

AP BIOLOGY

ESSAY QUESTIONS

1. Discuss the lock-and-key theory of enzyme-substrate interaction giving a specific example to illustrate the theory. Include in your discussion the effects of each of the following:
 - a. Substrate concentration
 - b. pH shifts
 - c. Temperature shifts
 - d. Competitive inhibition
2. Describe in detail the process of meiosis as it occurs in an organism with a diploid chromosome number of 4 ($2n = 4$). Include labeled diagrams in your discussion. Indicate when and how each of the following occurs in meiosis.
 - a. Crossing over
 - b. Nondisjunction
3. In humans, discuss the transport of gases (oxygen and carbon dioxide) by the blood and the exchange of these gases between the blood and cells of the body. Include in your discussion the cellular and fluid composition of the blood.
4. In flowering plants, describe in detail the transport of water, carbohydrates, and inorganic solutes (nitrates, for example). Discuss the theories that have been proposed to explain how these substances are transported.
5. Discuss the significance of each of the events listed below in the evolution of living organisms.
 - a. Primordial reducing atmosphere
 - b. Origin of photosynthesis
 - c. Increase in atmospheric oxygen and the development of the ozone layer.
 - d. Origin of eukaryotes
6. Many areas of North America that were once covered with many small lakes and ponds have undergone succession and are now continuously covered with forests. Give a detailed description of the events (biotic and abiotic factors) that lead to the establishment of a climax forest.

7. Discuss the biological importance of each of the following organic compounds in relation to cellular structure and function in plants and animals.
 - a. Carbohydrates
 - b. Proteins
 - c. Lipids
 - d. Nucleic acids

8. Describe the structural arrangement and function of the membranes associated with each of the following eukaryotic organelles.
 - a. Mitochondrion
 - b. Endoplasmic reticulum
 - c. Chloroplast
 - d. Golgi apparatus

9. Describe the structure and function of the mammalian kidney. Include a discussion of the regulation of water balance by kidney and hormonal interaction.

10. Describe the structure and function of the reflex arc in higher vertebrates. Include a description of the cell types and a discussion of the mechanism of transmission of the impulse.

11. Define, discuss, and give examples of each of the following close interactions of species.
 - a. Predator-prey relationships
 - b. Commensalism
 - c. Mutualism
 - d. Parasitism

12. Define, discuss, and give an example of how each of the following isolating mechanisms contributes to speciation in organisms.
 - a. Geographic barriers
 - b. Ecological (including seasonal) isolation
 - c. Behavioral isolation
 - d. Polyploidy

13. Describe the similarities and differences between the biochemical pathways of aerobic respiration and photosynthesis in eukaryotic cells. Include in your discussion the major reactions, the end products, and energy transfers.

14. A portion of a specific DNA molecule consists of the following sequence of nucleotide triplets.

TAC GGA CTT GGG TCC

The DNA sequence codes for the following short polypeptide.

methionine -- leucine -- glutamic acid -- proline -- arginine

Describe the steps in the synthesis of this polypeptide. What would be the effect of a deletion or an addition in one of the DNA nucleotides? What would be the effect of a substitution in one of the nucleotides?

15. Describe the following mechanisms of response to foreign material in the human body.
- The antigen-antibody response to skin graft from another person.
 - The reactions of the body leading to inflammation of a wound infected with bacteria.
16. In the life cycles of a fern and a flowering plant, compare and contrast each of the following.
- The gametophyte generation
 - Sperm transport and fertilization
 - Embryo protection
17. Describe the special relationship between the two terms in each of the following pairs.
- Convergent evolution of organisms and Australia
 - Blood groups and genetic drift.
 - Birds of prey and DDT
18. Define and explain the role of each of the following in social behavior.
- Territoriality
 - Dominance hierarchies
 - Courtship behavior

19. State the conclusions reached by Mendel in his work on the inheritance of characteristics. Explain how each of the following deviated from these conclusions.
 - a. Autosomal linkage
 - b. Sex-linked (X-linked) inheritance
 - c. Polygenic (multiple-gene) inheritance

20. Describe the fluid mosaic model of the plasma membrane. Discuss the role of the membrane in the movement of materials through it by each of the following processes.
 - a. Active transport
 - b. Passive transport

21. Relate the structure of an angiosperm leaf to each of the following.
 - a. Adaptations for photosynthesis and food storage.
 - b. Adaptations for food translocation and water transport.
 - c. Specialization adaptations to desert environment.

22. Describe the structure of a mammalian respiratory system. Include in your discussion the mechanisms of inspiration and expiration.

23. Describe the trophic levels in a typical ecosystem. Discuss the flow of energy through the ecosystem, the relationship between the different trophic levels, and the factors that limit the number of trophic levels.

24. Describe and give an example of the following. Include in your discussion the selective advantage of each.
 - a. Pheromones
 - b. Mimicry
 - c. Stereotyped behavior (instinct)

25. Describe the structure of a generalized eukaryotic plant cell. Indicate the ways in which a nonphotosynthetic prokaryotic cell would differ in structure from this generalized eukaryotic plant cell.

26. Experiments by the following scientists provided critical information concerning DNA. Describe each classic experiment and indicate how it provided evidence for the chemical nature of the gene.
 - a. Hershey and Chase -- bacteriophage replication
 - b. Griffith and Avery, MacLeod, and McCarty -- bacterial transformation
 - c. Messelson and Stahl -- DNA replication in bacteria

27. Define the following plant responses and explain the mechanism of control for each. Cite experimental evidence as part of your discussion.
- Phototropism
 - Photoperiodism
28. Discuss the sources and actions of each of the following pairs of hormones in humans and describe the feedback mechanisms that control their release.
- Insulin ... glucagon
 - Parathyroid hormone ... calcitonin
 - Thyrotropin (TSH) ... thyroxine (T_4)
29. Describe the modern theory of evolution and discuss how it is supported by evidence from two of the following three areas.
- Population genetics
 - Molecular biology
 - Comparative anatomy and embryology
30. Describe how the following adaptations have increased the evolutionary success of the organisms that possess them. Include in your discussion the structure and function related to each adaptation.
- C_4 metabolism
 - Amniotic egg
 - Four-chambered heart
 - Pollen
31. Describe the chemical composition and configuration of enzymes and discuss the factors that modify enzyme structure and/or function.
32. Describe the operon hypothesis and discuss how it explains the control of messenger-RNA production and the regulation of protein synthesis in bacterial cells.
33. Describe the structure of a bean seed and discuss its germination to the seedling stage. Include in your essay hormonal controls, structural changes, and tissue differentiation.

