Prokaryotes

Classwork
1. Describe the basic features present in all cells.
2. Describe the two types of prokaryotes found on Earth today.
3. Bacteria are normally thought to be bad. We spend a great deal of money in the US trying to kill bacteria that we come in contact with. Explain two ways bacteria can be helpful.
4. Archaea come from the Greek word meaning “ancient” They have been found in extreme conditions that may have resembled the earth over 3.5 million years ago. Describe how archaea are different from bacteria.
5. Prokaryotes are often named based on their morphology or shape. Describe four prokaryotic shapes.
6. Describe how the cell wall in bacteria is different from the cell wall in Archaea. What role does it play in bacteria?
7. Prokaryotes have evolved structure for movement. Describe the terms: chemotaxis and phototaxis. Describe what appendage used for movement.
8. Genetic information is important in all living organisms. Prokaryotes have a ring of DNA called a plasmid. Describe the function of plasmids in prokaryotes.

Homework
9. Explain the difference between the F plasmid and the R plasmid
10. Reproduction is essential to the definition of living organisms. Describe how prokaryotes reproduce.

Use the following web site to help you understand how antibiotic resistance in bacteria - http://www.niaid.nih.gov/topics/antimicrobialresistance/understanding/Pages/default.aspx
(You will have to navigate through the website to answer each question)

11. According to the center for disease control and prevention as of April 2011, how much does antibiotic resistance cost the US?
12. Describe three causes of antimicrobial drug resistance.
13. Explain when it is appropriate to use antibiotics to treat bacterial infections.
14. What are some ways to prevent antimicrobial resistance?
15. List and explain two examples of antimicrobial drug resistance as discussed in the article.

Eukaryotes

Classwork
16. Explain how the surface area to volume relationship can affect a cell's efficiency.
17. Cell organelles exemplify the statement: structure equals function. Choose five organelles and describe their structure and functions
18. Describe the parts of the endomembrane system along with their function.
19. Vesicles consist of an aqueous solution enclosed by a phospholipid bilayer. Relate the structure of a vesicle to its function in the cell.
20. Describe the structure on the mitochondria that is necessary for cell respiration, and explain what it is used to establish.
21. The plant's ability to stand upright relies on the simple process of diffusion. Since plants do not have a skeletal system, they rely on the rigid cell wall and turgor pressure to maintain rigidity. Explain how turgor pressure is related to the central vacuole.
22. Why do animal cells have extracellular matrix and not plants? Describe how they aid the animal cells.

Homework
23. One of the smallest, and yet most important components of the cell is the ribosome. Explain the difference between free and bound ribosomes.
24. Explain what is meant by compartmentalization and describe how it is an advantage for modern cells.
25. Packing, addressing and shipping are extremely important part of the cells activities. Explain how the endoplasmic reticulum and the Golgi apparatus work together to get proteins out of the cell.
26. Lysosomes are the waste disposal system of the cell. They digest worn out organelles and sometimes even digest old worn out cells, giving them the nickname “suicide-sacs”. Describe how lysosomes break down organic substances. Where are they made in the cell?
27. Endosymbiotic organelles are believed to have evolved from engulfed prokaryotes that once lived as independent organisms. Describe the two energy-converting organelles and explain what types of organisms contain them.
28. Looking a model of a plant cell one can two very distinct features, a cell wall and a large central vacuole. Describe the kinds of materials that are stored in a central vacuole.
29. The cell contains a network of fibers within the cytoplasm. Describe three types of these fibers and provide a functional example of their use.

Viruses
Classwork
30. Discuss why viruses are considered “obligate intracellular parasites”.
31. Sketch a flow chart of the lytic cycle, number the steps involved in this process.
32. Sketch a flow chart of lysogenic cycle, number the steps involved in this process.
33. Describe what is meant when a virus is called a temperate phage.
34. Compare the reproductive cycle of a DNA virus to an RNA virus.
35. A retrovirus in an RNA virus that replicates in a host cell. Describe the steps involved in replication of new viruses. Discuss the advantage of being a reto virus in terms of survival and replication.
36. What is meant by the term bacteriophage?

Homework
Read the following article “Are Viruses Alive?” and answer the questions that follow. 
http://www.scientificamerican.com/article.cfm?id=are-viruses-alive-2004
37. Although the scientific community has changed it mind as to whether viruses are living or nonliving, describe how they are viewed today.
38. Describe how Stanley and colleagues established what a virus is made of.
39. What does Marc van Regenmortel and Brian Mahy mean when they say a virus is “a kind of borrowed life”?
40. What does the author mean when he states that virus resemble seeds?
41. Philip Bell and the author do not believe that eukaryotes simply evolved a nucleus. What do they propose?
42. Mumps, smallpox, measles, and the flu are all different viruses. However one thing all viruses have in common is their general mode of operation. Describe this mode.
Cellular Defenses

Classwork
43. Describe how bacteria defend themselves against viruses?
44. Describe how restriction enzymes are able to “cut” DNA at exactly the same place every time they come in contact with a DNA molecule.
45. Discuss how a criminalist can determine if blood found at a crime scene belongs to the victim or the suspect.
46. What is skin’s role in the immune system?
47. Outline the body’s response to a microbe (such as through a scratch on the skin).
48. Differentiate between antigen and antibody.
49. Describe the lymph system and its role in immunity.
50. Describe what enable a cell to have heightened response the second time an antigen is detected.
51. Briefly describe the concept behind the development of a vaccine.
52. What is the “last line of defense” for the immune system?
53. What is a plant's “first line of defense” against pathogens?
54. Outline the steps of PAMP-triggered immunity (PTI).

Homework
55. How do scientist decide which restriction enzyme they will need to cut out a particular gene?
56. A restriction enzyme cuts DNA between the guanine and cytosine nucleotides in a sequence: 3’GGCC5’. Using this information determine the fragments of DNA created when the following DNA strand is digested with this restriction enzyme.

5’ATCCGGATAGCAATTGGCCTAGCAAAAAACCGGCGAACGACCCGGATATACG3’
3’TAGGCCATCGTTAAACCGGATCGTTTTGGCCGCTTGCTGGCC

57. Using your answer from the previous question, sketch the results of gel electrophoresis on the digested DNA strand.

Read the following article entitled “Immune Response” and answer the questions that follow. http://www.nlm.nih.gov/medlineplus/ency/article/000821.htm

58. Describe innate, acquired and passive immunity with examples. Which ones can you be born with?
59. Differentiate between B and T lymphocytes. (Watch the video before answering the question)
60. You are helping you neighbor move some scrap wood, when you suddenly get a splinter in you hand. Describe the inflammatory response that ensues.
61. Describe the humoral response to foreign invaders.
62. Describe the function of the Major Histocompatibility Complex.
63. Describe three types of barrier defense that plants use against foreign invaders.
64. Piercing, sucking insects often take a “test bite” out of plant. An insect can spread disease this way. Describe the immune response the plant may take.
65. Plants have a structural feature know as a trichome. Draw a plant, showing where the trichomes would be located. Describe how they may help in plant defense.
Free Response

1. Sketch a plant cell, an animal cell, and a bacterial cell. Label the organelles and other cellular structures.

2. (top left) A scanning electron micrograph of a red blood cell with a pit on the surface (9000X).
   (A) a transmission electron micrograph of two inclusion-bearing vacuoles within red blood cell. Ferritin (a protein that stores iron), hemoglobin (an iron-containing protein that carries oxygen), membranes, and remnants (leftovers) of mitochondria are present in the vacuoles (17,820X). (B) a transmission electron micrograph of the opening of the vacuole at the surface of the red blood cell (25,000X).

Erythrocytes: Pits and Vacuoles as Seen with Transmission and Scanning Electron Microscopy
Bertram Schnitzer, Donald L. Rucknagel, Herbert H. Spencer, and Masamichi Aikawa

a) How is the red blood cell able to make the pit or invagination seen in the cell membrane of the cell in the top left picture?
b) Describe the evidence that supports the idea that the vacuoles seen in the above micrographs merged with lysosomes.
c) Considering the function of red blood cells in the transport of materials from and to cells, describe a possible function of exocytotic vacuoles seen in the above micrographs.
During a humoral T cell dependent response, naïve B cells (Bn), expressing Immunoglobulins M and D (IgM and IgD), and naïve T cells (Tn) are activated by antigen (Ag), either directly or after processing by a dendritic cell (DC). Activated T cells, dictated by their priming, are polarized to one of several T helper (TH) cell types, each associated with a distinct cytokine profile.

