

USA BIOlympiad 2013

USABO Open Exam
February 5 to 15, 2013

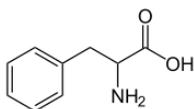
- 1. Which statement is true about enzymes? Enzymes**
 - A. Are made up of a base containing nitrogen, phosphate, and ribose.
 - B. Have activity that is independent of temperature and pH.
 - C. Lose some or all of their normal activity when their 3-D structure is disrupted.
 - D. Provide the activation energy needed to activate a reaction.
 - E. Work once only and then are destroyed.

- 2. You have a multicellular organism that reproduces asexually by fission. When you excise a ~10,000 cell portion of its body, both the original organism and the excised portion grow into fully formed, healthy organisms. You take one of the offspring and repeat the procedure for one hundred and twenty-three generations. Each time, the resulting organisms are healthy. What must be true of the nuclei of this species?**
 - A. The cells contain plasmids.
 - B. The cells have multiple forms of DNA polymerase.
 - C. The cells have the majority of their genome stored in circular DNA.
 - D. The cells contain active telomerase.
 - E. The cells contain active fissionase.

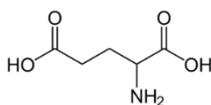
- 3. Which of the following correctly describes how the lifespan of a protein is regulated?**
 - A. The part of the sequence coded for by the UTR tags it for destruction.
 - B. Giant protein complexes called ubiquitins destroy proteins after they have remained in the cell for a certain time.
 - C. Proteins are methylated over time; heavily methylated proteins are destroyed by proteasomes.
 - D. Proteins are tagged with ubiquitins, which are recognized by proteasomes; the proteasomes destroy the proteins.
 - E. Proteins tagged with methyl groups are destroyed by ubiquitins.

4. Of the following amino acids, which is least likely to form strong interactions with other amino acids that contribute to the tertiary structure of a given protein?
- Histidine
 - Glutamate
 - Cysteine
 - Glycine
 - Serine
5. Thymine dimers arise when two adjacent thymine bases become covalently linked. This interferes with normal DNA geometry and will cause replication errors. Which of the following agents is the primary cause of the thymine dimers?
- Chemical mutagens
 - Beta emissions from radioactive decay
 - Gamma rays
 - X-rays
 - UV rays
6. Which of the following oligonucleotides would have the highest melting point when paired with the proper complementary strand?
- 5'-AAAAAAAA-3'
 - 5'-ATGCATGC-3'
 - 5'-CGCGCGCG-3'
 - 5'-TTTTGGGG-3'
 - 5'-TATATATA-3'
7. Which of the following is a way in which the cell increases gene expression in the nucleus?
- Acetylation of histone tails
 - DNA methylation
 - Locating a gene within heterochromatin
 - Dephosphorylating DNA
 - Alternative splicing
8. Below are the structures of five amino acids. Select the amino acid that would contribute most significantly to stability of the tertiary structure of a protein.

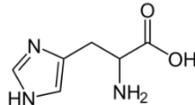
A.



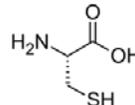
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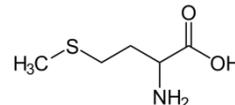
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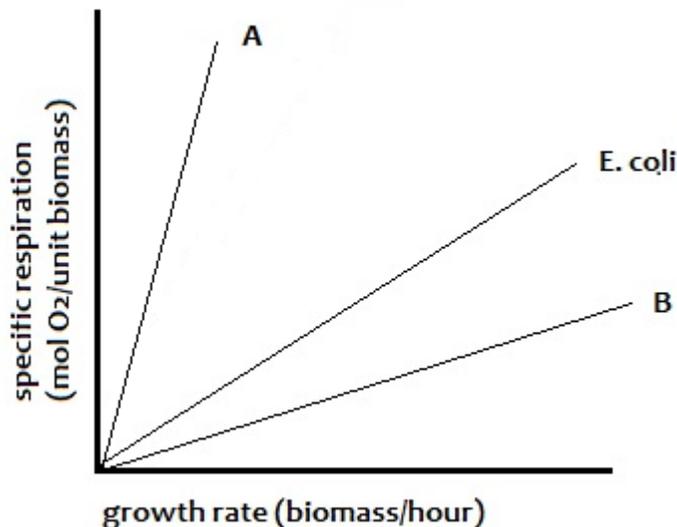
E.