34. Describe the anatomical and functional similarities and differences within each of the following pairs of structures.
 - a. Artery ... vein
 - b. Small intestine ... colon
 - c. Skeletal muscle ... cardiac muscle
 - d. Anterior pituitary ... posterior pituitary
35. Describe the process of ecological succession from a pioneer community to a climax community. Include in your answer a discussion of species diversity and interactions, accumulation of biomass, and energy flow.
36. Describe releasers, imprinting, and communication, as each of these terms relates to animal behavior. You may include in your answer a discussion of the classical studies of Nikolaas Tinbergen, Konrad Lorenz, and Karl von Frisch.
37. Describe the light reactions of photosynthesis and, for both a C₃ and a C₄ plant, trace the path of a carbon dioxide molecule from the point at which it enters a plant to its incorporation into a glucose molecule. Include leaf anatomy and biochemical pathways in your discussion of each type of plant.
38. Describe the biochemical composition, structure, and replication of DNA. Discuss how recombinant DNA techniques may be used to correct a point mutation.
39. Beginning at the presynaptic membrane of the neuromuscular junction, describe the physical and biochemical events involved in the contraction of a skeletal muscle fiber. Include the structure of the fiber in your discussion.
40. Describe the processes of fat and protein digestion and product absorption as they occur in the human stomach and small intestine. Include a discussion of the enzymatic reactions involved.
41. Describe the processes of speciation. Include in your discussion the factors that may contribute to the maintenance of genetic isolation.
42. Describe the biogeochemical cycles of carbon and nitrogen. Trace these elements from the point of their release from a decaying animal to their incorporation into a living animal.
43. Discuss the process of cell division in animals. Include a description of mitosis and cytokinesis, and of the other phases of the cell cycle. Do NOT include meiosis.

44. Describe the production and processing of a protein that will be exported from a eukaryotic cell. Begin with the separation of the messenger RNA from the DNA template and end with the release of the protein at the plasma membrane.
45. Describe the effects of plant hormones on plant growth and development. Design an experiment to demonstrate the effect of one of these plant hormones on plant growth and development.
46. Discuss the processes of exchange of O₂ and CO₂ that will occur at the alveoli and muscle cells of mammals. Include in your answer a description of the transport of these gases in the blood.
47. After an enzyme is mixed with its substrate, the amount of product formed is determined at 10-second intervals for 1 minute. Data from this experiment are shown below.

Time (sec)	0	10	20	30	40	50	60
Product formed (mg)	0.00	0.25	0.50	0.70	0.80	0.85	0.85

Draw a graph of these data and answer the following questions.

- a. What is the initial rate of this enzymatic reaction?
 - b. What is the rate after 50 seconds? Why is it different from the initial rate?
 - c. What would be the effect on product formation if the enzyme were heated to a temperature of 100°C for 10 minutes before repeating the experiment? Why?
 - d. How might altering the substrate concentration affect the rate of the reaction? Why?
 - e. How might altering the pH affect the rate of the reaction? Why?
48. Discuss Mendel's laws of segregation and independent assortment. Explain how the events of meiosis I account for the observations that led Mendel to formulate these laws.
 49. Trace the pathway in a flowering plant as the water moves from the soil through the tissues of the root, stem, and leaves to the atmosphere. Explain the mechanisms involved in conducting water through these tissues.
 50. Discuss the processes of cleavage, gastrulation, and neurulation in the frog embryo; tell what each process accomplishes. Describe an experiment that illustrates the importance of induction in development.

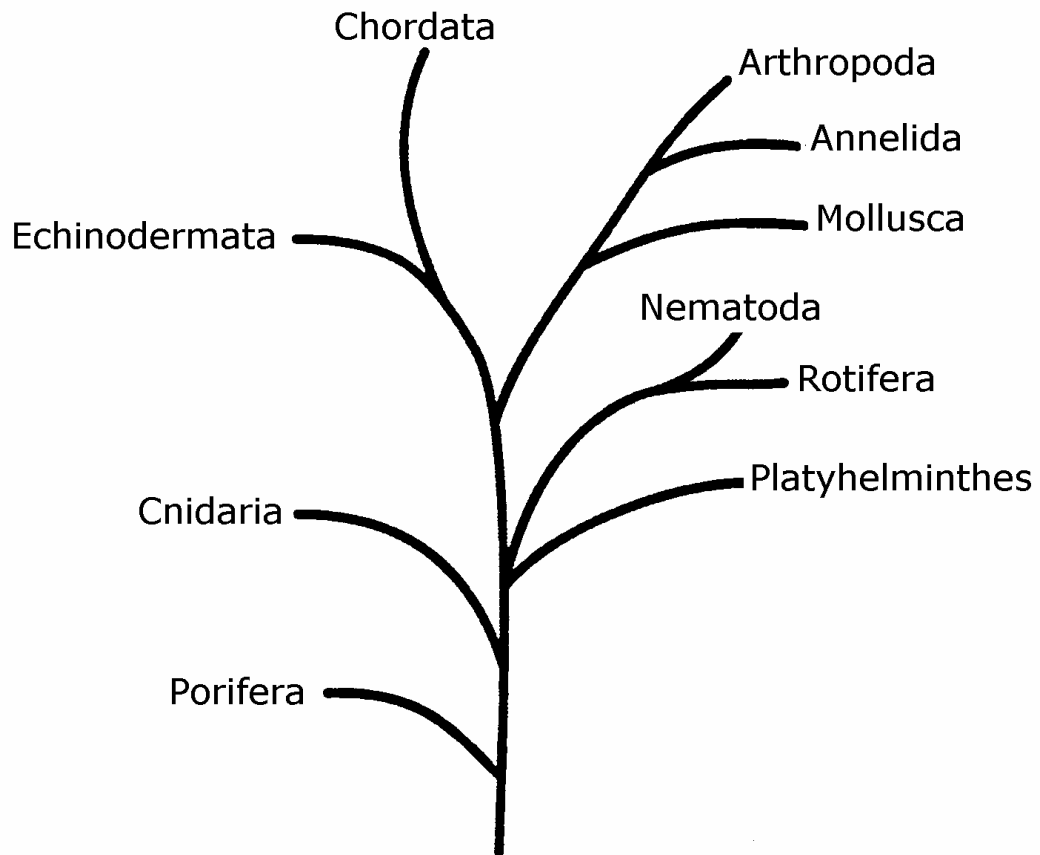
51. Explain what occurs during the Krebs (citric acid) cycle and electron transport by describing the following.
- The location of the Krebs cycle and electron transport chain in the mitochondria.
 - The cyclic nature of the reactions in the Krebs cycle.
 - The production of ATP and reduced coenzymes during the cycle.
 - The chemiosmotic production of ATP during electron transport.
52. Do the following with reference to the Hardy-Weinberg model.
- Indicate the conditions under which allelic frequencies (p and q) remain constant from one generation to the next.
 - Calculate, showing all work, the frequencies of the alleles and the frequencies of the genotypes in a population of 100,000 rabbits, of which 25,000 are white and 75,000 are agouti. (In rabbits the white color is due to a recessive allele, w and agouti is due to a dominant allele, W .)
 - If the homozygous dominant condition were to become lethal, what would happen to the allelic and genotypic frequencies in the rabbit population after two generations?
53. Describe negative and positive feedback loops, and discuss how feedback mechanisms regulate each of the following.
- The menstrual cycle in a nonpregnant human female.
 - Blood glucose levels in humans.
54. Using an example for each, discuss the following ecological concepts.
- Succession
 - Energy flow between trophic levels
 - Limiting factors
 - Carrying capacity

55. The results below are measurements of cumulative oxygen consumption by germinating and dry seeds. Gas volume measurements were corrected for changes in temperature and pressure.

