

**University of Toronto  
National Biology Competition**

**2006 Examination**

**Thursday, April 27, 2006**

Time: 75 minutes

Number of questions: 50

General Instructions

- Ⓒ Do not open this booklet until you are instructed to do so.
- Ⓒ Print your name at the top of this booklet.
- Ⓒ Indicate all of your answers to the questions on the separate Response Form. No credit will be given for anything written in this booklet, but you may use the booklet for notes or rough work. No additional time will be given after the exam to transfer your answers to the Response Form.
- Ⓒ After you have decided which of the suggested answers is best, COMPLETELY fill in the corresponding bubble on the Response Form. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely.
- Ⓒ Use your time effectively. Do not spend too much time on questions that are too difficult. Go on to other questions and come back to the difficult ones later if you have time. It is not expected that everyone will be able to answer all questions.
- Ⓒ Good luck and have fun!

*Should you guess the answers to questions about which you are not certain?*

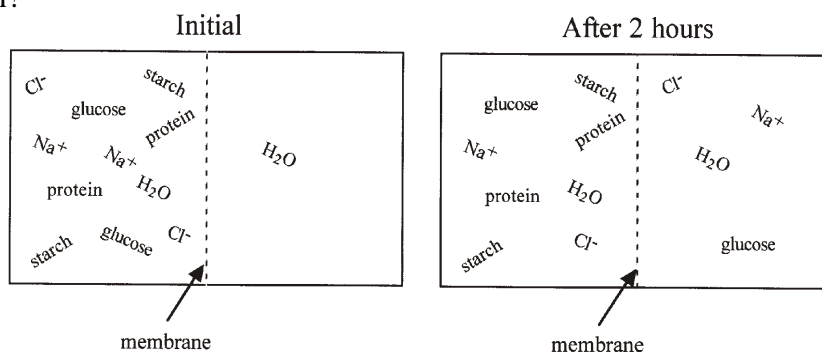
Since your score on the exam is based on the number of questions you answered correctly minus one-third of the number you answered incorrectly, it is improbable that guessing will improve your score (it is more likely to lower your score). (No points are deducted or awarded for unanswered questions.) However, if you are not sure of the correct answer but have some knowledge of the question and are able to eliminate one or more of the answer choices, then your chance of getting the right answer is improved, and it may be advantageous to answer such a question.

1. Of the following species interactions, which one does **NOT** reduce population size?
  - a. Commensalism
  - b. Predation
  - c. Competition
  - d. Brood parasitism
  - e. Amensalism
  
2. What type of mutation involves the addition or deletion of nucleotides?
  - a. Nonsense
  - b. Missense
  - c. Silent
  - d. Frameshift
  - e. Inversion
  
3. The Hardy-Weinberg model of genetic equilibrium:
  - a. assumes non-random mating and low levels of gene flow.
  - b. applies only to very small populations.
  - c. predicts how quantitative characters evolve.
  - d. predicts no change in allele and genotype frequencies in the absence of evolutionary forces.
  - e. is a null model whose predictions about genotype frequencies cannot be compared with observed frequencies.
  
4. Which of the following represent homologous structures?
  - i. A whale's flipper and a bat's wing.
  - ii. The wing of a flying fish and a dragonfly's wing.
  - iii. A human eye and the eye of an eagle.
  - iv. Sea urchin teeth and elephant tusks.
  - a. i and ii
  - b. i, ii, iii, and iv
  - c. i and iii
  - d. ii and iv
  - e. iii and iv
  
5. Which statement is **NOT** consistent with the fluid-mosaic model of cell membranes?
  - a. Proteins float in a phospholipid bilayer.
  - b. Hydrophilic proteins are always anchored in the membrane.
  - c. Lipid bilayers have the ability to fuse with other bilayers.
  - d. Temperature can affect the fluidity of the membrane.
  - e. Van der Waals interactions stabilize the membrane structure.

