

## USA Biology Olympiad 2004 Open Exam

Congratulations! You are about to take the USABO Open Exam, the first exam in a series of competitions to qualify for the USA Biology Olympiad and the International Biology Olympiad. ***This multiple-choice exam has no pass or fail. Please try to complete as much of the Open Exam as you can.*** Results and selection to the Semifinals are based on ranking across the United States.

The fact that you are taking this exam marks you as an outstanding biology student. By taking this exam, you may qualify to be one of the top 10% who will take the USABO Semifinal Exam in March 2004. The top 20 students from the Semifinal Exam will be selected to go on to attend the all-expense-paid USA Biology Olympiad at George Mason University. From the national Olympiad, four students will represent the United States at the International Biology Olympiad in Australia, July 11-17, 2004.

Please put away your books and other materials. Clear your desk of all but the following items:

- USA Biology Olympiad Open Exam
- Number 2 pencils and erasers
- Scrap paper
- Non-programmable calculator (*optional*)

You have 45 minutes to take this exam. Please wait until your teacher tells you before beginning the exam. Indicate your answer by filling in the correct box on your Scantron form, choice A, B, C, D or E, when applicable.

Please sign and date this exam, certifying your identity, acknowledging your participation in the USA Biology Olympiad and pledging that you have followed the rules governing this competition.

Full Name (Print Carefully): \_\_\_\_\_

Signature: \_\_\_\_\_

Teacher Name: \_\_\_\_\_

School Name: \_\_\_\_\_

Date: \_\_\_\_\_

*Instructions:* Please mark the correct answer (A, B, C, D or E, when applicable) by filling in the designated box on your Scantron sheet.

*Sample Question:*

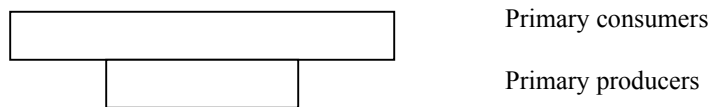
0. What insect transmits dog heartworm?
- [a] Dung beetles
  - [b] Flies
  - [c] Fleas
  - [d] Mosquitoes
  - [e] Dragonflies

1. Assume a person is placed on cortisol medication, a glucocorticoid. How would you expect the rates of ACTH and CRF hormone production to change in the person?
  - [a] ACTH production would increase, CRF production would increase
  - [b] ACTH production would increase, CRF production would decrease
  - [c] ACTH production would decrease, CRF production would decrease
  - [d] ACTH production would decrease, CRF production would increase
  - [e] ACTH and CRF production would not change
2. Carbon particles were injected into the blood of mice. In which of the following places would you most likely find the particles?
  - [a] In the glomerular filtrate
  - [b] In the adipose tissue of the liver
  - [c] In monocytes of the spleen
  - [d] In plasma cells of the bone marrow
  - [e] In the loops of Henle
3. Kidneys provide osmoregulation for the body. Consumption of which nutrient creates the greatest need for osmoregulation?
  - [a] Cellulose
  - [b] Fat
  - [c] Oil
  - [d] Protein
  - [e] Starch
4. During translation in prokaryotes, the ribosome binds to
  - [a] The TATA box
  - [b] The mRNA cap
  - [c] The terminator sequence
  - [d] An enhancer sequence
  - [e] The Shine-Dalgarno sequence
5. The quaternary structure of a protein is determined by
  - [a] Interactions between distant amino acids of the same polypeptide
  - [b] Interactions between close amino acids of the same polypeptide
  - [c] Interactions between amino acids of different polypeptide chains
  - [d] The arrangement of the alpha helices and beta sheets in the protein
  - [e] Binding of a coenzyme or cofactor to the protein
6. Which of the following is not a function of the parasympathetic division of the nervous system?
  - [a] Constriction of the bronchi in the lungs
  - [b] Constriction of the pupil of the eye
  - [c] Slowing of the heart rate
  - [d] Stimulation of the adrenal medulla
  - [e] Stimulation of activity of the stomach and the intestines
7. You place a growing seedling in an east-facing window. On which side of the plants will auxins accumulate?
  - [a] North side
  - [b] South side
  - [c] East side
  - [d] West side
  - [e] Equally distributed on all sides of the plant
8. Which of the following is NOT a characteristic of all mammalian species?
  - [a] Dorsal nerve cord
  - [b] Endothermic metabolism
  - [c] Lungs
  - [d] Mammary glands
  - [e] Placenta