Cumulative Oxygen Consumed (mL)					
Time (minutes)	0	10	20	30	40
22°C Germinating Seeds	0.0	8.8	16.0	23.7	32.0
Dry Seeds	0.0	0.2	0.1	0.0	0.1
10°C Germinating Seeds	0.0	2.9	6.2	9.4	12.5
Dry Seeds	0.0	0.0	0.2	0.1	0.2

- a. Using the graph paper provided, plot the results for the germinating seeds at 22°C and at 10°C.
 - b. Calculate the rate of oxygen consumption for the germinating seeds at 22°C, using the time interval between 10 and 20 minutes.
 - c. Account for the differences in oxygen consumption observed between:
 - (1) germinating seeds at 22°C and at 10°C;
 - (2) germinating seeds and dry seeds.
 - d. Describe the essential features of an experimental apparatus that could be used to measure oxygen consumption by a small organism. Explain why each of these features is necessary.
56. Describe the steps of protein synthesis beginning with the attachment of a messenger RNA molecule to the small subunit of a ribosome and ending with the release of the polypeptide from the ribosome. Include in your answer a discussion of how the different types of RNA function in this process.
57. Discuss the adaptations that have enabled flowering plants to overcome the following problems associated with life on land.
- a. The absence of an aquatic environment for reproduction
 - b. The absence of an aquatic environment to support the plant body
 - c. Dehydration of the plant

58. a. Describe the differences between the terms in each of the following pairs.
- (1) Coelomate *versus* acoelomate body plan
 - (2) Protostome *versus* deuterostome development
 - (3) Radial *versus* bilateral symmetry
- b. Explain how each of these pairs of features was important in constructing the phylogenetic tree shown below. Use specific examples from the tree in your discussion.



59. A group of students designed an experiment to measure transpiration rates in a particular species of herbaceous plant. Plants were divided into four groups and were exposed to the following conditions.

Group I	---	Room conditions (light, low humidity, 20°C, and little air movement)
Group II	---	Room conditions with increased humidity
Group III	---	Room conditions with increased air movement (fan)
Group IV	---	Room conditions with additional light

The cumulative water loss due to transpiration of water from each plant was measured at 10-minute intervals for 30 minutes. Water loss was expressed as milliliters of water per square centimeter of leaf surface area. The data for all plants in Group I (room conditions) were averaged. The average cumulative water loss by the plants in Group I is presented in the table below.

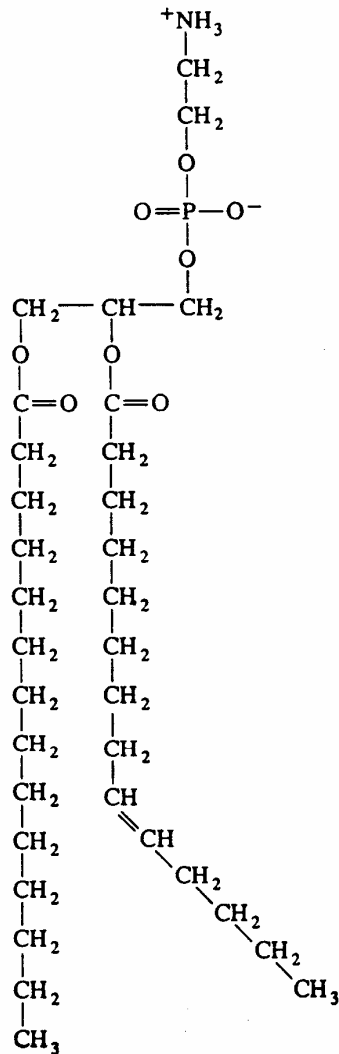
Average Cumulative Water Loss by the Plants in Group I	
Time (minutes)	Average Cumulative Water Loss (mL H₂O / cm²)
10	3.5×10^{-4}
20	7.7×10^{-4}
30	10.6×10^{-4}

- Construct and label a graph using the data for Group I. Using the same set of axes, draw and label three additional lines representing the results that you would predict for Groups II, III, and IV.
- Explain how biological and physical processes are responsible for the differences between each of your predictions and the data for Group I.
- Explain how the concept of water potential is used to account for the movement of water from the plant stem to the atmosphere during transpiration.

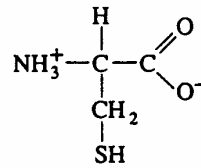
60. Carbon is a very important element in living systems.

- Describe the various characteristics of the carbon atom that make possible the building of a variety of biological molecules.
- Explain how reactions involving carbon-containing compounds can contribute to the greenhouse effect.
- The following structures are examples of two different categories of biological compounds. Describe how each category of compounds is important of the structure and function of living systems.

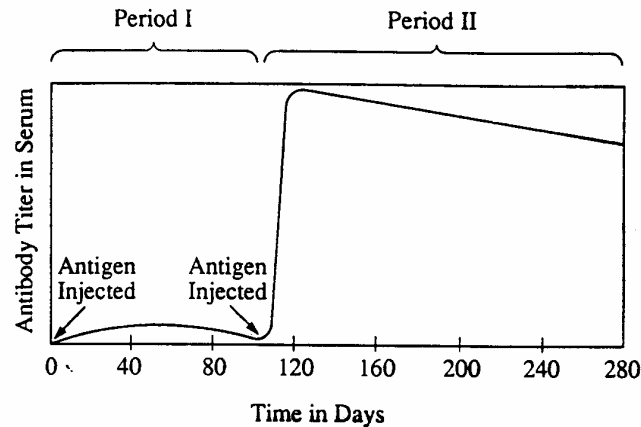
Category I



Category II



61. The graph below shows the response of the human immune system to exposure to an antigen. Use this graph to answer part a and b of this question.
- Describe the events that occur during period I as the immune system responds to the initial exposure to the antigen.
 - Describe the events that occur during period II following a second exposure to the same antigen.



- Explain how infection by the AIDS virus (HIV) affects the function of both T and B lymphocytes.
62. Discuss how each of the following has contributed to the evolutionary success of the organisms in which they are found.
- Seeds
 - Mammalian placenta
 - Diploidy
63. A laboratory assistant prepared solutions of $0.8M$, $0.6M$, $0.4M$, and $0.2M$ sucrose, but forgot to label them. After realizing the error, the assistant randomly labeled the flasks containing these four unknown solutions as Flask A, Flask B, Flask C, and Flask D.

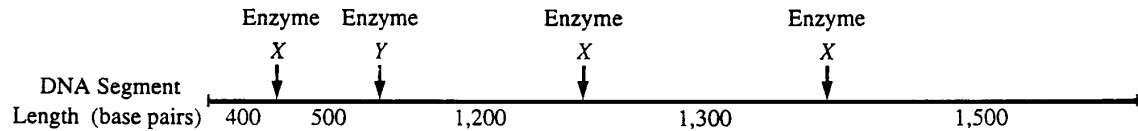
Design an experiment, based on the principles of diffusion and osmosis, that the assistant could use to determine which of the flasks contain each of the four unknown solutions. Include in your answer (a) a description of how you would set up and perform the experiment; (b) the results you would expect from your experiment; and (c) an explanation of those results based on the principles involved. (Be sure to clearly state the principles addressed in your discussion.)

64. Biological recognition is important in many processes at the molecular, cellular, tissue, and organismal levels. Select three of the following, and for each of the three that you have chosen, explain how the process of recognition occurs and give an example.
- Organisms recognize others as members of their own species.
 - Neurotransmitters are recognized in the synapse.
 - Antigens trigger antibody responses.
 - Nucleic acids are complementary.
 - Target cells respond to specific hormones.
65. Survival depends on the ability of an organism to respond to changes in its environment. Some plants flower in response to changes in day length. Some mammals may run or fight when frightened. For both of these examples, describe the physiological mechanisms involved in the response.
66. Evolution is one of the major unifying concepts of modern biology.
- Explain the mechanisms that lead to evolutionary change.
 - Describe how scientists use each of the following as evidence for evolution.
 - Bacterial resistance to antibiotics
 - Comparative biochemistry
 - The fossil record
67. Membranes are important structural features of cells.
- Describe how membrane structure is related to the transport of materials across a membrane.
 - Describe the role of membranes in the synthesis of ATP in either cellular respiration or photosynthesis.
68. Living organisms play an important role in the recycling of many elements within an ecosystem. Discuss how various types of organisms and their biochemical reactions contribute to the recycling of either carbon or nitrogen in an ecosystem. Include in your answer one way in which human activity has an impact on the nutrient cycle you have chosen.
69. Many physiological changes occur during exercise.
- Design a controlled experiment to test the hypothesis that an exercise session causes short-term increases in heart rate and breathing rate in humans.
 - Explain how at least three organ systems are affected by this increased physical activity and discuss interactions among these systems.

70. Assume that a particular genetic condition in a mammalian species causes an inability to digest starch. This disorder occurs with equal frequency in males and females. In most cases, neither parent of affected offspring has the condition.
- (a) Describe the most probable pattern of inheritance for this condition. Explain your reasoning. Include in your discussion a sample cross(es) sufficient to verify your proposed pattern.
 - (b) Explain how mutation could cause this inability to digest starch.
 - (c) Describe how modern techniques of molecular biology could be used to determine whether the mutant allele is present in a given individual.
71. Genetic variation is the raw material for evolution.
- a. Explain **three** cellular and/or molecular mechanisms that introduce variation into the gene pool of a plant or animal population.
 - b. Explain the evolutionary mechanisms that can change the composition of the gene pool.
72. Discuss how cellular structures, including the plasma membrane, specialized endoplasmic reticulum, cytoskeletal elements, and mitochondria, function together in the contraction of skeletal muscle cells.
73. Enzymes are biological catalysts.
- a. Relate the chemical structure of an enzyme to its specificity and catalytic activity.
 - b. Design a quantitative experiment to investigate the influence of pH **or** temperature on the activity of an enzyme.
 - c. Describe what information concerning the structure of an enzyme could be inferred from your experiment.
74. Select **two** of the following three pairs and discuss the evolutionary relationships between the two members each pair you have chosen. In your discussion include structural adaptations and their functional significance.
- PAIR A: green algae
 vascular plants
- PAIR B: prokaryotes
 eukaryotes
- PAIR C: amphibians
 Reptiles

75. Angiosperms (flowering plants) and vertebrates obtain nutrients from their environment in different ways.
- (A) Discuss the type of nutrition and the nutritional requirements of angiosperms and vertebrates.
 - (B) Describe 2 structural adaptations in angiosperms for obtaining nutrients from the environment. Relate structure to function.
 - (C) Interdependence in nature is evident in symbiosis. Explain two symbiotic relationships that aid in nutrient uptake, using examples from angiosperms and/or vertebrates. (Both examples may be angiosperms, both may be vertebrates, or one may be from each group.)
76. The problems of survival of animals on land are very different from those of survival of animals in an aquatic environment. Describe four problems associated with animal survival in terrestrial environments but not in aquatic environments. For each problem, explain an evolutionary solution.
77. Energy transfer occurs in all cellular activities. For 3 of the following 5 processes involving energy transfer, explain how each functions in the cell and give an example. Explain how ATP is involved in each example you choose.
- Cellular movement
 - Active transport
 - Synthesis of molecules
 - Chemiosmosis
 - Fermentation

78. The diagram below shows a segment of DNA with a total length of 4,900 base pairs. The arrows indicate reaction sites for two restriction enzymes (enzyme X and enzyme Y).



- (A) Explain how the principles of gel electrophoresis allow for the separation of DNA fragments.
- (B) Describe the results you would expect from the electrophoretic separation of fragments from the following treatments of the DNA segment above. Assume that the digestion occurred under appropriate conditions and went to completion.
- I. DNA digested with only enzyme X
 - II. DNA digested with only enzyme Y
 - III. DNA digested with enzyme X and enzyme Y combined
 - IV. Undigested DNA
- (C) Explain both of the following.
- (1) The mechanism of action of restriction enzymes.
 - (2) The different results you would expect if a mutation occurred at the recognition site for enzyme Y.
79. The unique properties (characteristics) of water make life possible on Earth. Select three properties of water and:
- a) for each property, identify and define the property and explain it in terms of the physical / chemical nature of water.
 - b) For each property, describe one example of how the property affects the functioning of living organisms.

80. Structure and function are related in the various organ systems of animals. Select two of the following four organ systems in vertebrates:

- Respiratory
- Digestive
- Excretory
- Nervous

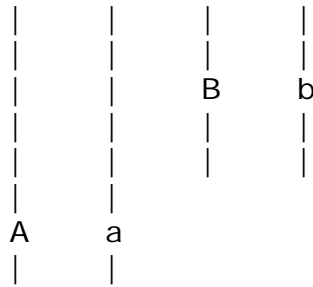
For each of the two systems you choose, discuss the structure and function of two adaptations that aid in the transport or exchange of molecules (or ions). Be sure to relate structure to function in each example.

81. Numerous environmental variables influence plant growth. Three students each planted a seedling of the same genetic variety in the same type of container with equal amounts of soil from the same source. Their goal was to maximize their seedling's growth by manipulating environmental conditions. Their data are shown below:

	Plant Seedling Mass (grams)	
	<u>Day 1</u>	<u>Day 30</u>
Student A	4	24
Student B	5	35
Student C	4	64

- Identify three different environmental variables that could account for differences in the mass of the seedlings at day 30. Then choose one of these variables and design an experiment to test the hypothesis that your variable affects growth of these seedlings.
- Discuss the results you would expect if your hypothesis is correct. Then provide a physiological explanation for the effect of your variable on plant growth.

82. An organism is heterozygous at two genetic loci on different chromosomes.



- Explain how these alleles are transmitted by the process of mitosis to daughter cells.
- Explain how these alleles are distributed by the process of meiosis to gametes
- Explain how the behavior of these two pairs of homologous chromosomes during meiosis provides the physical basis for Mendel's two laws of inheritance.

Labeled diagrams that are explained in your answer may be useful.

83. Photosynthesis and cellular respiration recycle oxygen in ecosystems. Respond to TWO (and only two) of the following:

- Explain how the metabolic processes of cellular respiration and photosynthesis recycle oxygen.
- Discuss the structural adaptations that function in oxygen exchange between each of the following organisms and its environment: a plant; an insect; a fish.
- Trace a molecule of O_2 from the environment to a muscle cell in a vertebrate of your choice.

84. The survival of organisms depends on regulatory mechanisms at various levels. Choose THREE from the following examples. Explain how each is regulated

- The expression of a gene
- The activity of an enzyme
- The cell cycle
- The internal water balance of a plant
- The density of a population

85. A scientist working with *Bursatella leachii*, a sea slug that lives in an intertidal habitat in the coastal waters of Puerto Rico, gathered the following information about the distribution of the sea slugs within a ten-meter square plot over a 10-day period.

