Multiple choice. (1 point each) Choose the one best answer to each of the following questions.

D. Which of the following are made up of prokaryotic cells?
A. Bacteria and fungi
B. Archaea and fungi
C. Protozoa and animals
D. Bacteria and archaea

B. The ultimate limit of what we are able to see with a microscope is defined by __.
A. magnification
B. resolution
C. light intensity
D. visual acuity

B. When the oil-immersion lens is used __.
A. light rays are scattered so unnecessary background material is not seen.
B. light rays are concentrated by minimizing refraction to increase clarify
C. objects are held in place on the microscope slide
D. magnification of objects is increased about ten-fold

A. In general, eukaryotic cells are __.
A. larger than prokaryotic cells
B. smaller than prokaryotic cells
C. about the same size a prokaryotic cells
D. not physiologically comparable to prokaryotic cells and therefore eukaryotic and prokaryotic cell sizes should not be compared either

A. Which of the following statements accurately describes membrane linkages?
A. Eubacteria have ester linkages; Archaea have ether linkages.
B. Archaea have ester linkages; Eukarya have ether linkages.
C. Eukarya have ester linkages; Eubacteria have ether linkages.
D. Eubacteria and Eukarya have ester linkages; Archaea linkages are not known.

C. The periplasm is a(n) __.
A. Part of the outer cell membrane of gram negative organisms.
B. Part of the inner cell membrane of gram negative organisms.
C. Space between the cytoplasmic membrane and the outer membrane layers.
D. Alternate names for the inner cell membrane of any prokaryotic cell.

C. Pseudopeptidoglycan is a characteristic of the walls of __.
A. Eubacterial prokaryotic cells.
B. Eukaryotic cells.
C. Archaean prokaryotic cells.
D. Eubacterial and Archaean prokaryotic cells.

C. Which of the following statements is false?
A. The flagellar protein subunit is flagellin.
B. In flagellar motion, the basal body acts as a motor.
C. Flagella rotate at a constant speed and in a constant direction.
D. The hook is the wider region between the basal body and the filament.
_D_ The membrane of a gas vesicle is composed of __.

A. various phospholipids  
B. both glycoproteins and phospholipids 
C. carbohydrate 
D. protein 

__D__ __ is found only in the cell wall of gram-positive bacteria.

A. porins  
B. \(N\)-acetyltalosaminuronic acid  
C. lipopolysaccharide  
D. teichoic acid 

__A__ Penicillin can kill bacteria because it interferes with __.

A. transpeptidation 
B. integrity of the \(\beta\)-1,4 linkage between NAM and NAG 
C. cell membrane selective permeability 
D. all of the above 

__C__ Which of the following types of optics would provide the greatest contrast and best reveal the sub-cellular structural detail for observing the bacterial cell?

A. bright field  
B. dark field  
C. phase contrast 

__A__ Bacteria in which the flagella are distributed as tufts at one end of the cell are described as ___.

A. lophotrichously flagellated. 
B. peritrichously flagellated. 
C. polarly flagellated. 
D. amphitrichously flagellated 

__B__ Which of the following is a component of pseudomurein?

A. \(N\)-acetylmuramic acid 
B. \(N\)-acetyltalosaminuronic acit 
C. Diaminopimelic acid 
D. Lysine 

__D__ Which of the following discovered that medical students were responsible for many cases of child-bed fever due to the fact that they did not wash their hands between their dissection class and their work in the maternity ward?

A. John Snow  
B. Robert Koch  
C. Joseph Lister  
D. Ignaz Semmelweis 

__A__ Which of the following was one of the first to use an epidemiological approach to solving a disease outbreak when he identified a specific water pump as the source of a cholera epidemic in London?

A. John Snow  
B. Robert Koch  
C. Joseph Lister  
D. Ignaz Semmelweis
B. Which of the following identified the causative agents of such deadly diseases as anthrax and tuberculosis?

A. John Snow  
B. Robert Koch  
C. Joseph Lister  
D. Ignaz Semmelweis

C. Which of the following used carbolic acid to disinfect surgical wounds and made surgery a much safer procedure due to the decrease in patients dying of infected surgical wounds.

A. John Snow  
B. Robert Koch  
C. Joseph Lister  
D. Ignaz Semmelweis

C. Which of the following areas of microbiology was not a major research interest of Louis Pasteur?

A. fermentation  
B. vaccine production  
C. nitrogen fixation  
D. sterilization

B. Cocci arranged in "grape-like" clusters are known as ___.

A. streptococci  
B. staphylococci  
C. sarcinae  
D. micrococci

B. Lipopolysaccharide (LPS) is associated with ___.

A. The outer membrane of Gram positive bacteria.  
B. The outer membrane of Gram negative bacteria.  
C. The cytoplasmic membrane of Gram positive bacteria.  
D. The cytoplasmic membrane of Gram negative bacteria.