9. Suppose the *lac* repressor of *E. coli* is mutated so that it never binds to the operator. Which of the following is true?
- [a] Glucose digesting enzymes are never produced
  - [b] Lactose digesting enzymes are never produced
  - [c] Lactose digesting enzymes are always produced
  - [d] The result depends on the concentration of glucose
  - [e] The result depends on the concentration of lactose

10. You examine a leaf cross-section under a microscope and find many loosely packed cells. These cells have many chloroplasts and relatively thin cell walls. These cells are:
- [a] Collenchyma
  - [b] Endodermis
  - [c] Parenchyma
  - [d] Sclerenchyma
  - [e] Xylem

11. For the biomass pyramid shown below, choose the correct statement:



- [a] Producers reproduce quickly but are also consumed at a rapid rate
  - [b] Biomass decreases with higher trophic levels
  - [c] Humans represent the lowest trophic level (bottom rectangle)
  - [d] This biomass pyramid is consistent with an algal bloom
  - [e] This biomass pyramid is not possible
12. Which of the following would be most likely to increase competition among the members of the vole population in a given area?
- [a] An increase in the number of hawk predators
  - [b] An increase in the reproduction rate of voles
  - [c] An increase in temperature
  - [d] An increase in the food supply
  - [e] An epidemic of rabies within the vole population
13. Tobacco mosaic virus has RNA rather than DNA as its genetic material. If the RNA genome from a tobacco mosaic virus is mixed with proteins from a human rhinovirus, the result is a mixed virus. If that virus could infect a cell and reproduce, what would you expect the resulting viruses to be like?
- [a] A hybrid including genetic material from tobacco mosaic virus and proteins from the rhinovirus
  - [b] A hybrid including proteins from tobacco mosaic virus and genetic material from the rhinovirus
  - [c] Rhinovirus
  - [d] Tobacco mosaic virus
  - [e] No viruses would result because no viral DNA was present
14. An amphipathic molecule is a molecule that has
- [a] 2 different forms that are mirror images of each other
  - [b] An amino group
  - [c] A hydrophilic end and a hydrophobic end
  - [d] A positively charged end and a negatively charged end
15. The function of a molecular chaperone is to
- [a] Act as an energy source during the polymerization of amino acids into a polypeptide
  - [b] Act as a carrier molecule and bring "activated" monomers to a polymer for incorporation
  - [c] Bind to specific structures on the polypeptide in order to assist the folding of a protein into its correct three-dimensional shape
  - [d] Unfold proteins with the incorrect three-dimensional shape and refold them into the proper shape
  - [e] Transport rRNA from the nucleus to the cytoplasm

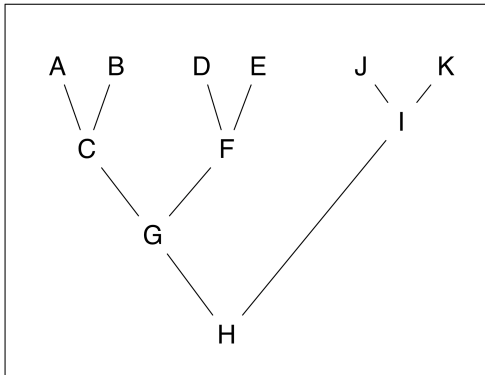
16. Ethidium Bromide is used in electrophoresis of DNA fragments because:
- [a] It makes the fragments visible under UV light
  - [b] It makes the DNA fragments more mobile in the gel
  - [c] It increases the conductivity of electricity through the gel
  - [d] It helps determine the size of the fragments
  - [e] It maintains a stable pH
17. The species *Homo sapiens* first appeared in which geologic epoch?
- [a] Miocene
  - [b] Paleocene
  - [c] Pleistocene
  - [d] Pliocene
  - [e] Eocene
18. Which of the following marine communities would be LEAST affected by a volcanic eruption or meteor impact that injected enough debris into the atmosphere to reduce sunlight by 50% for two years?
- [a] Benthic community
  - [b] Coral reef community
  - [c] Deep sea vent community
  - [d] Estuary community
  - [e] Pelagic community
19. All of the following are modified stems except:
- [a] Stolons
  - [b] Tendrils
  - [c] Rhizomes
  - [d] Tubers
  - [e] Bulbs
20. Which statement describing plant structure is true?
- [a] Sclerenchyma cells provide support for the plant body
  - [b] Collenchyma cells form the outer cell layer of the plant
  - [c] Wood is formed from old epidermal cells
  - [d] Stomates are pores in the roots that allow nutrients to enter
  - [e] Parenchyma cells have thicker cells walls than other plant cells
21. The Hardy-Weinberg equilibrium principle assumes all of the following statements EXCEPT:
- [a] The proportion of alleles in a population tends to remain stable
  - [b] The frequencies of dominant and recessive alleles for a given trait in a gene pool of a large population can be determined mathematically
  - [c] Genotype frequencies in a large population are unaffected by Mendelian segregation and recombination of alleles
  - [d] For a given trait the frequency of dominant alleles is greater than that of recessive alleles
  - [e] For a given trait the frequency of the genotype of the heterozygous population can be determined mathematically
22. Professor Jones is running an experiment with his graduate students in his physiology lab. One group of students drinks a liter of water, another group drinks a liter of coffee, and a third group drinks a liter of concentrated salt solution. The volume of urine produced by all individuals in the three groups is measured over a period of several hours. At the end of the monitoring period, which group will have produced the greatest volume of urine and which group the least?
- [a] Those who drank coffee will produce the most urine, while those who drank water will produce the least
  - [b] Those who drank coffee will produce the most urine, while those who drank the salt solution will produce the least
  - [c] Those who drank the salt solution will produce the most urine, while those who drank water will produce the least
  - [d] Those who drank the salt solution will produce the most urine, while those who drank coffee will produce the least
  - [e] There will be no difference between the three groups
23. A protein is usually tagged for degradation by proteasome activity by which of the following proteins?
- [a] Caspase
  - [b] Kinase
  - [c] Protease
  - [d] Ubiquinone
  - [e] Ubiquitin

24. Which of the following statements is true of territorial behavior?
- [a] Intruders win the majority of confrontations
  - [b] Intruders are most likely to escalate a battle
  - [c] "Owners" defend mainly against male intruders
  - [d] "Owners" defend mainly against conspecifics
  - [e] Contests are seldom "ritualized"
25. You extract RNA from liver cells and then carry out an agarose gel electrophoresis of the liver RNA. The RNA fragments are then transferred to an RNA-binding membrane (nitrocellulose or nylon) using capillary action. Next, you hybridize a probe for gene X to the RNA on the membrane. Which of the following statements regarding your experiment is true?
- [a] You are trying to determine how many copies of Gene X are in liver cells
  - [b] You are trying to determine if the Gene X protein is present in liver cells
  - [c] You are trying to determine if Gene X is expressed in liver cells
  - [d] You are trying to determine the chromosomal location of Gene X
  - [e] You are trying to determine whether Gene X has a mutant sequence
26. A toxin exists that inhibits the enzyme succinate dehydrogenase. If this were used in an experiment to stop respiration, how many net  $\text{NADH}^+$  and ATP molecules would be generated from each glucose molecule up to that stage?
- [a] 4, 4
  - [b] 4, 6
  - [c] 4, 8
  - [d] 6, 2
  - [e] 6, 4
27. Which of the following characteristics is an adaptation of temperate climatic zone plants?
- [a] Leaves with drip tips
  - [b] Sunken stomata
  - [c] Succulent leaves
  - [d] Dormant buds
  - [e] Very shallow roots
28. Which of the following statements is true:
- [a] A short day plant will flower if it has over a half day of darkness interrupted by a short flash of light
  - [b] A long night plant will flower if it has over a half day of darkness interrupted by a short flash of light
  - [c] A long day plant will flower if it has over a half day of darkness interrupted by a short flash of light
  - [d] A long day plant will flower if it has over a half day of uninterrupted darkness
29. Which of the following is NOT a second messenger?
- [a] Calcium ion
  - [b] Magnesium ion
  - [c] Diacyl glycerol
  - [d] Inositol trisphosphate ( $\text{IP}_3$ )
  - [e] Cyclic AMP
30. The reduction phase of the Calvin cycle is equivalent to which of the following processes in reverse?
- [a] Electron transport chain
  - [b] Krebs cycle
  - [c] Light reactions of photosynthesis
  - [d] Energy investment phase of glycolysis
  - [e] Energy payoff phase of glycolysis
31. Which of the choices below correctly ranks [from least to greatest] the contribution of the various ecosystems as to their "Average Net Primary Production per unit area ( $\text{kcal}/\text{m}^2/\text{yr}$ )."
- [a] Open ocean, tropical rainforest, savanna, temperate forest
  - [b] Tropical rain forest, open ocean, savanna, temperate forest
  - [c] Open ocean, savanna, temperate forest, tropical rain forest
  - [d] Savanna, tropical rainforest, temperate forest, open ocean
  - [e] Open ocean, tropical rainforest, temperate forest, open ocean

32. In most terrestrial mammalian species, parental investment is greater for female parents than for male parents. This is because:
- [a] Females often court and mate with multiple males
  - [b] Females often choose poor quality mates
  - [c] Females are often injured in fighting for mates
  - [d] Males are typically polyandrous
  - [e] Females are typically 'K-selected', whereas males are more often 'r-selected'
33. Which of the following is part of the egg-producing structure in plants?
- [a] The megagametophyte of angiosperms
  - [b] The plasmodesmata of angiosperms
  - [c] The microgametophyte in gymnosperms
  - [d] The antheridium of mosses
  - [e] The sori of ferns
34. A booster dose of a vaccination helps to:
- [a] Increase the blood antibody level by increasing the number of effector cells
  - [b] Increase the blood antibody level by decreasing the number of T-suppressor cells
  - [c] Increase the MHC recognition sites by increasing effector cells
  - [d] Maintain a high monocyte count
  - [e] Decrease the number of monocytes
35. In mice, one gene regulates color. Homozygous recessive organisms are white, homozygous dominant organisms are black, and some organisms exhibit incomplete dominance (gray fur). A gray male and a gray female produce an offspring of unknown gender. What is the probability that the mouse will NOT be born with white fur?
- [a] 1/4
  - [b] 1/3
  - [c] 1/2
  - [d] 3/4
  - [e] 1
36. The most phytoplankton in a lake would be found in which zone?
- [a] Aphotic zone
  - [b] Benthic zone
  - [c] Limnetic zone
  - [d] Oligotrophic zone
  - [e] Profundal zone
37. Hemoglobin, an iron-containing protein in erythrocytes, binds oxygen molecules. Myoglobin, a protein in muscle cells, is used for oxygen storage. What can be deduced about the relative oxygen affinities of hemoglobin and myoglobin?
- [a] Myoglobin has greater oxygen affinity than hemoglobin
  - [b] Hemoglobin has greater oxygen affinity than myoglobin
  - [c] Both have roughly the same oxygen affinity
  - [d] Neither has a significant oxygen affinity
38. In an experiment, a plant is grown at a particular level of light and in a certain concentration of CO<sub>2</sub>. With CO<sub>2</sub> constant and light intensity gradually increasing to a preset level, oxygen production increases up to a point and then levels off. If light is increased beyond the preset level, no further increase in oxygen production is noted. In a second experiment, the same increasing regimen of light is used, but a higher level of CO<sub>2</sub> is supplied. O<sub>2</sub> production in the second experiment continues to increase beyond the point where it leveled off in the first experiment. From these observations, one might conclude:
- [a] Light is the only limiting factor
  - [b] CO<sub>2</sub> concentration is the only limiting factor
  - [c] Both light and CO<sub>2</sub> concentration are limiting factors throughout the time course of the reaction
  - [d] Light is limiting up to a point and then CO<sub>2</sub> becomes a limiting factor
  - [e] Neither light nor CO<sub>2</sub> concentration are limiting

39. Plant systematists have found that monocots were not the first flowering plants to evolve. This would suggest that:
- [a] They must be more complex than previously thought
  - [b] They were misplaced in their lineage
  - [c] Evolution does not always proceed from simple to complex
  - [d] They do not represent a true clade
  - [e] They evolved from a different ancestral group than other flowering plants did
40. In a certain population of 100 deer, 34 births and 25 deaths were recorded in one year. Assuming no immigration or emigration occurred, what is  $r$  for that population?
- [a] 0.09
  - [b] 0.25
  - [c] 0.34
  - [d] 0.66
  - [e] 0.90
41. A patient is suffering from kidney failure. Which of the following symptoms will most likely be present in this patient?
- [a] A collapse of blood glucose level
  - [b] An accumulation of uric acid in the blood
  - [c] A higher salt concentration in the blood
  - [d] A swelling of the liver
  - [e] An excretion of vital amino acids
42. An investigator found 150 different diatom species in one mile of a stream. None of the species comprised more than 5% of the total population. In a second observation twenty-five miles downstream, there were only 20 different diatom species, with 2 species representing 80% of the total population. What is the best explanation of these two observations?
- [a] The stream is bigger at mile 25
  - [b] The nature of the stream bottom changed
  - [c] The stream velocity changed
  - [d] Organic wastes high in nitrates and phosphates entered the stream somewhere between the two sampling stations
  - [e] There must have been something wrong with the sampling methods
43. All of the following are modified stems except:
- [a] Stolons
  - [b] Tendrils
  - [c] Rhizomes
  - [d] Tubers
  - [e] Bulbs
44. ATP is an important molecule in metabolism because
- [a] It is readily obtained from an organism's environment
  - [b] It is extremely stable
  - [c] It contains valuable nutrients
  - [d] It has high-energy phosphate bonds
  - [e] Its phosphate bonds are very easily formed but not easily broken
45. Crossing over contributes to the genetic variation of a species by exchanging chromosomal segments between non-sister chromatids of homologous chromosomes. In the production of which type of cell does the crossing over occur?
- [a] Chondrocytes
  - [b] Gametes
  - [c] Leukocytes
  - [d] Osteoblasts
  - [e] Sporophytes
46. In a population of 15 **AA**, 25 **Aa**, and 10 **aa** individuals, the frequency of the **a** allele is:
- [a] 0.20
  - [b] 0.30
  - [c] 0.45
  - [d] 0.50
  - [e] 0.55

47. Use the cladogram below to answer the following question.



Which group represents a monophyletic taxon?

- [a] A and B
  - [b] A, B, D, and E
  - [c] D, E, F, and G
  - [d] H, I, J, and K
  - [e] A, B, C, D, E, F, and G
48. A ribozyme is
- [a] A precursor form of an rRNA molecule
  - [b] An enzyme involved in the synthesis of RNA molecules
  - [c] A protein that digests RNA molecules
  - [d] A ribose molecule linked to an enzyme
  - [e] An RNA molecule that functions as an enzyme
49. When an ant in a colony dies, the live ants will throw the dead ant out of the anthill. If a live ant from the colony, Ant X, is sprayed with a chemical characteristic of dead ants, the live ants will repeatedly throw Ant X out of the anthill, until the chemical on Ant X wears off. What is the best behavioral explanation of ant colony?
- [a] The ants are exhibiting a negative taxis triggered by the chemical
  - [b] The other ants can learn only through trial and error
  - [c] The ants exhibit a learned behavior
  - [d] The live ants continue the behavior until they have been habituated
  - [e] The chemical acts as a sign stimulus for a fixed action pattern
50. Vascular plants share all of the following characteristics EXCEPT:
- [a] Alternation of generations
  - [b] Development of seeds
  - [c] Dominance of the sporophyte
  - [d] Lignin in cell walls
  - [e] Xylem and phloem