6. In ecology, which of the following would most likely be considered a K-selected trait?
- Excellent dispersal ability
  - Short lifespan
  - Type III survivorship curve
  - Rapid rate of development of individuals
  - A few, large offspring
7. After implantation of the developing embryo, degeneration of the corpus luteum is prevented by an increase in the concentration of which hormone?
- Luteinizing hormone (LH)
  - Follicle-stimulating hormone (FSH)
  - Estrogen
  - Human chorionic gonadotropin (HCG)
  - Progesterone

8. The membrane illustrated below (at time zero, and again after two hours) allows molecules to pass through it according to what criterion?

- Temperature of the solution
- Electric charge of the molecules
- Size of the molecules
- Concentration of the solution
- Isomer of the molecules



9. I lack respiratory, excretory, and circulatory systems, have bilateral larva, deuterostome development, and move using a water vascular system. Who am I?
- Echinoderm
  - Jellyfish
  - Chordate
  - Mollusc
  - Segmented worm
10. Which of the following reactions could be coupled to endergonic reaction  $X \rightarrow Y$  ( $\Delta G = +3.22$  kJ/mol), so that the coupled reaction would be favourable?
- $A \rightarrow B$ ,  $\Delta G = +6.44$  kJ/mol
  - $C \rightarrow D$ ,  $\Delta G = +3.22$  kJ/mol
  - $E \rightarrow F$ ,  $\Delta G = 0$  kJ/mol
  - $G \rightarrow H$ ,  $\Delta G = +5.71$  kJ/mol
  - $I \rightarrow J$ ,  $\Delta G = +1.61$  kJ/mol

11. In a class experiment, students put a plastic bag around each of four potted plants of the same type, age, and size. A cup of water was added to the soil of two plants and the other two were left almost dry. The soil of all plants was then covered with aluminum foil. One “dry soil” and one “wet soil” plant were placed in the light and the other two plants were placed in the dark under the same temperature conditions. After 24 hours, the students looked for water droplets inside the plastic bags and constructed the following table:

	Dry Soil	Wet Soil
Light	Some droplets	Lots of droplets
Dark	Very few droplets	Very few droplets

Which statement best explains these results?

- Plant roots do not take up water in the dark.
  - The presence of water triggers stomata to open.
  - During the process of photosynthesis, the plant heats up, causing moisture to evaporate from the soil.
  - Stomata close in the dark and during drought conditions.
  - Light triggers cellular respiration, which releases moisture from the plant.
12. Which of the following is an example of primary succession?
- Soil formation in the crater of an extinct volcano.
  - Growth of a jack pine forest after a major forest fire.
  - Restoration of a tall grass prairie ecosystem on a former wheat field.
  - Starfish colonizing a coral reef.
  - Spruce trees growing on land after logging companies have clear-cut the original forest.
13. In the mammalian circulatory system, excess fluid remaining in tissue spaces (interstitial fluid) is:
- used to form urine.
  - removed in the form of sweat.
  - drained away by the lymphatic system.
  - moved back into the capillary bed.
  - absorbed by fat cells.
14. Which statement is **FALSE**?
- An adaptation is a trait that allows an organism to survive and reproduce better in its present environment.
  - Different adaptive phenotypes can arise from the same genotype.
  - A trait can be disadvantageous now even though it once had an adaptive function.
  - The phenotype having the highest fitness can vary over geographic space and time.
  - Adaptation is a process that occurs within individuals within a single generation.

15. If a polypeptide was encoded by the following mRNA sequence how long (number of amino acids) would it be? (A table of the genetic code is provided.)

