Lactobacillus

35. Some species in this genus are human skin flora, growing in areas with reduced oxygen concentration (such as armpits) and associated with unpleasant body odor. Other species in this genus are essential in the manufacture of Swiss cheese.

36. The British and Germans used a member of this genus to produce organic solvents during WWII.

37. Acetoin is a waste product excreted during fermentation processes in this genus.

38. Members of this genus are characterized by mixed acid fermentation.

The following choices are used for questions 39 - 41.

(a) serological tests  
(b) biochemical tests  
(c) G + C content  
(d) nucleic acid hybridization  
(e) nucleic acid sequencing

39. Fermentation tests and tests for the presence of specific enzymes are examples of this type of test.

40. The simplest way to perform this test is to determine the “melting point,” or denaturation temperature, of the organisms DNA.

41. This type of test uses group-specific antibodies to identify microorganisms.

42. In this test, single-stranded DNA from two different species is mixed, and the ability of the DNA to form double-stranded DNA is determined. This gives an approximate indication of how closely related the two species are.
The following choices are used for questions 43 - 45.

(a) transformation  
(b) transduction  
(c) conjugation  

43. In this method, bacterial viruses are used to transfer genes from the donor to the recipient.

44. When an Hfr strain is crossed with an F- strain in an interrupted mating experiment, the DNA is transferred from the donor to the recipient by this mechanism.

45. Gene distances given by this method are based on the time it takes for the genes to be transferred from donor to recipient cells. Therefore, the map distances on the chromosome maps are stated in units of “minutes.”

The following choices are used for questions 46 – 48.

(a) Actinobacteria  
(b) Firmicutes  
(c) Proteobacteria  
(d) Spirochaetes  
(e) Cyanobacteria  

46. Oxygenic photoesynthesis is a notable characteristic in this phylum of bacteria.

47. This phylum of bacteria contains the “classical” gram-negative organisms such as *E. coli*.

48. This phylum of bacteria is also known as the “low G-C gram-positive” group.
The following choices are used for questions 49 - 50.

(a) Light energy is used to remove electrons from a reduced electron donor. The resulting electron transport produces ATP and NADH to be used for carbon fixation.

(b) Pyruvic acid is oxidized to form CO₂. Electrons are temporarily stored on NADH, then are transferred to an electron transport chain and a final inorganic electron acceptor. As a result, a lot of ATP is made.

(c) Pyruvic acid is reduced to form a reduced organic acid or alcohol. During this process, NAD is regenerated, but no additional ATP is made.

(d) Glucose is partially oxidized to form pyruvic acid, with a small amount of ATP and NADH made.

(e) A reduced inorganic electron donor is oxidized without the need for light energy. The resulting electron transport produces ATP and NADH to be used for carbon fixation.

49. This statement describes glycolysis.

50. This statement describes chemolithotrophic metabolism.