9. Which of the following statements about cellular ultrastructure is FALSE?

- A. Nonmotile eukaryotic cilia are composed of 9 doublets of microtubules in a ring, with no microtubules in the center ('9+0').
- B. Bacterial flagella are composed of 9 doublets of microtubules in a ring, with two microtubules in the center ('9+2').
- C. Motile eukaryotic cilia are composed of 9 doublets of microtubules in a ring, with two microtubules in the center ('9+2').
- D. Centrioles are composed of nine triplets of microtubules arranged in a ring.
- E. The basal bodies of eukaryotic flagella are composed of nine triplets of microtubules arranged in a ring.

10. In a secret cabinet of a lab, you find two Petri dishes in storage and a mysterious lab notebook. In an effort to identify the bacteria, you run some tests (taking all necessary safety precautions) and look through the lab notebook. You find that the two Petri dishes contain the same type of nutrient medium and both bacteria seem to be *Escherichia sp.*, but that the bacteria in plate 1 are producing large amounts of a variety of neurotoxins. The bacteria in plate 2 are not producing any major exported product. You also find this chart in the lab notebook:



Given that Strain 2 is normal *E. coli* (the control) and Strain 1 is a genetically engineered strain of *E. coli*, which line is most likely to represent strain 1, and why?

- A. Line B, since strain 1 should exhibit lower than normal growth efficiency.
- B. Line B, since strain 1 should exhibit higher than normal growth efficiency.
- C. Line A, since strain 1 should exhibit lower than normal growth efficiency.
- D. Line A, since strain 1 should exhibit higher than normal growth efficiency.
- E. The *E. coli* line should represent both, since Strain 1 should have the same growth efficiency as a normal *E. coli* strain.

11. Which of the following chemicals or groups of chemicals is not a major determinant of flower color?

- A. Flavonols
- B. Carotenoids
- C. Cyanidin
- D. Phytoalexins
- E. Betacyanins

12. Which of the following is not a characteristic of cycads?

- A. Secondary growth from a vascular cambium
- B. Fruit
- C. True leaves
- D. Insect pollination
- E. Presence of neurotoxins and carcinogens in plant tissues

13. Which of the following does not take part in the light reactions of photosynthesis?

- A. Photosystem I
- B. Photosystem II
- C. Rubisco
- D. ATP synthase
- E. Cytochrome complex

14. Lettuce seeds receive flashes of far red and red light in this order: far red, red, far red, red, red, red, red, far red. The seeds will

- A. Germinate since far red light induces germination.
- B. Germinate since the first flash of light determines germination.
- C. Germinate since there are more flashes of red light.
- D. Not germinate since the flashes of light have destroyed the seeds.
- E. Not germinate since only the last flash of light determines germination.

15. Which of the following statements about alternation of generations in land plants is TRUE?

- A. The gametophyte produces haploid cells by meiosis.
- B. In nonvascular plants (Bryophyta), the gametophyte stage is dominant.
- C. The sporophyte produces diploid spores that later undergo meiosis.
- D. The gametophyte stage is diploid.
- E. (A) and (D) are BOTH true.

16. Which of the following best describes the function of sporopollenin in green algae?

- A. It reduces the risk of desiccation in exposed zygotes.
- B. It facilitates recognition of other individuals of the same species.
- C. It augments the effectiveness of the chloroplasts.
- D. It digests invasive bacterial cells.
- E. It deters predation by herbivores.

17. Place the following statements regarding photosynthesis in C4 plants in the correct order:

- I. ATP is used to convert pyruvate to phosphoenolpyruvate (PEP).
- II. Mesophyll cells export four-carbon products such as malate through plasmodesmata to the bundle-sheath cells.
- III. PEP carboxylase adds CO₂ to PEP to produce oxaloacetate.
- IV. CO₂ is used to produce G3P in the Calvin cycle.
- V. CO₂ is released in cells that contain the protein rubisco, which binds it.

- A. II, V, IV, I, III
- B. V, II, III, IV, I
- C. I, III, V, II, IV
- D. I, III, II, V, IV
- E. I, V, III, II, IV

18. Many important foods are fruits. Which of the following is not a fruit or part of a fruit?

- A. Corn
- B. Jalapeño
- C. Rhubarb
- D. Squash
- E. Tomato

19. Which of the following is not formed from neural crest cells?

- A. Peripheral nerves
- B. Bones of the middle ear
- C. Parts of teeth
- D. Bones of the jaw
- E. Muscles of the face