5'-CGAUGUCCAAGUGAUGCAUAAAGAGUAGC-3'

- 5
- 7
- 8
- 9
- 10

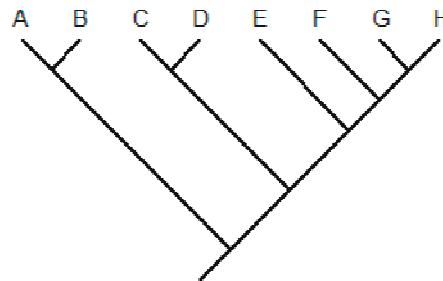
		Second Position							
		U		C		A		G	
First Position	U	UUU Phe UUC UUA Leu UUG	UCU UCC Ser UCA UCG	UAU Tyr UAC UAA Stop UAG Stop	UGU Cys UGC UGA Stop UGG Trp	U C A G			
	C	CUU Leu CUC CUA CUG	CCU Pro CCC CCA CCG	CAU His CAC CAA Gln CAG	CGU Arg CGC CGA CGG	U C A G			
	A	AUU Ile AUC AUA Met AUG	ACU Thr ACC ACA ACG	AAU Asn AAC AAA Lys AAG	AGU Ser AGC AGA Arg AGG	U C A G			
	G	GUU Val GUC GUA GUG	GCU Ala GCC GCA GCG	GAU Asp GAC GAA Glu GAG	GGU Gly GGC GGA GGG	U C A G			
		Third Position							

16. A scientist grew some animal cells in an isotonic medium with a very low concentration of a particular ion, and he measured the concentration of the ion in the cytoplasm of a single cell. When he added a solution of the ion to the medium around the cell (but keeping the medium isotonic to the cell), the concentration of the ion in the cytoplasm increased by 25%. When he repeated the experiment adding an inhibitor of cellular respiration to the ion solution in the medium, the cytoplasmic concentration only increased by 5%. From the results of this experiment, and your knowledge of transport across membranes, which statement is **FALSE**?
- The cell can take up the ion by both passive and active transport.
  - Carrier proteins are usually involved in passive transport of ions across animal cell membranes.
  - Active transporters change their shape during the transport of an ion across a membrane.
  - Ions cannot cross membranes by simple diffusion.
  - In the absence of the inhibitor, active transport accounted for most of the uptake of the ion.
17. John gave his mother a plant for Mother's Day that had a single stem, pairs of oval leaves, and an elaborate network of purple veins. She thought that it would look better if the plant was more bushy, so she cut off the tip. Why did she do this?
- Cutting off the tip of a monocot stem makes more bulbs form in the soil.
  - Removing the terminal meristem of a plant makes more buds form from the roots.
  - Cutting a stem releases ethylene, which triggers bud formation along the stem.
  - Removing the terminal meristem of a dicot releases gibberellins that trigger the growth of shoot meristems.
  - Removing the terminal meristem of a dicot also removes the source of auxin, which suppresses the growth of shoot apical meristems.

18. In humans, red-green colour-blindness is controlled by a gene on the X chromosome. A man and woman with normal colour vision marry. Both of their fathers were colour-blind. What is the probability that their first child will be colour-blind?

- 0
- 1/2
- 1/3
- 1/4
- 1/8

19. A monophyletic group is defined as including an ancestor and all of its descendants. The cladogram (branching diagram) below depicts the relationships between eight species. Which of the following represents a monophyletic group?



- A + B + C
- B + C + D + E
- C + D + E
- C + E + F + G + H
- F + G + H

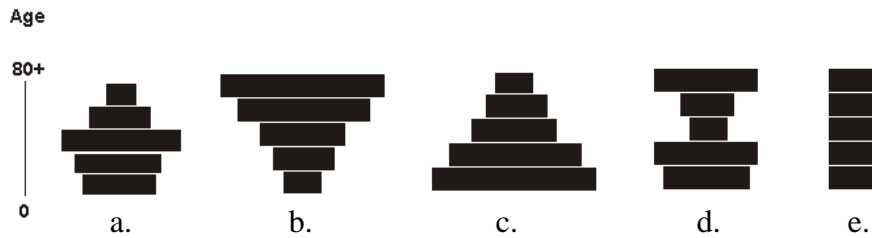
20. When you listen to a human heartbeat through a stethoscope, the softer “lub” of the “lub-dub” sound the heart makes is caused by which of the following actions?

- Closing of the atrioventricular valves (mitral and tricuspid).
- Closing of the semilunar valves (aortic and pulmonary).
- