

2023 TJ Biology Olympiad Winter Contest

DIRECTIONS: Read each question carefully and choose the best answer(s). All questions have five (5) answer choices, and unless indicated otherwise, only one choice is correct. You will have until the end of the block to answer or guess as many questions as possible. You may start immediately. NO CHEATING!

A set of correct answers for one question will garner one point (no partial credit). All other answers, or lack thereof, will receive zero points (no guessing penalty). Also, although the “Tiebreaker” will not affect your raw score, in the event of a tie, the contestant with the highest number of tiebreaker answers will earn a better rank.

Finally, all answers MUST be submitted on this [answer sheet](#).

Good luck!

1. In a dihybrid cross of two heterozygous individuals, what is the expected phenotypic ratio among their children?
 - a. 1:1
 - b. 3:1
 - c. 1:2:1
 - d. 1:1:1:3
 - e. 9:3:3:1

2. Which of the following neurotransmitters is primarily associated with signal transmission between motor neurons and muscular cells?
 - a. Serotonin
 - b. Dopamine
 - c. Acetylcholine
 - d. GABA
 - e. Norepinephrine

3. Imagine you are on a spaceship that is malfunctioning, and your only hope is to figure out which of the following cell types presents antigens to T cells during the immune response. Which one of the following solves this problem?
 - a. Red blood cells
 - b. Macrophages
 - c. Natural killer cells
 - d. Neutrophils
 - e. Cytotoxic B cells

4. Arnav tagged a mystery organelle with red and green fluorescent markers. He finds that this organelle functions as a selective barrier that allows passage of enough oxygen, nutrients, and wastes to service the entire cell. Which organelle did he find?
 - a. Plasma Membrane
 - b. Lysosome
 - c. Golgi Apparatus
 - d. Mitochondria
 - e. Peroxisome

5. Which of the following is NOT a function of the digestive system?
 - a. Peristalsis

- b. Nutrient absorption
- c. Excretion of waste
- d. Filtration of blood waste products
- e. Secretion of enzymes

6. The Grinch comes across a new species in his cave home. He notices that this species, unlike himself and Max, breathes by pushing air down into its lungs. What other animal also performs this kind of respiration?

- a. Stork
- b. Frog
- c. Canary
- d. Snake
- e. Lizard

7. Oh no! Rudolph hit a cloud and fell out of the sky onto a deserted island. On this island, there are two kinds of plants: Rednose Fern (100 kJ/kg) and Elfweed (50 kJ/kg). Santa is a bit busy, so he will need to survive by himself for a whole week. If Rudolph needs to consume at least 500 kJ of energy every day, which combination of food will allow him to survive?

- a. 10 pounds of Elfweed
- b. 5 pounds of Rednose Fern
- c. 8 pounds of Elfweed and 1 pound of Rednose Fern
- d. 100 pounds of Rednose Fern
- e. 10 pounds of Elfweed and 40 pounds of Rednose Fern

8. While preparing for his Christmas Eve journey, Santa takes a break to enjoy some celery sticks. Curious about osmoregulation, he wonders about the role of electrolytes. Which of the following electrolytes is crucial for maintaining osmotic balance and proper nerve function in the human body?

- a. Sodium (Na^+)
- b. Calcium (Ca^{2+})
- c. Potassium (K^+)
- d. Magnesium (Mg^{2+})
- e. Iron (Fe^{3+})

9. Santa's cat is climbing on a mound of books in Santa's study when she accidentally knocks over the whole stack. She becomes intrigued when she sees that

a book with a big sunflower on it has landed open to a page with the word “CATECHOLAMINES” written on it. Select the answer that most accurately explains what this term is to Santa’s cat.

- a. Catecholamines are a class of hormones derived from the amino acid tryptophan
- b. Catecholamines are a class of hormones derived from endorphins
- c. Catecholamines are a class of hormones derived from tyrosine
- d. Catecholamines are a type of savannah cat known for their amine coats
- e. Catecholamines are a type of domesticated cat known for their work in coal mines

10. As of December 15, 2023, how many editions of Campbell Biology have been published?

- a. 9
- b. 10
- c. 11
- d. 12
- e. 13

11. Oh no! One of Santa’s naughty elves stole food from the Christmas table! Luckily, Santa is able to tell which item was taken, as he knows the elf chooses the item that will remain undigested in the stomach the longest. Help determine which food was stolen?