20. The lymphatic system is most involved in the absorption of nutrients from which of the following foods?

- A. Bacon
- B. Banana
- C. Lettuce
- D. Skim milk
- E. White bread

21. **Beriberi, a disease characterized by tingling, poor coordination, and reduced blood circulation, can be avoided by consuming adequate amounts of which of the following?**
- A. Zinc
 - B. Thiamine
 - C. Folic acid
 - D. Magnesium
 - E. Vitamin A
22. **Which of the following hormones is NOT secreted by the anterior pituitary gland?**
- A. Prolactin
 - B. Oxytocin
 - C. Luteinizing hormone
 - D. Thyroid-stimulating hormone
 - E. Adrenocorticotrophic hormone
23. **Which gland is directly controlled by messages from nerves leading into it?**
- A. Adrenal cortex
 - B. Adrenal medulla
 - C. Anterior pituitary
 - D. Testes
 - E. Ovaries
24. **The binding affinity of hemoglobin to O₂ in the bloodstream is greatest at relatively**
- A. High pH and high CO₂ concentration.
 - B. High pH and low CO₂ concentration.
 - C. Low pH and high CO₂ concentration.
 - D. Low pH and low CO₂ concentration.
 - E. Low pH, and does not depend on CO₂ concentration.
25. **The 2011 Nobel Prize in Physiology was awarded to Bruce Beutler, Jules Hoffmann, and Ralph Steinman in part for their discovery of the Toll receptors in fruit flies. The Toll-like receptors (TLRs) are their equivalent in mammals. Which of the following statements regarding TLRs is FALSE?**
- A. TLRs function in the adaptive immune system as signaling receptors.
 - B. TLRs are found both on the plasma membrane of cells well as the inner surfaces of vesicles.
 - C. Specific TLRs are capable of recognizing pathogen-associated molecular patterns (PAMPs) such as flagellin, double-stranded RNA, and lipopolysaccharide (LPS).
 - D. Signaling of TLRs promotes phagocytosis of foreign material.
 - E. ALL of the above are true.

- 26. Which of the following is important for the coordinated rhythmic nature of heart contraction?**
- A. Acetylcholine transmission between cardiac myocytes.
 - B. Desmosomes between cardiac myocytes.
 - C. Gap junctions between cardiac myocytes.
 - D. Plasmodesmata between cardiac myocytes.
 - E. Tight junctions between cardiac myocytes.
- 27. Sam was walking through an alley when he spotted a small lump next to the dumpster. When he examined the lump, he found that it was a newborn baby that was not breathing. He called “911” to report the incident. When the police arrived, they questioned Sam regarding whether the baby was alive when he found it. He said, “No.” The baby was autopsied to determine if it were alive or dead at birth. Which of the following results of the autopsy would prove that the baby was born dead and not alive?**
- A. Discoloration of the lungs.
 - B. Dissected lung(s) floats in water.
 - C. Dissected lung(s) sinks in water.
 - D. Lungs collapsed.
 - E. Lungs inflated with fluid.
- 28. If one were to follow the path of a human erythrocyte starting from an artery that leads to the duodenum, the erythrocyte will most likely pass through ___ capillary beds before reaching the right ventricle of the heart.**
- A. 1
 - B. 2
 - C. 3
 - D. 4
 - E. 5
- 29. If one were to compare the length of the Loop of Henle and collecting ducts to the overall length of each mammal below, which would have the highest ratio?**
- A. Asian elephant
 - B. Brazilian rabbit
 - C. Harbor seal
 - D. Kangaroo rat
 - E. Flying squirrel

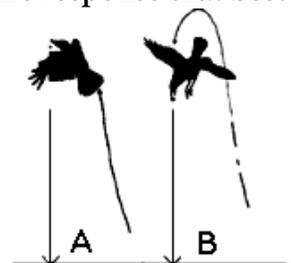
30. While conducting research on *Euglena*, a researcher observed that the contractile vacuole ceased functioning yet the rest of the organism seemed healthy and active. Which of the following is MOST likely responsible for the cessation of contractile vacuole action?

- A. Moving the *Euglena* from a lighted to darkened environment.
- B. Moving the *Euglena* from a freshwater to a seawater environment.
- C. Moving the *Euglena* from a seawater to a freshwater environment.
- D. Lowering the pH of the medium from 7.0 to 6.5.
- E. Lowering the temperature of the medium from 20°C to 15°C.

31. Last year, Katya joined five of her best friends for an adventure rafting 42 miles on the Tara River in Montenegro's Durmitor National Park. One evening, they pulled into the bank to rest and have dinner. Katya decided she would explore the area for few wild strawberries and found very few of them. She gathered all the strawberries she saw and brought them back for the group to have on their pancakes the next morning. Katya had such a wonderful time that when her friend Charles asked her to do the trip again, she readily agreed. They made port in the same spot as last year and again, Katya with Charles sought out strawberries. This time though, the hillsides were covered with wild strawberries and they gathered only the largest and most ripe berries for their pancakes. This is an example of:

- A. Associative learning
- B. Cognitive thinking
- C. Operant conditioning
- D. Optimal foraging
- E. Trial-and-error learning

32. Reto Zach studied the whelk-eating behavior of the Northwestern crow. Below are two flight paths that the crow could assume when eating whelks. Select the flight path that would be used most often and the response that best supports your answer.



- A. Flight Path A: the crow is maximizing the height to drop the whelk.
- B. Flight Path A: the crow is adding force to the downward movement to the whelk by flying higher.
- C. Flight Path A: the crow has a wider view of his surroundings to assure that another bird will not steal the whelk.
- D. Flight Path B: the crow can see where the whelk lands.
- E. Flight Path B: the crow is throwing the whelk to the ground.

33. Each morning, Chuck goes downstairs and brews his morning coffee. His faithful dog Ozzie stays in bed until he hears Chuck place dry dog food into Ozzie's dish. As soon as Ozzie hears the first piece of dog food clink on the dish, he bounds down the steps from his comfortable bed to eat his morning meal. This is an example of
- A. Habituation
 - B. Imprinting
 - C. Classical conditioning
 - D. Operant learning
 - E. Maturation
34. Which of the following is NOT a reason that *Drosophila melanogaster* was originally used as a model organism in Thomas Morgan's 1907 genetics experiments?
- A. Generation time is brief.
 - B. It has only four chromosomes, which are easily visible.
 - C. It reproduces prolifically.
 - D. It was easy to manipulate genetically.
 - E. It is a relatively simple organism to breed in the lab.
35. Which of the following is correct?
- A. Acetylation of histones facilitates expression of the DNA associated with the acetylated histone.
 - B. Methylation of DNA facilitates expression.
 - C. G proteins attaching to histones facilitate expression of DNA.
 - D. Deacetylation of histones facilitates expression of DNA wrapped around the acetylated histone.
 - E. Methylation of histones facilitates expression of DNA wrapped around the acetylated histone.
36. Which of the following could NOT be the blood type of a child born to a mother with AB⁺ blood and a father with B⁻ blood?
- A. A⁺
 - B. AB⁻
 - C. O⁺
 - D. A⁻
 - E. AB⁺

- 37. X-linked agammaglobulinaemia is a rare X-linked disorder that interferes with the body's ability to fight infection. A man with X-linked agammaglobulinaemia marries a woman who is not affected. Which of the following best predicts their children's potential for inheriting X-linked agammaglobulinaemia?**
- A. All their children, regardless of sex, will have X-linked agammaglobulinaemia.
 - B. All their sons will have X-linked agammaglobulinaemia, and all their daughters will be carriers.
 - C. Approximately 50% of their daughters will have X-linked agammaglobulinaemia, and all their sons will be normal.
 - D. Approximately 50% of their sons will have X-linked agammaglobulinaemia, and all their daughters will be carriers.
 - E. None of their children will have X-linked agammaglobulinaemia, but their daughters will be carriers.
- 38. In a population of papillons that contains genetic variation under the influence of natural selection, what is the correct sequence of the following events?**
- I. Allele frequency within the population change.**
 - II. Differential reproduction occurs.**
 - III. Environmental changes occur.**
 - IV. New selective pressures occur.**
- A. IV, III, II, I
 - B. IV, III, I, II
 - C. III, II, IV, I
 - D. III, IV, II, I
 - E. III, IV, I, II
- 39. Which of the following pairs represent two distinct species?**
- A. House mouse, Fancy mouse
 - B. Mayan Indian, Inuit Indian
 - C. Monarch butterfly, Viceroy butterfly
 - D. Papillon, Chihuahua
 - E. Soldier ant, Drone ant

40. You are studying the four genes E, F, G, H. In the chart below, you will find the crossing over frequencies for each pair of genes.

	F	G	H
E	22	17	12
F		5	10
G			5

Which of the following expresses the gene sequence on the chromosome?

- A. EGFH
- B. EGHF
- C. EHGF
- D. EFGH
- E. EFHG

41. Olney, IL, is known for its white squirrel population. In this squirrel population, assume that 10% of the genes are for albino coat color and 90% are for gray coat. If Hardy-Weinberg assumptions are true, what percentage of the squirrels are heterozygous?