Independently of the interaction with B cells, T cell activation leads to T cell memory (Tm). We depict here the classical view of TH1, TH2, and TH17 cells. B cells, induced to proliferate by T cell–derived signals, undergo immunoglobulin class-switch recombination (CSR), differentiation into antigen secreting cells (ASCs), or a combination of both (class-switched ASCs). CSR in B cells (different colored ASCs) is dictated by TH-derived cytokines and the transcription factors they induce. Shown here are IFN-γ–inducing T-bet in B cells, required for CSR to IgG2a in mouse; IL-4 inducing STAT6, usually required for CSR to IgG1 and IgE; and TGF-β inducing Rorα, required for CSR to IgA. Activated B and TH cells may also up-regulate the transcription factor Bcl-6 and establish germinal centers (GCs) in which the affinity of the antibody for antigen is improved. TH cells in the GCs, called TFH cells, are distinct from early TH subsets, secreting IL-21 in addition to other, priming-specific cytokines. From the GCs, affinity-matured LLPCs and memory B cells are produced, expressing immunoglobulin isotypes that reflect the TH type in the initial priming. It now appears that the persistence of switched memory B cells depends on continued expression of
the transcription factors required for their induction—T-bet for IgG2a and Rorα for IgA. Thus, the appearance of different classes of antibody, specialized in clearing specific types of pathogens, in the memory compartments can be traced back to the initial interactions between DC and T cells. A complication of a deterministic system is in responses inducing multiple cytokines, such as in influenza, and whether these operate independently, competitively (overlapping graded expression of transcription factors within cells), or are localized to specific tissues.

Diversity Among Memory B Cells: Origin, Consequences, and Utility
David Tarlinton and Kim Good-Jacobson
Science 13 September 2013: 341 (6151), 1205-1211.

a) Using the above synopsis, order the picture puzzle to make a diagram that describes the T-cell dependent humoral immune response.

b) Use the above diagram to show how the immune system will deal with a viral infection.

b) Using the specific examples from the diagram, how will an organism be better prepared after a humoral response to an antigen than before coming in contact with an antigen.
4. *Myxococcus xanthus* is a bacterium with an interest for studies of development because it has an organized multicellular phase in its life cycle. Bacteriophage P1 can bind to *M. xanthus* and inject its DNA into this organism despite the wide taxonomic gap separating *Myxococcus* from *Escherichia coli*, the source of the P1 virus.

<table>
<thead>
<tr>
<th>Addition</th>
<th>Chloramphenicol-resistant colonies</th>
</tr>
</thead>
<tbody>
<tr>
<td>$7 \times 10^9$ P1CM particles</td>
<td>83</td>
</tr>
<tr>
<td>$3.5 \times 10^8$ P1CM particles</td>
<td>36</td>
</tr>
<tr>
<td>$3.5 \times 10^8$ P1 particles</td>
<td>&lt;1</td>
</tr>
<tr>
<td>None</td>
<td>&lt;1</td>
</tr>
<tr>
<td>$8 \times 10^9$ P1CM DNA molecules</td>
<td>3</td>
</tr>
</tbody>
</table>

A specialized transducing derivative of P1, called P1CM, can carry a gene for chloramphenicol (antibiotic) resistance from *E. coli* into *M. xanthus* and generate unstable drug-resistant strains. Transfer of chloramphenicol resistance to *M. xanthus* by P1CM is shown in the table above. The indicated number of phage particles or the number of molecules of DNA extracted from phage with phenol (13) were mixed with $1.5 \times 10^8$ exponentially growing *Myxococcus xanthus* cells in a total volume of 0.3 ml of 2 percent Bacto-Casitone containing 2.5 mM CaCl$_2$, and incubated for 17 hours at 32°C with aeration. Finally the mixture was divided into four portions and plated on Casitone agar containing chloramphenicol (25 /g/ml). Colonies were counted after incubation at 30°C for 4 days. The total number of colonies for the four portions is reported.

**Gene Transfer to a Myxobacterium by Escherichia coli Phage P1**

D Kaiser and M Dworkin


a) Why was P1CM particles able to produce bacteria colonies that could grow on chloramphenicol-containing plates, but P1 particles were not able to?

b) Why might you get a colony growing on the plates labeled “None”?

c) The addition of naked “P1CM DNA molecules” as opposed to the entire P1CM virus was able to produce 3 vs. 83 colonies for the entire virus. Describe the implications of this finding.
5. Pathogens of all lifestyle classes express pathogen (or microbial)–associated molecular patterns (PAMPs or MAMPs) as they colonize plants. Plants perceive these via extracellular receptors (PRRs) and initiate PRR-mediated immunity (PTI; step 1). Pathogens deliver virulence effectors to both the plant cell apoplast (between cell membrane and cell wall) to block PAMP/MAMP perception (not shown) and to the plant cell interior (step 2). These effectors are addressed to specific subcellular locations where they can suppress PTI and facilitate virulence (step 3). Intracellular NLR receptors can sense effectors in three principal ways: first, by direct receptor ligand interaction (step 4a); second, by sensing effector-mediated alteration in a decoy protein that structurally mimics an effector target, but has no other function in the plant cell (step 4b); and third, by sensing effector-mediated alteration of a host virulence target, like the cytosolic domain of a PRR (step 4c). It is not yet clear whether each of these activation modes proceeds by the same molecular mechanism, nor is it clear how, or where, each results in NLR-dependent effector-triggered immunity (ETI).

Pivoting the Plant Immune System from Dissection to Deployment
Jeffery L. Dangl, Diana M. Horvath, and Brian J. Staskawicz
Science 16 August 2013: 341 (6147), 746-751

a) Why are plant nonspecific defenses not sufficient to thwart the efforts of these pathogens?
b) How is PTI different from ETI?
c) How must the pathogens effectors interact with cellular products to infect plants?
d) How are organelles involved in creating an immune response in plants?
Cells-Answer Key

1. Plasma membrane, contain a semi-fluid called cytosol/cytoplasm, chromosomes, and ribosomes.
2. Bacteria that are single celled organisms that have cell walls that contain peptidoglycan and plasmid DNA. Archaea are single celled organisms that are similar in size to bacteria, cell walls and circular DNA.
3. Bacteria are found in digestive system to help break down food, antibiotics are derived from bacteria, found in food like yogurt and cheese
4. Their genes and factors involved in their gene expression are more like those of eukaryotes. They do not have peptidoglycan in their cell walls.
5. Shapes are: Bacilli, helical, cocci, club, and corkscrew. Include sketches
6. Bacteria contain peptidoglycan, a polymer of sugars and amino acid. It gives structural strength and helps regulate osmotic pressure in the cytoplasm. Petidoglycan is also involved during binary fission.
7. Chemotaxis is the movement in response to chemicals. Phototaxis is the movement in response to light. The appendage used for movement is flagella. It is a tail-like whip that either pulls or pushes the prokaryote.
8. They contain genes for adaptations such as antibiotic resistance, make a sex pili, making toxins and guarding against heavy metal toxins
9. The F plasmid deals with fertility and forms the sex pili, the R plasmid give antibiotic resistance to the prokaryote.
10. Prokaryotes reproduce through binary fission; this process involves duplication of all organelles and DNA, then splitting in half.
11. 20 billion in excess healthcare, 35 million in social cost, and 8 million in additional days of stay in hospitals.
12. Answers may vary, but can include: not finishing medicine, overuse of antibiotics, and fast mutation rates of bacteria.
13. If there is a known bacterial infection, the cause of the infection has been cultured in the lab. If the cause is unknown, and bacteria is suspected.
14. Use only disease-appropriate medicine as prescribed by your healthcare provider. Don't share your prescription with others that are sick. Don't save your antibiotic and use it the next time you get sick.
15. TB, MRSA, VRE, Gonorrhea – gram-negative bacteria. MRSA is an example of mutant strain of bacteria that has evolved from overuse of antibiotics. With TB, the strains have mutated enough making them resistant to treatments that use to work on the older strains.
16. Volume determines the amount of chemical activity that can be performed, but surface area determines what can enter or leave the cell, such as product, materials needed to run reactions, and waste products.
17. May include: nucleus which houses the cell's genetic information, lysosomes which contain hydrolytic enzymes for the breakdown of food molecules or the recycling of cellular components, ribosomes which synthesize proteins, peroxisomes which breakdown H₂O₂, mitochondria which conduct cellular respiration, vacuoles which (depending on type) contain food or water for an organism or expel water, endoplasmic reticulum which folds and transport proteins and lipids in the cell, chloroplasts which perform photosynthesis, Golgi apparatus which packages molecules for transport outside of the cell.
18. Nucleus, rough ER, smooth ER, Golgi apparatus, vesicles, lysosomes, and plasma membrane. The endomembrane system makes proteins, then processes and ships them to their final destination.
19. Vesicles are used for transporting proteins and other molecules across the cell membrane. The phospholipid bilayer of the vesicle fuses with the phospholipid bilayer of the cell and spills the contents of the vesicle into the extracellular fluid. In endocytosis, the vesicle is
formed when a section of cellular membrane pinches off to form a vesicle transporting molecules into the cell.