A. Which of the following genera consists of endospore forming bacteria?

A. Bacillus  
B. Streptococcus  
C. Saccharomyces  
D. Escherichia

B. Which of the following is not a characteristic of certain thermophilic bacteria that enables them to survive growth at high temperatures.

A. heat stable enzymes  
B. extra thick peptidoglycan layer  
C. high G+C content of chromosomal DNA  
D. lipids rich in saturated fatty acids  
E. membranes containing C₄₀ hydrocarbons instead of fatty acids

D. When doing a colony count ___.

A. It is assumed that each colony arose from only one organism.  
B. Only viable cells are counted  
C. The medium must be suitable for colonial growth  
D. All of the above
When water activity is low, an organism must __

A. Increase its internal solute concentration.
B. Increase its external solute concentration.
C. Decrease its internal solute concentration.
D. Decrease its external solute concentration.

are applied to living tissues; are used on inanimate objects.

A. Disinfectants / sterilants
B. Antiseptics / steriliants
C. Antiseptics / disinfectants
D. Disinfectants / sterilants

Matching. (1 point each) Match the definition in the left column with the appropriate term in the right column. Note, not all terms will be used.

| __F__ Structures that provide buoyancy for prokaryotic cells | A. Autolysin |
| __W__ Process which involves several cycles of gentle heating (65°C) and cooling. | B. Catalase |
| __M__ Chemist who ultimately disproved spontaneous generation. | C. Compatible solutes |
| __K__ Another name for peptidoglycan | D. Diaminopimelic acid |
| __E__ Molecule found in high concentrations in endospores | E. Dipicolinic acid |
| __R__ Proteins that form channels in the outer membranes of gram-negative bacteria. | F. Gas vesicles |
| __P__ Fiber like structures on the surface of bacteria that aid in attachment to surfaces. | G. Generation time |
| __D__ Amino acid found in the pentapeptide of the peptidoglycan of all gram-negative bacteria. | H. Loewenhook |
| __Q__ Bacterial carbon and energy storage polymer used to make biodegradable plastics | I. Lysine |
| __S__ Bacterial cell which has lost its peptidoglycan layer but remains intact | J. Lysozyme |
| __J__ Enzyme found in saliva that cleaves the β-1,4 linkage of the peptidoglycan layer. | K. Murein |
| __T__ The wall formed during prokaryotic cellular division | L. Niedham |
| __G__ The time required for the formation of two cells from one. | M. Pasteur |
| __C__ Molecules found in halophiles that protect them from the low water activity of their environment. | N. Pasteurization |
| __B__ Enzyme that protects bacteria from damage caused by hydrogen peroxide. | O. Periplasm |
| __V__ Molecules found associated with the peptidoglycan of gram-positive bacteria. | P. Pili |

Short answer. (1 point each)

What is chemotaxis?

The directed movement of a bacterium toward an attractant (nutrient) or away from a repellent.
How does a random-walk lead to movement in a general direction such as toward oxygen as seen during chemotaxis?

Through an alternating pattern of runs and tumbles with tumbles being more frequent as the microbe moves away from an attractant and runs being longer as the microbe moves toward an attractant.

What is the difference between a psychrophilic and a psychrotolerant organism?

**Psychrophilic organisms** have an optimal growth temperature below 15°C whereas a **psychrotolerant organism** has an optimal growth temperature in the mesophilic temperature range but is capable of growth at colder temperatures.

The **Gram** stain is an example of a differential stain.

A bacterium that has an optimal growth temperature of 30°C would be described as a **Mesophile**.

A **Bacteriostatic** antibiotic would inhibit the growth of a bacterium but not kill it.

The **β-lactam** antibiotics are the most important clinical antibiotics.

Name two forms of oxygen that are toxic to living organisms.

**Superoxide, singlet oxygen, hydrogen peroxide, hydroxyl radical**

Microbes such as *Deinococcus radiodurans* that are able to survive high levels of radiation exposure probably possess what type of protective mechanism?

Because radiation kills cells by damaging DNA radiation resistant bacteria have very active DNA repair systems.

List two characteristics of endospores that make them resistant to normally deadly environmental conditions.

**Endospores are highly dehydrated (provides heat resistance), they contain large amounts of small acid soluble DNA binding proteins (protects DNA from damage), thick outer layers (protects from chemical insults)**

What are the three stages of regeneration of a vegetative cell from an endospore?

**Activation, germination and outgrowth**

List two ways in which bacterial growth and death are similar?