- A. 90
- B. 81
- C. 18
- D. 9
- E. 1

42. Evolution of Batesian mimicry is dependent upon

- A. Brain-controlled deposition of pigment by the mimic in response to seeing the model.
- B. Evolution by the model and the mimic of similar adaptations to the same selection pressures.
- C. Greater predation on the non-mimicking individuals of the mimic species than on the mimicking individuals.
- D. Genetic drift as a result of a very small population.
- E. Similar genetic potential inherited from the common ancestor of the model and the mimic.

43. Hackweed has a diploid number of 8 and thale cress has a diploid number of 10. Suppose these two plants produce a single fertile hybrid. When this new species produces gametes, how many chromosomes would each gamete have?

- A. 4
- B. 5
- C. 9
- D. 18
- E. 36

44. Which of the following is an example of Batesian mimicry?

- A. A delicious viceroy butterfly is colored similarly to an unpalatable monarch butterfly.
- B. A poison dart frog's brilliant colors warn predators of its toxicity.
- C. A tiger's stripes allow it to blend in with the grasses in its natural habitat.
- D. A young monkey mimics an older one to learn how to obtain food.
- E. Honeybees and bumblebees are both bright yellow and black, warning predators that they can sting.

45. A mother antelope and its child are galloping along the plains, when they encounter a group of hungry lions. If the two antelopes try to escape the lions together, there is a 75% chance that both will be consumed and eaten, and a 25% chance that both will escape alive. If, however, the mother sacrifices herself to the lions, she may be able to buy her baby additional time to escape.

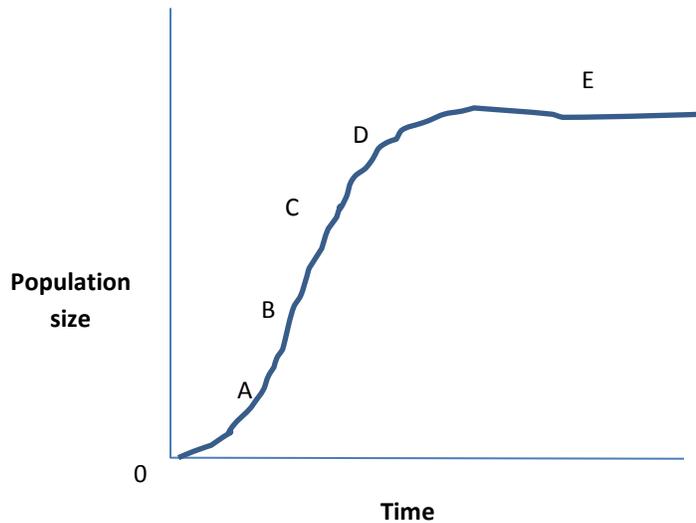
What is the minimum chance that the baby can have to escape from the lions following such a sacrifice such that the mother's action will be evolutionarily favored? You may assume that the baby antelope, once escaped, will be guaranteed to survive into a reproducing adult, and that the mother antelope is at the beginning of reproductive age.

- A. 25%
- B. 33%
- C. 50%
- D. 66%
- E. 75%

46. Which of the following statements concerning ecological niches is FALSE?

- A. Similar species can coexist in the same environment following resource partitioning.
- B. Following sympatric speciation, the two daughter species can occupy the same niche due to their shared genetic lineage.
- C. Due to competitive exclusion, no two species in a given environment can occupy the same niche.
- D. The fundamental niches of two species sharing an environment cannot have any overlap due to the principle of competitive exclusion.
- E. Two or more of the above statements are FALSE.

47. In the graph below, which point indicates that birth rate equals death rate?



48. Which ecosystem is the most unstable?

- A. African grassland
- B. Alpine tundra
- C. Belize tropical rain forest
- D. Saskatchewan wheat field
- E. Mojave desert

49. Which of the following families is a monocot?

- A. Asteraceae
- B. Fabaceae
- C. Myrtaceae
- D. Orchidaceae
- E. Roseaceae

50. As marine mammals, dolphins possess the following derived characteristics distinctive to their class and in their lineage:

- I. A four-chambered heart and efficient circulatory system.
- II. Body hair and a fat layer beneath the skin.
- III. An amniotic egg with four extraembryonic membranes.
- IV. Mammary glands.
- V. A calcified internal skeleton.

- A. II and IV only.
- B. II and III only.
- C. I, II, and IV only.
- D. I, III, and IV only.
- E. I, II, III, IV, and V.