DISTRIBUTION OF SLUGS WITHIN A TEN-METER SQUARE PLOT

<u>Time of Day</u>	<u>Average Distance Between Individuals (cm)</u>
Midnight	8.0
4 A.M.	8.9
8 A.M.	44.8
Noon	174.0
4 P.M.	350.5
8 P.M.	60.5
Midnight	8.0

- a. For the data above, provide information on each of the following.
- Summarize the pattern.
 - Identify THREE physiological or environmental variables that could cause the slugs to vary their distance from each other.
 - Explain how each variable could bring about the observed pattern of distribution.
- b. Choose ONE of the variables that you identified and design a controlled experiment to test your hypothetical explanation. Describe results that would support or refute your hypothesis.

86. In a laboratory population of diploid, sexually reproducing organisms a certain trait is studied. This trait is determined by a single autosomal gene and is expressed as two phenotypes. A new population was created by crossing 51 pure breeding (homozygous) dominant individuals with 49 pure breeding (homozygous) recessive individuals. After four generations, the following results were obtained.

NUMBER OF INDIVIDUALS

Generation	Dominant	Recessive	Total
1	51	49	100
2	280	0	280
3	240	80	320
4	300	100	400
5	360	120	480

- a. Identify an organism that might have been used to perform this experiment and explain why this organism is a good choice for conducting this experiment.
- b. On the basis of the data, propose a hypothesis that explains the change in the phenotypic frequency between generation 1 and generation 3.
- c. Is there evidence indicating whether or not this population is in Hardy-Weinberg equilibrium? Explain.
87. Cells transport substances across their membranes. Choose THREE of the following four types of cellular transport.
- Osmosis
 - Active transport
 - Facilitated diffusion
 - Endocytosis/exocytosis

For each of the three transport types you choose,

- a) describe the transport process and explain how the organization of cell membranes functions in the movement of specific molecules across the membrane; and
- b) explain the significance of each type of transport to a specific cell (you may use different cell types as examples.)

88. By using the techniques of genetic engineering, scientists are able to modify genetic material so that a particular gene of interest from one cell can be incorporated into a different cell.

- Describe a procedure by which this can be done.
- Explain the purpose of each step of your procedure.
- Describe how you could determine whether the gene was successfully incorporated.

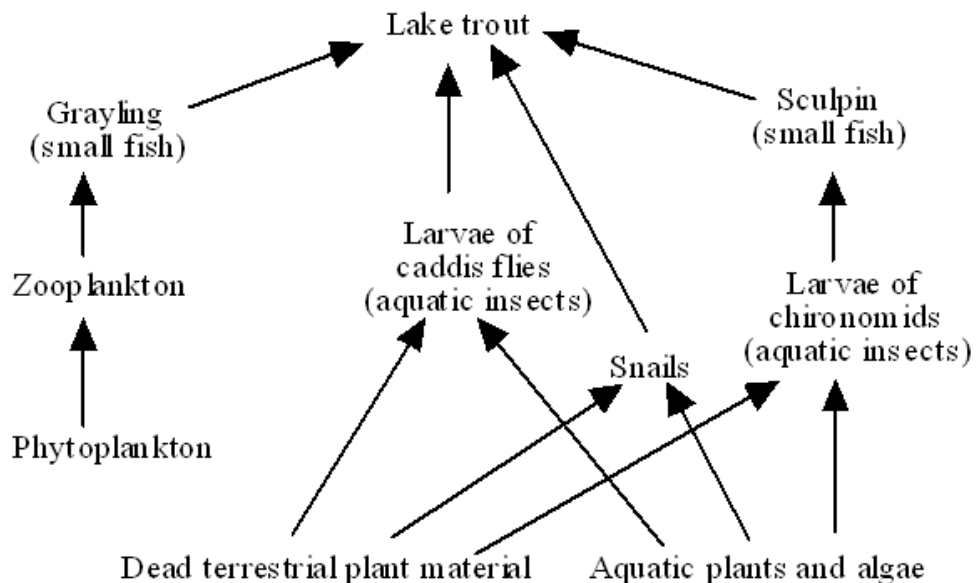
Describe an example of how gene transfer and incorporation have been used in a biomedical or commercial application.

89. The evolutionary success of organisms depends on reproduction. Some groups of organisms reproduce asexually, some reproduce sexually, while others reproduce both sexually and asexually.

- a) Using **THREE** different organisms, give an example of one organism that reproduces sexually, one that reproduces asexually, and one that reproduces BOTH sexually and asexually. For each organism given as an example, describe two reproductive adaptations. These adaptations may be behavioral, structural, and/or functional.
- b) What environmental conditions would favor sexual reproduction? Explain. What environmental conditions would favor asexual reproduction? Explain.

90. Interdependence in nature is illustrated by the transfer of energy through trophic levels. The diagram below depicts the transfer of energy in a food web of an arctic lake located in Alaska.

- Choosing organisms from four different trophic levels of this food web as examples, explain how energy is obtained at each trophic level.
- Describe the efficiency of energy transfer between trophic levels and discuss how the amount of energy available at each trophic level affects the structure of the ecosystem.
- If the cells in the dead terrestrial plant material that washed into the lake contained a commercially produced toxin, what would be the likely effects of this toxin on this food web? Explain.



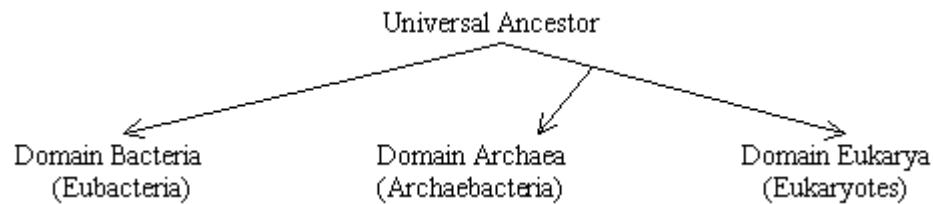
91. The rate of photosynthesis may vary with changes that occur in environmental temperature, wavelength of light, and light intensity. Using a photosynthetic organism of your choice, choose only ONE of the three variables (temperature, wavelength of light, or light intensity) and for this variable

- design** a scientific experiment to determine the effect of the variable on the rate of photosynthesis for the organism;
- explain** how you would measure the rate of photosynthesis in your experiment;
- describe** the results you would expect. **Explain** why you would expect these results.

92. Communication occurs among the cells in a multicellular organism. Choose THREE of the following examples of cell-to-cell communication, and for each example, **describe** the communication that occurs and the types of responses that result from this communication.

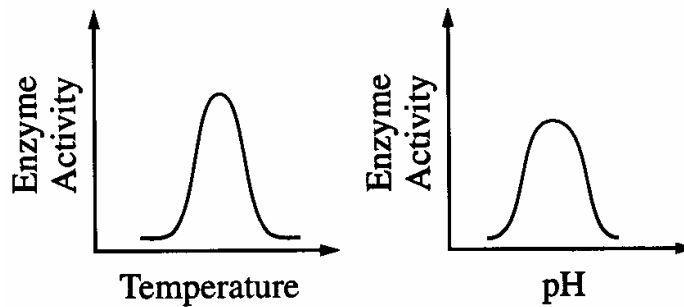
- Communication between two plant cells
- Communication between two immune-system cells
- Communication **either** between a neuron and another neuron, **or** between a neuron and a muscle cell
- Communication between a specific endocrine-gland cell and its target cell

93. Scientists recently have proposed a reorganization of the phylogenetic system of classification to include the domain, a new taxonomic category higher (more inclusive) than the Kingdom category, as shown in the following diagram.



- **Describe** how this classification scheme presents different conclusions about the relationships among living organisms than those presented by the previous five-kingdom system of classification.
 - **Describe** three kinds of evidence that were used to develop the taxonomic scheme above, and explain how this evidence was used. The evidence may be structural, physiological, molecular, and/or genetic.
 - **Describe** four of the characteristics of the universal ancestor.
94. Scientists seeking to determine which molecule is responsible for the transmission of characteristics from one generation to the next knew that the molecule must (1) copy itself precisely, (2) be stable but able to be changed, and (3) be complex enough to determine the organism's phenotype.
- **Explain** how DNA meets each of the three criteria stated above.
 - Select **one** of the criteria stated above and **describe** experimental evidence used to determine that DNA is the hereditary material.

95. The effects of pH and temperature were studied for an enzyme-catalyzed reaction. The following results were obtained.



- a) How do (1) temperature and (2) pH affect the activity of this enzyme? In your answer, include a discussion of the relationship between the structure and the function of this enzyme, as well as a discussion of how structure and function of enzymes are affected by temperature and pH.
- b) Describe a controlled experiment that could have produced the data shown for either temperature or pH. Be sure to state the hypothesis that was tested here.
96. Feedback mechanisms are used by organisms to maintain the steady-state physiological condition known as homeostasis. Choose **three** of the following and for each, explain how feedback mechanisms maintain homeostasis.
- Blood glucose concentration.
 - Calcium ion concentration in blood.
 - Body temperatures in mammals.
 - Osmolarity of the blood.
 - Pulse rate in mammals.
97. Information transfer is fundamental to all living organisms. For **two** of the following examples, explain in detail how the transfer of information is accomplished.
- The genetic material in one eukaryotic cell is copied and distributed to two identical daughter cells
 - A gene in a eukaryotic cell is transcribed and translated to produce a protein
 - The genetic material from one bacterial cell enters another via transformation, transduction, **or** conjugation

98. To survive, organisms must be capable of avoiding, and/or defending against, various types of environmental threats. Respond to **each** of the following.
- Describe how adaptive coloration, mimicry, **or** behavior function as animal defenses against predation. Include **two** examples in your answer.
 - Describe how bacteria **or** plants protect themselves against environmental threats. Include **two** examples in your answer.
 - Compare the human primary immune response with the secondary immune response to the same antigen.
99. In biological systems, structure and function are related. Choose three of the following components of organ systems.
- | | |
|-----------|-----------|
| alveolus | villus |
| sarcomere | capillary |
| nephron | neuron |
- For each component, **describe** the structure of the component and **explain** how that structure is responsible for the function of that component.
 - For the three components that you chose in part a, **explain** how the structure of the component contributes to the functioning of the organ system to which it belongs.
100. Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he traveled and collected specimens in South America and on the Galapagos Islands.
- Explain** the theory of evolution by natural selection as presented by Darwin.
 - Each of the following relates to an aspect of evolution by natural selection. **Explain** three of the following.
 - Convergent evolution and the similarities among species (ecological equivalents) in a particular biome (e.g. tundra, taiga, etc.)
 - Natural selection and the formation of insecticide-resistant insects or antibiotic-resistant bacteria.
 - Speciation and isolation.
 - Natural selection and behavior such as kinesis, fixed-action-pattern, dominance hierarchy, etc.
 - Natural selection and heterozygotes advantage.

101. A biologist measured dissolved oxygen in the top 30 centimeters of a moderately eutrophic (mesotrophic) lake in the temperate zone. The day was bright and sunny, and the wind was calm. The results of the observations are presented below.

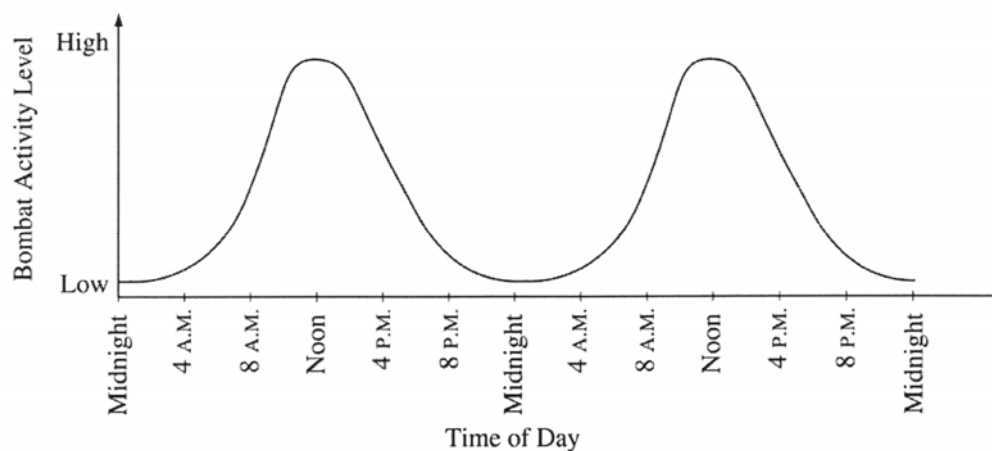
Hour	[O ₂]
6:00 am	0.9 mg/L
8:00 am	1.7 mg/L
10:00 am	3.1 mg/L
12:00 am	4.9 mg/L
2:00 pm	6.8 mg/L
4:00 pm	8.1 mg/L
6:00 pm	7.9 mg/L
8:00 pm	6.2 mg/L
10:00 p.m.	4.0 mg/L
12:00 midnight	2.4 mg/L

- (a) Using the graph paper provided, **plot** the results that were obtained. Then, using the same set of axes, draw and label an additional line/curve representing the results that you would predict had the day been heavily overcast.
- (b) **Explain** the biological processes that are operating in the lake to produce the observed data. **Explain** also how these processes would account for your prediction of results for a heavily overcast day.
- (c) **Describe** how the introduction of high levels of nutrients such as nitrates and phosphates into the lake would affect subsequent observations. **Explain** your prediction.
102. Proteins—large complex molecules—are major building blocks of all living organisms. Discuss the following in relation to proteins.
- (a) The chemical composition and levels of structure of proteins.
- (b) The roles of DNA and RNA in protein synthesis.
- (c) The roles of proteins in membrane structure and transport of molecules across the membrane.

103. The human genome illustrates both continuity and change.

- (a) Describe the essential features of two of the procedures/techniques below. For each of the procedures/techniques you describe, explain how its application contributes to understanding genetics.
- The use of a bacterial plasmid to clone and sequence a human gene
 - Polymerase chain reaction (PCR)
 - Restriction fragment length polymorphism (RFLP) analysis
- (b) All humans are nearly identical genetically in coding sequences and have many proteins that are identical in structure and function. Nevertheless, each human has a unique DNA fingerprint. Explain this apparent contradiction.

104. The activities of organisms change at regular time intervals. These changes are called biological rhythms. The graph depicts the activity cycle over a 48-hour period for a fictional group of mammals called pointy-eared bombats, found on an isolated island in the temperate zone.



- (a) Describe the cycle of activity for the bombats. Discuss how three of the following factors might affect the physiology and/or behavior of the bombats to result in this pattern of activity.
- temperature
 - food availability
 - presence of predators
 - social behavior
- (b) Propose a hypothesis regarding the effect of light on the cycle of activity in bombats. Describe a controlled experiment that could be performed to test this hypothesis, and the results you would expect.

105. The complexity of structure and function varies widely across the animal kingdom. Despite this variation, animals exhibit common processes. These include the following:

- transport of materials
- response to stimuli
- gas exchange
- locomotion

(a) Choose two of the processes above and for each, describe the relevant structures and how they function to accomplish the process in the following phyla:

Cnidaria (e.g. hydra, jellyfish)
 Annelida (e.g. earthworm)
 Chordata (e.g. mouse)

(b) Explain the adaptive (evolutionary) value(s) of the structural examples you described in part a.

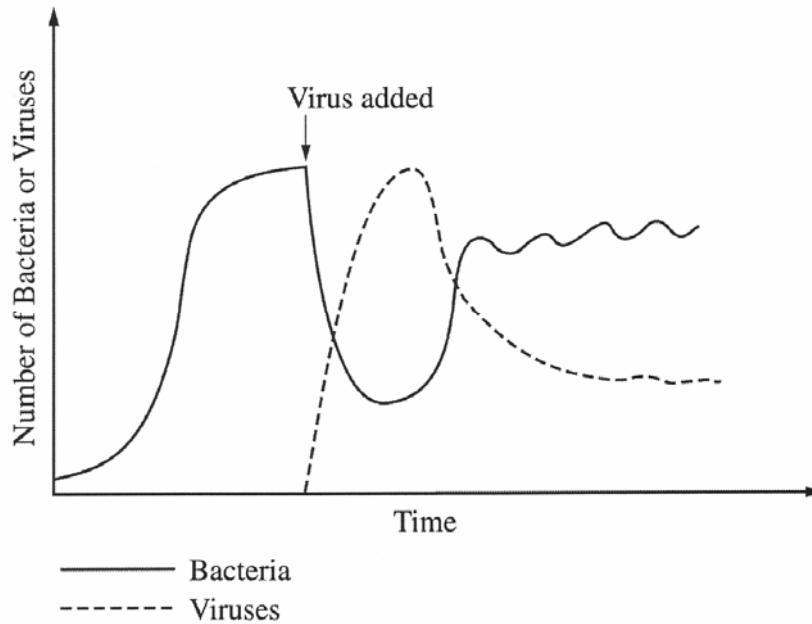
106. The following experiment was designed to test whether different concentration gradients affect the rate of diffusion. In this experiment, four solutions (0% NaCl, 1% NaCl, 5% NaCl, and 10% NaCl) were tested under identical conditions. Fifteen milliliters (mL) of 0% NaCl were put into a bag formed of dialysis tubing that is permeable to Na⁺, Cl⁻, and water. The same was done for each NaCl solution. Each bag was submerged in a separate beaker containing 300 mL of distilled water. The concentration of NaCl in mg/L in the water outside each bag was measured at 40-second intervals. The results from the 5% bag are shown in the table below.

Concentration in mg/mL of NaCl Outside the 5% NaCl Bag

Time (seconds)	NaCl (mg/L)
0	0
40	130
80	220
120	320
160	400

- (a) On the axes provided, graph the data for the 5% NaCl solution.
- (b) Using the same set of axes, draw and label three additional lines representing the results that you would predict for the 0% NaCl, 1% NaCl, and 10% NaCl solutions. Explain your predictions.
- (c) Farmlands located near coastal regions are being threatened by encroaching seawater seeping into the soil. In terms of water movement into or out of plant cells, explain why seawater could decrease crop production. Include a discussion of water potential in your answer.

107. Bacteria were cultured in a system that allowed for the continual addition of fresh nutrients and the removal of waste products. Bacteriophage (virus) were added at the time shown and the following population changes were observed.



- (c) Describe and explain the observed results.
- (d) Discuss the infection cycle of a DNA virus from attachment to lysis.
- (e) Describe how the genome of a retrovirus like HIV (Human Immunodeficiency Virus) becomes incorporated into the genome of the host cell.

108. In mammals, heart rate during periods of exercise is linked to the intensity of exercise.
- (c) Discuss the interactions of the respiratory, circulatory, and nervous systems during exercise.
 - (d) Design a controlled experiment to determine the relationship between intensity of exercise and heart rate.
 - (e) On the axes provided below, indicate results you expect for both the control and the experimental groups for the controlled experiment you described in part B. Remember to label the axes.

109. The physical form of cells and organisms is often influenced by special structural polymers. Chose one polymer from each of the following three pairs of polymers:

Pair 1: tubulin...myosin

Pair 2: cellulose...chitin

Pair 3: messenger RNA...transfer RNA

For each of the three polymers you have chosen, describe its

- (d) structure, and
 - (e) role in a cell or organism.
110. A triploblastic animal is one in which three germ layers form during embryonic development. Triploblastic animals include acoelomate, pseudocoelomate, and coelomate (eucoelomate) organisms.
- (a) Identify the three germ layers of a triploblastic embryo and discuss the fates of these germ layers in embryonic development.
 - (b) Describe acoelomate, pseudocoelomate, and coelomate body plans. Identify an animal that is representative of each of these types of body plan.
 - (c) Compare and contrast the digestive systems of an acoelomate and a coelomate organism.

111. In fruit flies, the phenotype for eye color is determined by a certain locus. **E** indicates the dominant allele and **e** indicates the recessive allele. The cross between a male wild-type fruit fly and a female white-eyed fruit fly produced the following offspring.

	Wild-type Male	Wild-type Female	White-eyed Male	White-eyed Female	Brown-eyed Female
F1	0	45	55	0	1

The wild-type and white-eyed individuals from the F1 generation were then crossed to produce the following offspring

	Wild-type Male	Wild-type Female	White-eyed Male	White-eyed Female	Brown-eyed Female
F2	23	31	22	24	0

- Determine the genotypes of the original parents (P generation) and explain your reasoning. You may use Punnett squares to enhance your description, but the results from the Punnett squares must be discussed in your answer.
- Use a Chi-square test on the F2 generation data to analyze your prediction of the parental genotypes. Show all your work and explain the importance of your final answer.
- The brown-eyed female in the F1 generation resulted from a mutational change. Explain what a mutation is, and discuss two types of mutations that might have produced the brown-eyed female in the F1 generation.

Critical Values of the Chi-Squared Distribution

Probability (p)	Degrees of Freedom (df)				
	1	2	3	4	5
0.05	3.84	5.99	7.82	9.49	11.1

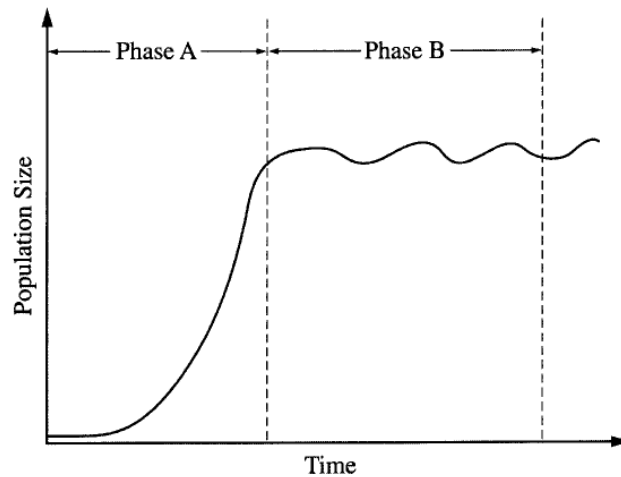
$$\chi^2 = \sum \left[\frac{(o - e)^2}{e} \right]$$

where o = **observed** number of individuals
 e = **expected** number of individuals
 Σ = the **sum of the values** (in this case, the differences, squared, divided by the number expected)

112. Regulatory (control) mechanisms in organisms are necessary for survival. Choose **THREE** of the following examples and explain how each is **regulated**.

- (i) Flowering in plants.
- (ii) Water balance in plants
- (iii) Water balance in terrestrial vertebrates
- (iv) Body temperature in terrestrial vertebrates

113. Many populations exhibit the following growth curve:



- (a) Describe what is occurring in the population during Phase A.
- (b) Discuss **THREE** factors that might cause the fluctuations shown in Phase B.
- (c) Organisms demonstrate exponential (r) or logistic (K) reproductive strategies. Explain these two strategies and discuss how they affect population size over time.

114. Death is a natural and necessary part of life cycles at all levels of organization.

- (a) Discuss **TWO** examples of how cell death affects the development and functioning of a multicellular organism.
- (b) Discuss **ONE** example of how substances are degraded and reused in cells.
- (c) Discuss the evolutionary significance of death.

115. A difference between prokaryotes and eukaryotes is seen in the organization of their genetic material.
- Discuss** the organization of the genetic material in prokaryotes and eukaryotes.
 - Contrast** the following activities in prokaryotes and eukaryotes:
 - Replication of DNA
 - Transcription or translation
 - Gene regulation
 - Cell division
116. Hormones play important roles in regulating the lives of many living organisms.
- For TWO of the following physiological responses, **explain** how hormones cause the response in plants.
 - increase in height
 - adjustment to change in light
 - adjustment to lack of water
 - For TWO of the following physiological responses, **explain** how hormones cause the response in animals.
 - increase in height
 - adjustment to change in light
 - adjustment to lack of water
 - Describe** TWO different mechanisms by which hormones cause their effects at the cellular level.
117. Water is important for all living organisms. The functions of water are directly related to its physical properties.
- Describe** how the properties of water contribute to TWO of the following.
 - transpiration
 - thermoregulation in endotherms
 - plasma membrane structure
 - Water serves as a reactant and a product in the carbon cycle. **Discuss** the role of water in the carbon cycle.
 - Discuss** the impact of one human activity on the water cycle.

118. Biologists are interested in preserving the diversity of living organisms on the planet.
- (a) **Explain** THREE of the following processes or phenomena, using an appropriate example for each.
- mutation
 - adaptive radiation
 - polyploidy
 - population bottlenecks
 - growth of the human population
- (b) For each process or phenomenon you selected in (a), **discuss** its impact on the diversity of life on Earth.
119. Meiosis reduces chromosome number and rearranges genetic information.
- (a) **Explain** how the reduction and rearrangement are accomplished in meiosis.
- (b) Several human disorders occur as a result of defects in the meiotic process. **Identify** ONE such chromosomal abnormality; what effects does it have on the phenotype of people with the disorder? **Describe** how this abnormality could result from a defect in meiosis.
- (c) Production of offspring by parthenogenesis or cloning bypasses the typical meiotic process. **Describe** either parthenogenesis or cloning and **compare** the genomes of the offspring with those of the parents.
120. Darwin is considered the “father of evolutionary biology.” Four of his contributions to the field of evolutionary biology are listed below.
- The nonconstancy of species
 - Branching evolution, which implies the common descent of all species
 - Occurrence of gradual changes in species
 - Natural selection as the mechanism for evolution
- (a) For EACH of the four contributions listed above, **discuss** one example of supporting evidence.
- (b) Darwin’s ideas have been enhanced and modified as new knowledge and technologies have become available. **Discuss** how TWO of the following have modified biologists’ interpretation of Darwin’s original contributions.
- Hardy-Weinberg equilibrium
 - Punctuated equilibrium
 - Genetic engineering

121. A controlled experiment was conducted to analyze the effects of darkness and boiling on the photosynthetic rate of incubated chloroplast suspensions. The dye reduction technique was used. Each chloroplast suspension was mixed with DPIP, an electron acceptor that changes from blue to clear when it is reduced. Each sample was placed individually in a spectrophotometer and the percent transmittance was recorded. The three samples used were prepared as follows.

- Sample 1 – chloroplast suspension + DPIP
- Sample 2 – chloroplast suspension surrounded by foil wrap to provide a dark environment + DPIP
- Sample 3 – chloroplast suspension that has been boiled + DPIP

Percent Transmittance in Three Samples

Time (min)	Light, Unboiled % Transmittance Sample 1	Dark, Unboiled % Transmittance Sample 2	Light, Boiled % Transmittance Sample 3
0	28.8	29.2	28.8
5	48.7	30.1	29.2
10	57.8	31.2	29.4
15	62.5	32.4	28.7
20	66.7	31.8	28.5

- On the graph provided, **construct** and **label** a graph showing the results for the three samples.
- Identify** and **explain** the control or controls for this experiment.
- The differences in the curves of the graphed data indicate that there were differences in the number of electrons produced in the three samples during the experiment. **Discuss** how electrons are generated in photosynthesis and why the three samples gave different transmittance results.

122. Organisms rarely exist alone in the natural environment. The following are five examples of symbiotic relationships.

- Plant root nodules
- Digestion of cellulose
- Epiphytic plants
- AIDS (acquired immune deficiency syndrome)
- Anthrax

Choose FOUR of the above and for each example chosen.

- identify** the participants involved in the symbiosis and describe the symbiotic relationship, and
- discuss** the specific benefit or detriment, if any, that each participant receives from the relationship.

123. Prokaryotes are found throughout the biosphere. Answer two of the following.
- Provide three examples of adaptations found in various prokaryotes. Explain how these three adaptations have ensured the success of prokaryotes.
 - Discuss how prokaryotes early in Earth's history altered environments on Earth.
 - Discuss three ways in which prokaryotes continue to have ecological impact today.

124. In most aquatic environments, primary production is affected by the light available to the community of organisms.

Using measurements of dissolved oxygen concentration to determine primary productivity, design a controlled experiment to test the hypothesis that primary productivity is affected by either the intensity **or** the wavelength of light. In your answer, be sure to include the following.

- A statement of the specific hypothesis that you are testing.
- A description of your experimental design (Be sure to include a description of what data you would collect and how you would present and analyze the data using a graph.)
- A description of results that would support your hypothesis.

125. Homeostasis, maintaining a steady-state internal environment, is a characteristic of all living organisms. Choose three of the following physiological parameters and for each, describe how homeostasis is maintained in an organism of your choice. Be sure to indicate what animal you have chosen for each parameter. You may use the same animal or different animals for your three descriptions.

- Blood-glucose levels
- Body temperature
- pH of the blood
- Osmotic concentration of the blood
- Neuron resting-membrane potential

126. Organisms differ from one another and yet share characteristics.
- Select two kingdoms and briefly describe three characteristics used to distinguish between members of one kingdom and members of the other.
 - Describe three characteristics (at least one molecular and one cellular) that members of these two kingdoms share.
 - Propose an explanation for the existence of similarities and differences between the two kingdoms.