20. Cell respiration takes place near a membrane, specifically the inner mitochondrial membrane. A proton gradient can be built in the inner membrane space. The membrane or cristae separates the inner matrix volume with less protons from the outside, having more protons. The protons pass through ATP syntase into the matrix.

21. The central vacuole contains more solute that the surrounding fluid, water will diffuse into the vacuole through the process of osmosis. This in turn pushes against the cell wall making it turgid.

22. The extracellular matrix provides support, segregates tissues to the animal cells, and regulates intercellular communication. The extracellular matrix is not in plants due to the presence of the cell wall.

23. Free ribosomes move freely through the cytoplasm and produce proteins and enzymes used internally by the cell. Bound ribosomes are attached to internal membranes in the cells endomembrane system, specifically the rough endoplasmic reticulum.

24. Allows incompatible chemical reactions to be separated, increases the efficiency of chemical reactions, allows substrates required for particular reactions to be localized and maintained at high concentrations within organelles.

25. Proteins produced in the rough ER bud off and migrate to the Golgi. At the Golgi they are chemically modified so they can be marked and sorted. This marking ensures they will end up at their proper destination.

26. The lysosome membrane comes in contact with the organelle or invader to be degraded. Hydrolytic enzymes break down, digesting the components.

27. Mitochondria can be found in all eukaryotes. They convert chemical energy to ATP through aerobic cellular respiration. Chloroplast can be found in plant and some protists. They convert solar radiation into energy. The energy is stored for later use by the organisms.

28. Water, vital chemical pigments, and waste products are stored in the central vacuole.

29. Microfilament is the thinnest filaments of the cytoskeleton. They are used for cytokinesis, change in cell shape, and cell movement. This movement can also be seen in muscle movement of the actin filaments. Most intermediate filaments are found in the cytoplasm, their principle function is to reinforce cells and to organize cells into tissues. Microtubules are involved in cell division, motility, and cell communication.

30. They can only reproduce within a host cell.

31. A sketch including the infection of a host cell by nucleic acid only, generation of viral particles using host cell machinery, synthesis of full viruses, and lysis of host cell.

32. A sketch including the infection of a host cell by nucleic acid only, integration of viral DNA into host cell DNA, and reproduction of the host cell.

33. The virus can use both the lytic and lysogenic cycles. The virus will switch from the lysogenic cycle to the lytic cycle, separating its viral DNA from the host DNA, then go directly to the lytic cycle.

34. Most DNA viruses use the DNA polymerase from the host cell to replicate new genomes. RNA viruses inject RNA in the host and use virally encoded RNA polymerases to generate viral proteins directly from the viral RNA.

35. After entering the host cell it uses reverse transcriptase to produce DNA from its RNA. This DNA is then incorporated into the host DNA. Viral proteins are made and assembled. The advantage is the RNA is smaller. They are more complex viruses and have systems to bypass cell defenses.

36. A bacteriophage or phage is a virus that infects a bacterium.

37. Viruses today are thought of as being in a gray area between living and nonliving: they cannot replicate on their own but can do so in truly living cells and can also drastically affect the behavior of their hosts.
38. A virus consists of nucleic acids (DNA or RNA) enclosed in a protein coat that may also shelter viral proteins involved in infection.
39. Virus needs a host to infect, inject their DNA into and have the host replicate the virus.
40. Seed are dormant and have potential to become living given the right conditions. Viruses have the potential to act like living organism if they infect the right cells.
41. The nucleus may have evolved from a persisting large DNA virus that made a permanent home within prokaryotes.
42. First they infect a host cell with its genetic information. Next, they hijack the molecular machinery of the host cell and get it to build more viruses. The parts are assembled and the viruses leave to go infect more cells.
43. Bacteria are able to use restriction enzymes which recognize specific nucleic acid sequences to cut out foreign DNA.
44. They look for specific sequences in pieces of DNA (some are palindromes in the DNA code). The restriction enzymes will digest the DNA at these places.
45. Choose restriction enzymes that will cut the gene near the ends and not in the middle of the gene. Also choose restriction enzymes that will give you the desired end, such as a sticky end or a blunt end.
46. The skin is a non-specific barrier defense against microbes.
47. Infection of a microbe causes the release of histamines, which in turn cause the dilation of blood vessels in the area of infection. Dilation of the blood vessels increases the blood flow to the area causing inflammation and bringing an increased concentration of white blood cells to the area to engulf and destroy invading microbes.
48. An antibody is produced by an organism as a “memory” of invading cells. Antigens are molecules produced by cells which attach to antibodies allowing for cellular recognition.
49. The thymus and bone marrow are part of the lymph system which produce white blood cells. The lymph nodes (as well as the tonsils, spleen, skin, etc) are lymphatic organs that store naïve mature lymphocytes and initiate the adaptive immune response.
50. Active T and B cells can clone themselves making memory cells. The memory cells have receptors for a specific antigen, allowing for faster response.
51. A vaccine is derived from weakened microbe, parts of microbes, killed microbes or inactivated bacterial toxins. When injected they trigger an immune response, leaving memory cells to help when encounter by an active form.
52. Cell-mediated response resulting in death of the infected cell.
53. The outer covering of the plant, such as waxy leaves.
54. 1. A pathogen activates a receptor on the exterior of the plant cell. 2. A signal is sent to the nucleus. 3. A response is generated releasing a microbial agent that will hopefully kill the pathogen. 4. If the pathogen is not destroyed, programmed cell death occurs, killing the infected cell.
55. Scientists sequence the DNA. Then they choose a restriction enzyme that will cut the DNA at a sequence upstream and downstream of the desired gene.
56. 5’ ATCC; GGATAGCAATTCGCTAGCAAAACC; GCCGAACGACC; 3’ TAGG; CCTAGTTAACCAGCATCGTTTTGG; CCGCTTGCTGG;

GGATATACGCG3’
CCTATATGC5’
57. + ATCC; GGATATACGCG; GCCGAACGACC; + TAGG; CCTATATGC; CCGCTTGCTGG;

GGATAGCAATTCGCTAGCAAAACC -
CCTAGTTAACCAGCATCGTTTTGG -
58. Innate immunity is the defense that you are born with; it is non-specific. Ex. Cough reflex, tears, skin, skin oils, stomach acid. Acquired immunity develops with exposure to various antigens, such as getting the flu shot each year. Passive Immunity is due to antibodies produced in a body other than your own. You can be born with immunity passed through the placenta from the mother.

59. T lymphocytes are made in the bone marrow but mature in the thymus gland. They become helper, killer and suppressor cells. They are responsible for cell-mediated immunity. B-lymphocytes mature and develop in the bone marrow. They are able to recognize and destroy specific foreign invaders.

60. The damaged cells release histamine, bradykinin, and prostaglandins. Blood vessels leak fluid into the tissues causing swelling. The chemicals attract white blood cells called phagocytes that eat the germs.

61. B lymphocytes are release to act on the foreign invader. They produce and secrete specific antibodies to a specific antigen. If the same invader enters again the cell will be recognized and quickly destroyed.

62. The MHC code for proteins found on the cells surface and help the immune system recognize foreign invaders. After the pathogen is fragmented, the part binds to the MHC on the cells surface. This provides a display for the T-cells. When the T-Cells recognize the antigen fragment it can bind to it and begin the immune response.

63. The outer covering, which can be waxy, sticky, or thick cuticles.

64. Each individual plant cell is responsible for its own defense. As soon as the bite is taken, PAMPs activate receptors and trigger immunity. The plant may secrete an antimicrobial agent that fill the cytoplasm and secreted from the cell membrane. Or the plant may kill the infected cells by signaling programmed cell death.

65. Trichomes are fine outgrowths or appendages on plants. They may be uncomfortable for insects that wish to feed on the plants.

1. Bacterial cell sketch should include: cell wall, cell membrane, capsule, flagella, pili, nucleoid region, and ribosomes. Animal cell sketch should include: cell membrane, nucleus, mitochondria, endoplasmic reticulum, Golgi apparatu, and lysosomas. Plant cell sketch should include: cell wall, cell membrane, nucleus, mitochondria, endoplasmic reticulum, Golgi apparatu, lysosomas, and chloroplasts.

Learning Objectives:

LO 4.6 The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions. [See SP 1.4]

2. Question 2
   a. With the assistance of proteins, the phospholipid bilayers fuse at one end of the vacuole and expose the interior of the vacuole to the outside of cell, while maintain the integrity of the cell membrane. In the micrograph, we are looking at the inside of the exiting vacuole from the outside of the cell.
   b. The evidence that supports the fusing of the vacuoles with lysosomes is the remnants of mitochondria and proteins that have been broken down by proteinases and/or other enzymes present in lysosomes.
   c. A possible function of the removal of proteins and mitochondria from the inside of the cell in vacuoles is to improve the efficiency of cellular function and recycling of materials for reuse in other parts of the organism. Red blood cells must be uncluttered to
transport materials more effectively; Red blood cells have a 7 month life span, so they don’t require many mitochondria towards the end of their lifecycle.

Learning Objectives:

**LO 2.13** The student is able to explain how internal membranes and organelles contribute to cell functions. [See SP 6.2]

**LO 4.4** The student is able to make a prediction about the interactions of subcellular organelles. [See SP 6.4]

**LO 4.5** The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions. [See SP 6.2]

**LO 4.6** The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions. [See SP 1.4]

**Question 3**

b) The virus is represented by the antigen in the diagram. The antigen can activate B cells or T cells by binding cell surface receptors. T cell activation lead to creation memory T cells. T cells and B cells interacted with T helper cells to get B cells to reproduce and mature into antibody secreting cells; The ASCs produce antibodies that bind the antigen and mark it for destruction by macrophages or cytotoxic T cells. T helper cells also help B cells create groupings of cells that help improve antigen binding and produce memory B cells and long-lived plasma cells that will expedite the antibody producing process the second time the antigen is encountered.

c) The memory T cells, memory B cells, the long-lived plasma cells, and antibody producing B cells will decrease the response time to antibody production and elimination of the foreign substance.

Learning Objectives:

www.njctl.org  PSI AP Biology  Cells: The Basis of Life
LO 2.29 The student can create representations and models to describe immune responses. [See SP 1.1, 1.2]

LO 2.32 The student is able to use a graph or diagram to analyze situations or solve problems (quantitatively or qualitatively) that involve timing and coordination of events necessary for normal development in an organism. [See SP 1.4]

LO 2.33 The student is able to justify scientific claims with scientific evidence to show that timing and coordination of several events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms. [See SP 6.1]

4. Question 4
   a) The P1 virus or bacteriophages do not contain the DNA sequence that confers antibiotic resistance to chloramphenicol. The P1 particles experiment served as a control to isolate the variable chloramphenicol genes that can give antibiotic resistance or some other factor can be identified.
   b) The plates labeled “None” might be contaminated with some other bacterial strain that found its way past the sterile techniques used in plating bacteria.
   c) This shows that the bacteria have mechanisms to take up DNA from the environment and incorporate the DNA into plasmids or the bacterial chromosome. The viral delivery by injection of the DNA into the bacteria is more efficient.

Learning Objectives:
LO 3.29 The student is able to construct an explanation of how viruses introduce genetic variation in host organisms. [See SP 6.2]

5. Question 5
   a) The pathogens have adaptations that go through the nonspecific plant defenses, such as the cell wall, and deliver effector molecules into the interior of the cell to disrupt receptor-mediated immunity initiation or persistence.
   b) PTI is initiated by cell surface receptors that recognize pathogens in the extracellular environment, while ETI is a secondary response to the presence of foreign proteins or molecules inside the cell; PTI is the primary response because the pathogen will be in the surrounding environment before it comes in contact with plant tissues. ETI is a secondary response due to the lack of effectiveness of the PTI response or to increase the intensity of the overall immune response.
   c) The effectors must prevent the cell signaling pathway from the cell surface receptors to the expression of genes inside the nucleus. The effectors will modify the structures of the cellular products to prevent the proteins from functioning properly.
   d) The cell membrane and cell wall have receptors that sense or bind molecules associated with pathogens; the receptors initiate a cascade of molecular signals or contacts and modifications that signal to molecules in the nucleus to begin producing RNA messages to make proteins that will combat the pathogens at hand. The message must leave the nucleus and be used by ribosomes to make the proteins that the RNA encodes. The ribosomes deliver the proteins to endoplasmic reticulum. The endoplasmic reticulum, sometime using the Golgi, will send the proteins to location that the proteins are designated to function in.

Learning Objectives:
LO 2.29 The student can create representations and models to describe immune responses. [See SP 1.1, 1.2]

LO 4.5 The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions. [See SP 6.2]
LO 4.6 The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions. [See SP 1.4]