**Both are exponential processes, both are greatly affected by environmental factors such as pH, Salt, temp. etc.**

Indicate which of the following curves illustrates the activity of a bacteriocidal, bacteriostatic and bacteriolytic agent.
**Short Essay Questions.** Please answer 3 of the following 4 short essay questions (5 points each - 5 bonus points possible for answering all 4 questions)

Draw a bacterial growth curve that plots optical density (Absorbance at 600 nm) versus time over a period of several days. Assume that a bacterial culture was allowed to grow to saturation and for several days and then inoculated into fresh medium. Be sure to label the axis, indicate the phases of the growth curve and explain what is happening during each phase.

![Growth curve diagram](image)

The figure above which is from your textbook illustrates what this curve should look like (the dashed line). During the lag phase, the bacteria are "re-tooling". The enzymes necessary for growth are being synthesized. During the exponential of log phase, the cells are dividing at their maximal rate. During the stationary phase the bacteria have begun to run out of nutrients or toxic by-products have reached high enough levels to inhibit further cell division. During the death phase, a portion of the population becomes inviable. This happens at a constant logarithmic rate.

Describe the process of peptidoglycan synthesis.

Peptidoglycan synthesis occurs outside the cytoplasmic membrane. Therefore, the disaccharide of \(N\)-acetylmuramic acid and \(N\)-acetyl glucosamine (the "building blocks" of the growing peptidoglycan polymer) plus the associated pentapeptide and (if present) interbridge must be synthesized in the cytoplasm and transported outside the cell. Before translocation the transmembrane carrier molecule (bactoprenol) is attached to \(N\)-acetylmuramic acid plus a pentapeptide. \(N\)-acetylglucosamine and the interbridge molecule (if gram-positive) is added. The disaccharide/pentapeptide is translocated across the cytoplasmic membrane with the aid of the bactoprenol. Once outside the cell, the disaccharide/pentapeptide is joined to the growing glycan polymer. Openings in the polymer for insertion of the disaccharideare created through the action of autolysin. Once the disaccharide/pentapeptide is incorporated into the glycan chain, synthesis is not yet complete. Cross-linking between adjacent strands of glycan polymer must be formed. The process of cross-linkage formation is transpeptidization. In the transpeptidation reaction, the peptide bond between the two terminal D-alanine residues of the pentapeptide is cleaved. The internal D-alanine residue is then linked to the diaminopimelic acid (gram-negative bacteria) or lysine (gram-positive bacteria) or interbridge amino acid residue (when present) of a pentapeptide attached to an \(N\)-acetylmuramic acid of an adjacent glycan polymer. Cleavage of the terminal D-alanine residue provides the energy for peptide bond formation.
Describe how thioglycolate medium is used to determine the relationship of an organism to oxygen. Explain the function of the various key ingredients of the thioglycolate medium. Describe the growth pattern you would expect to observe for a strict aerobe, strict anaerobe, facultative and microaerophilic organism (a drawing would be sufficient).

Thioglycolate medium is used for the cultivation of anaerobic, aerobic, facultative or microaerophilic microorganisms. This is made possible by the formation of a gradient of oxygen concentrations throughout the test tube. The presence of thioglycolate removes free molecular oxygen from the medium which can be visualized with the redox indicator resazurin. Resazurin turns pink in the presence of free molecular oxygen so the tube containing thioglycolate plus resazurin is colorless except at the very top where oxygen from the headspace of the culture tube diffuses into the top layer of the medium. To further minimize diffusion of oxygen into the culture medium, a low percentage of agar (0.2%) is used to produce a semi-solid state.

Strict aerobic organisms would only grow in the upper portion of the medium - corresponding to the highest free molecular oxygen concentrations.

Strict anaerobic organisms would grow only in the lower portion of the medium - corresponding to regions where there is no available free molecular oxygen.

Facultative organisms would grow throughout the medium although growth would tend to be more dense in the oxic portion of the medium.

Microaerophilic organisms would grow at the interphase between the oxic and anoxic zones of the medium where the concentration of free molecular oxygen would be sufficient to support respiration but not too high to kill the bacteria.

Explain the difference between sterilization, disinfection and sanitization. Give one example of each type of treatment and how each treatment affects bacteria (if at all).

Sterilization is the killing or removal of all living organisms, spores and viruses from a growth medium or equipment. Disinfection is the elimination of nearly all pathogens but not all microorganisms. Sanitization is the reduction in the number of microorganisms on the surface of an object.

Preparation of culture media in an autoclave is an example of sterilization. The high temperature and pressure of the autoclave is sufficient to kill all bacteria, spores and viruses. Treatment of surfaces with bleach is an example of disinfection in which most pathogens are killed but some microorganisms are able to survive. Wiping down the countertop in a food preparation area is an example of sanitization.