- a. Butter
- b. Candy canes
- c. Christmas ham
- d. Roasted carrots
- e. Mashed potatoes

12. Frosty the Snowman had a very shiny nose. Unfortunately, he also has a mysterious mutation that causes his body to constantly secrete vasopressin. Which of the following would be higher in Frosty the Snowman compared to a normal person?

- a. Osmolarity of the interstitial fluid
- b. Osmolarity of the proximal tubule
- c. Filtrate volume in the proximal tubule
- d. Filtrate volume in the collecting duct

- e. Number of sodium cotransport channels in the collecting duct

13. Which one of the following ion channels plays the most crucial role in the creation and propagation of action potentials in neurons?

- a. Ligand-gated potassium channels
- b. Voltage-gated sodium channels
- c. Chloride leak channels
- d. Mechanosensitive calcium channels
- e. None of the above are involved

14. Muntha was experimenting with different types of compounds to see which one would bind to Rudolph enzyme 1 (RE1). When a particular compound binded to the RE1, it formed a disulfide bond with a cysteine near the binding site, and decreased enzymatic activity. This type of compound is known as a:

- a. Cofactor
- b. Coenzyme
- c. Catalyst
- d. Allosteric inhibitor
- e. None of these

15. Which of the following did NOT chase the Gingerbread Man in the classic story?

- a. Man
- b. Woman
- c. Cow
- d. Fox
- e. Rabbit

16. Which of the following correctly describes what happens as blood moves from the arteries to capillaries?

- a. Velocity: increase; Area: decrease; Blood pressure: decrease
- b. Velocity: increase; Area: increase; Blood pressure: decrease
- c. Velocity: stays the same; Area: increase; Blood pressure: decrease
- d. Velocity: decrease; Area: decrease; Blood pressure: decrease
- e. Velocity: decrease; Area: increase; Blood pressure: decrease

17. After landing in Dallas, TX on Christmas Eve, Santa Claus parks his sleigh and reindeer in a nearby forest and takes his bag of presents to drop off gifts in homes.

However, after returning to the forest to take his sleigh and reindeer to the next city, he notices that Dancer and Prancer have developed a severe allergic reaction. The reindeer are sneezing and have rashes all over their body. Santa recalls that Dallas is an area with a high pollen count. Which of the following is true regarding the molecules present in the two reindeers' bodies?

- a. There is a significantly low amount of Immunoglobulin A present
- b. There is a significantly low amount of Immunoglobulin G present
- c. There is a significantly high amount of Immunoglobulin E present
- d. There is a significantly high amount of Immunoglobulin A present
- e. There is a significantly low amount of Immunoglobulin D present

18. Santa Claus eats roughly 336,150,386 cookies every year. Before entering every home and after leaving through the chimney, Santa measures his blood's hormone levels to ensure that he does not suffer a medical condition from eating too many cookies and drinking too much milk. Which of the following results does Santa see after eating the cookies compared to before?

- a. No change in insulin, lower glucagon
- b. Higher insulin, lower glucagon
- c. Higher insulin, higher glucagon
- d. Lower insulin, higher glucagon
- e. Lower insulin, no change in glucagon

19. In the North Pole Reindeer Genetics Lab, Santa is investigating the inheritance of antler size, a trait controlled by a polygenic system. If antler size is influenced by the additive effects of four different genes, each contributing equally, and there are two possible alleles at each gene locus (big antler allele, B, and small antler allele, b), what is the potential number of different phenotypes for antler size in the offspring?

- a. 2
- b. 4
- c. 8
- d. 16
- e. 32

20. In the North Pole Wetlands, there is a complex network of interactions among various species. The "Iceberry Bush" produces berries that are a vital food source for both "Arctic Foxes" and "Snowy Owl" populations. Additionally, "Polar Frogs" inhabit the wetlands and contribute to nutrient cycling through their tadpole stage. If

the temperature in the North Pole increases due to climate change, leading to earlier melting of the ice in the wetlands, how might this impact the interactions among these species?

- a. Increased predation on Iceberry Bushes by Arctic Foxes.
- b. Reduced availability of berries for the Snowy Owl population.
- c. Decreased reproduction of Polar Frogs due to warmer temperatures.
- d. Increased competition between Arctic Foxes and Snowy Owls for food.
- e. Enhanced nutrient cycling due to prolonged tadpole stage in Polar Frogs.

21. Suppose you are studying the nitrogen cycling in a pond ecosystem over the course of a year. While you are collecting data, a flock of 100 Canada geese lands and spends the night during a fall migration. These geese appear in three colors: white green, and red. While there are three possible colors, the gene for color is determined by two alleles. The white allele (w) is dominant to the red allele (r), and the red allele is dominant to the green allele (g). The frequency of white geese is 61%. You also know that half the population are homozygous for the color allele (their genotypes are either ww, rr, or gg). Assuming Hardy-Weinberg Equilibrium conditions apply, approximately how many geese would you expect to find having the genotype rg in your pond ecosystem?

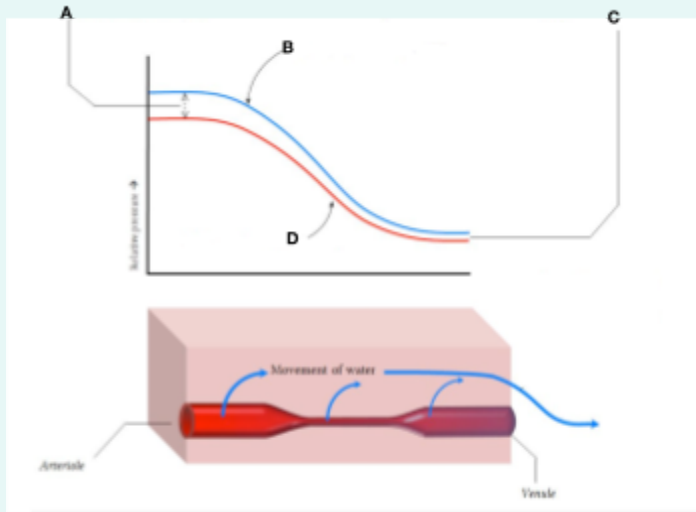
- a. 3
- b. 5
- c. 8
- d. 10
- e. 14

22. You are conducting an environmental study concerning the growth of penguins in Antarctica. You place them in a contained facility, where they will be allowed to grow and produce into multiple generations over a specified period of time. Unfortunately, you have lost your notebook that had all the population data, and you need to make a graph of the population trend! Fortunately for you, you know that these penguins exhibit a logistic growth pattern, and after 16 months, they reach their carrying capacity ($K = 300$). When was the penguins' growth rate the greatest?

- a. After 8 months
- b. After 10 months
- c. When the population was equal to half the carrying capacity
- d. When the population was just less than the carrying capacity

- e. Population growth rate depends on none of these

23. Dr. Claus shows you the Starling model in order to help understand how appropriate distribution of fluid is maintained between the capillaries and surrounding tissues. The equation states that the net flow of fluid across the capillary depends on the balance of osmotic and hydrostatic pressures (net filtration pressure). Which of the following is NOT True?



$$J_v \propto \underbrace{([P_c - P_i])}_{\text{Net Filtration Pressure}} - \underbrace{[\pi_{pp} - \pi_{ip}]}_{\text{Net Osmotic Pressure}}$$

$$J_v = K_{f,c} ([P_c - P_i] - \sigma_d [\pi_{pp} - \pi_{ip}])$$

- The difference at C is less than the difference at A due to the dilution of interstitial fluid
- B represents the hydrostatic pressure difference while D represents the oncotic pressure difference
- Net movement of water does not change direction along the length of the capillary
- Water that flows out into the interstitial fluid is ultimately returned to circulation via the lymphatic system
- Blood pressure decreases along the length of the capillary

24. In the Christmas song “The Twelve Days of Christmas”, how many total gifts are given by the end of the twelfth day?

- 1
- 12
- 78
- 144
- 364

25. You are studying a novel enzyme inhibitor. After analyzing Michaelis-Menten kinetics, you conclude that it binds to both the enzyme itself and the enzyme-substrate complex. What is this an example of?

