

AP Biology Essay Questions

The following is a comprehensive list of essay questions that have been asked on past AP exams. The questions are organized according to units. The lab-based questions have been removed.

Unit 1 (Basic Chemistry and Water)

1. 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.

Unit 2 (Organic Chemistry, Biochemistry, and Metabolism)

2. Describe the chemical composition and configuration of enzymes and discuss the factors that modify enzyme structure and/or function.
4. 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 experiments.

Unit 3 (Cell Structure and Function, Cell division)

5. Describe the fluid-mosaic model of a 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

6. Describe the structure of a eukaryotic plant cell. Indicate the ways in which a non-photosynthetic prokaryotic cell would differ in structure from this generalized eukaryotic plant cell.

7. 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.

9. 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 membranes; and
- b Explain the significance of each type of transport to a specific cell (you may use different cell types as examples.)

Unit 4 (Photosynthesis and Cellular Respiration)

10. 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.

12. 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.

13. Explain what occurs during the Krebs (citric acid) cycle and electron transport by describing the following:

- a The location of the Krebs cycle and electron transport chain in mitochondria.
- b The cyclic nature of the reactions in the Krebs cycle.

- c The production of ATP and reduced coenzymes during the cycle.
- d The chemiosmotic production of ATP during electron transport.

14. Membranes are important structural features of cells.

- a Describe how membrane structure is related to the transport of materials across the membrane.
- b Describe the role of membranes in the synthesis of ATP in either cellular respiration or photosynthesis.

15. 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

Unit 5 (Meiosis, Mendelian Genetics, DNA Replication)

17. State the conclusions reached by Mendel in his work on the inheritance of characteristics. Explain how each of the following deviates from these conclusions.

- a Autosomal linkage.
- b Sex-linked (X-linked) inheritance.
- c Polygenic (multiple-gene) inheritance.

18. Experiments by the following scientists provided critical information concerning DNA. Describe each classical 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 Meselson and Stahl- DNA replication in bacteria

19. 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.

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

- a Explain how these alleles are transmitted by the process of mitosis to daughter cells.
- b Explain how these alleles are distributed by the process of meiosis to gametes.
- c 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.

Unit 6 (Protein Synthesis, Gene Expression, DNA Technology)

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

TAC GAA CTT GGG TCC

This 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 effects of a substitution in one of the nucleotides?

22. Describe the operon hypothesis and discuss how it explains the control of messenger RNA production and the regulation of protein synthesis in bacterial cells.

23. 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.**

24. Describe the biochemical composition, structure, and replication of DNA. Discuss how recombinant DNA techniques may be used to correct a point mutation.

25. 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.

26. Describe the steps of protein synthesis, beginning with the attachment of a messenger RNA molecule to the small subunit of a ribosome and ending generalized 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.

29. 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.
- 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.
 - Explain how a mutation could cause this inability to digest starch.
 - Describe how modern techniques of molecular biology could be used to determine whether the mutant allele is present in a given individual.

Unit 7 (Evolution, Population Genetics, Speciation)

29. 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.
30. Describe the modern theory of evolution and discuss how it is supported by evidence from two of the following areas.
- population genetics
 - molecular biology
 - comparative anatomy and embryology
31. Describe the process of speciation. Include in your discussion the factors that may contribute to the maintenance of genetic isolation.
33. Evolution is one of the major unifying themes 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.
34. Genetic variation is the raw material for evolution.
- Explain three cellular and/or molecular mechanisms that introduce variation into the gene pool of a plant or animal population.
 - Explain the evolutionary mechanisms that can change the composition of the gene pool.

Unit 8 (Chemical Evolution, Prokaryotes, Eukaryote Evolution, Protista)

36. 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.

Universal Ancestor

Domain Bacteria Domain Archaea Domain Eukarya
(Eubacteria) (Archaeobacteria) (Eukaryotes)

- 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.

Unit 9 (Introduction to Plants, Fungi, Invertebrates)

37. In the life cycles of a fern and a flowering plant, compare and contrast each of the following:

- a The gametophyte generation.
- b Sperm transport and fertilization.
- c Embryo protection.

38. Describe the differences between the terms in each of the following pairs.

- a Coelomate versus acoelomate body plan.
- b Protostome versus deuterostome development.
- c Radial versus bilateral symmetry.
- d 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.

Unit 10 (Vertebrates, Basic Animal Structure and Function)

39. Select two of the following three pairs and discuss the evolutionary relationships between the two members of each pair you have chosen. In your discussion include structural adaptations and the functional significance.

Pair A: green algae---vascular plants

Pair B: prokaryotes---eukaryotes

Pair C: amphibians---reptiles

Unit 11 (Animal Nutrition, Circulation, Respiration, Immune System)

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

41. 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.

42. Describe the following mechanisms of response to foreign materials in the human body.

- a The antigen-antibody response to a skin graft from another person.**
- b The reactions of the body leading to inflammation of a wound infected by bacteria.**

43. Discuss the processes of exchange of O₂ and CO₂ that occur at the alveoli and muscle cells of mammals. Include in your answer a description of the transport of these gases in the blood.

45. The graph below shows the response of the human immune system to exposure to an antigen. Use this graph to answer part a and part b of this question.

- a Describe the events that occur during period I as the immune system responds to the initial exposure to the antigen.**
- b Describe the events that occur during period II following a second exposure to the same antigen.**
- c Explain how infection by the AIDS virus (HIV) affects the function of both T and B-lymphocytes.**

Unit 12 (Homeostasis, Reproduction, Development)

47. 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.

48. 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.

Unit 13 (Endocrine System, Nervous System, Sensory and Motor Mechanisms)

49. Discuss the sources and actions of each of the following pairs of hormones in humans and describe the feedback mechanisms that control their release.

- a Insulin---glucagon
- b Parathyroid hormone---calcitonin
- c Thyrotropin (TSH)---thyroxine (T4)

50. 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.

52. Describe the negative and positive feedback loops, and discuss how feedback mechanisms regulate each of the following.

- a The menstrual cycle in non-pregnant human female.
- b Blood glucose levels in humans.

53. Discuss how cellular structures, including the plasma membrane, specialized endoplasmic reticulum, cytoskeletal elements, and mitochondria, function together in the contraction of skeletal muscle cells.

54. 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.

Unit 14 (Plant Structure and Function)

55. 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 Specialized adaptations to a desert environment.

56. Define the following plant responses and explain the mechanism of control for each. Cite experimental evidence as part of your discussion.

- a Phototropism
- b Photoperiodism

57. 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.

58. 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.

59. 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.

60. 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.

Unit 15 (Ecology)

63. Define and explain the role of each of the following in social behavior.

- a Territoriality.
- b Dominance hierarchies.
- c Courtship behavior.

64. 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.

65. Describe and give an example of each of the following. Include in your discussion the selection advantage of each.

- a Pheromones.
- b Mimicry.
- c Stereotyped behavior (instinct).

66. 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.

67. Describe releasers, imprinting, and communications, as each of these terms relates to animal behavior. You may include in your answer a discussion of the classical studies of Niko Tinbergen, Konrad Lorenz, and Karl von Frisch.

68. 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.

69. Using an example for each, discuss the following ecological concepts.

- a **Succession**
- b **Energy flow between trophic levels.**
- c **Limiting factors.**
- d **Carrying capacity.**

70. 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 in the nutrient cycle you have chosen.

71. 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.

72. 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 (J)

- a **Choosing organisms from four different trophic levels of this food web as examples, explain how energy is obtained at each trophic level.**
- b **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.**
- c **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.**

Cumulative Essays

74. 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.

- a C4 metabolism
- b Amniotic egg
- c Four-chambered heart
- d Pollen

75. Describe the anatomical and functional similarities and difference 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

76. Discuss how each of the following has contributed to the evolutionary success of the organisms in which they are found.

- a seeds
- b mammalian placenta
- c diploidy

77. 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.)

78. The problem of survival of animals on land is 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.

79. 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.

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

- a Explain how the metabolic processes of cellular respiration and photosynthesis recycle oxygen.
- b Discuss the structural adaptations that function in oxygen exchange between each of the following organisms and its environment: a plant; an insect; a fish.
- c Trace a molecule of O₂ from the environment to a muscle cell in a vertebrate of your choice.

81. 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 chose, explain how the process of recognition occurs and give an example of each.

- a Organisms recognize others as members of their own species.
- b Neurotransmitters are recognized in the synapse.
- c Antigens trigger antibody response.
- d Nucleic acids are complementary.
- e Target cells respond to specific hormones.

82. 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

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