- a. Uncompetitive inhibition
- b. Competitive inhibition
- c. Noncompetitive inhibition
- d. Irreversible inhibition
- e. Suicide inhibition

26. After a long night of gift delivery, Santa finds himself feeling fatigued, and his endocrine system is working hard to regulate various physiological processes. Which intricate hormonal feedback loop plays a crucial role in maintaining Santa's blood glucose levels within a narrow range?

- a. Insulin stimulates the liver to release glucose, while glucagon promotes glucose uptake by adipose tissue
- b. Cortisol inhibits the release of insulin, while growth hormone enhances insulin sensitivity in muscle cells
- c. Ghrelin stimulates insulin secretion, while leptin inhibits glucagon release from the pancreas
- d. Somatostatin inhibits both insulin and glucagon release, ensuring a stable blood glucose level
- e. Thyroid stimulating hormone(TSH) directly regulates insulin production in the pancreatic islets

27. Interleukin-2 is an interleukin, which is a group of cytokine signaling molecules in the immune system. Which of the following best describes the function of Interleukin-2?

- a. Promotes inflammation and tissue damage.
- b. Stimulates the production of antibodies by B cells.
- c. Inhibits the activation of T cells.
- d. Enhances the activity of natural killer (NK) cells.
- e. Causes allergic reactions and histamine release.

28. To carry Santa Claus's sleigh around the globe, Santa's reindeer need to extract energy from food sources such as cookie treats, carrots, or hay. Immediately after

eating these food items, Santa urges his reindeer to take off and travel to the next city. At that moment, which fuel source would the reindeer most likely use?

- a. Muscle proteins
- b. Muscle and liver glycogen
- c. Fat stored in the liver
- d. Fat stored in adipose tissue
- e. Blood proteins

29. The intricate process of long-term potentiation (LTP) involves complex molecular interactions that contribute to lasting changes in synaptic strength. Considering this complexity, which of the following molecular events is most closely associated with the phenomenon of long-term potentiation?

- a. Rapid influx of calcium ions into the presynaptic neuron, initiating intracellular signaling cascades.
- b. Increased release of inhibitory neurotransmitters, modulating the excitability of the postsynaptic neuron.
- c. Enhanced responsiveness of postsynaptic receptors, leading to increased excitatory neurotransmitter binding.
- d. Upregulation of acetylcholinesterase activity, promoting the rapid degradation of acetylcholine in the synaptic cleft.
- e. Activation of presynaptic autoreceptors, inhibiting further release of neurotransmitters.

30. As Santa prepares to travel across different climates, he wonders about osmoregulation in marine organisms that inhabit both the icy Arctic and the salty seas. In a quest for adaptation, these organisms face the challenge of osmoregulation in diverse environments. Which of the following mechanisms is a sophisticated strategy employed by some marine animals to maintain osmotic balance in varying salinities?

- a. Hyperfiltration through the kidneys to eliminate excess solutes
- b. Counter-current exchange in gill structures to minimize ion loss
- c. Increased production of antidiuretic hormone (ADH) to reduce water reabsorption
- d. Expansion of the swim bladder to adjust buoyancy in changing water densities
- e. Activation of ion-pumping proteins in the skin to regulate osmotic gradients

TIEBREAKER 1: Select ALL amino acids that would be found in an alpha helix.

- a. Methionine
- b. Aspartate
- c. Arginine
- d. Lysine
- e. Glycine

TIEBREAKER 2: In the Christmas classic *Home Alone*, Kevin is tasked with the ultimate challenge of defending his home against intruders. As part of his elaborate plan of rigging his house with booby traps, he places some rusty nails on the basement steps. While climbing up the stairs, Marv steps with his bare foot, causing him to bleed profusely. In addition to the bleeding, the injury leads to a bacterial infection, causing rapid muscle spasms. SELECT ALL that are correct regarding his body's response to the injury?

- a. Capillaries will widen, allowing antimicrobial cells to enter damaged tissue
- b. His body will secrete renin to counter the sudden drop in blood pressure
- c. The blood clotting process will be activated to seal any injured blood vessels
- d. Signaling molecules will recruit Memory-T Cells near the injury site
- e. After developing the bacterial infection, the toxin produced by the bacteria prevents the release of glycine from CNS neurons, causing rapid muscle spasms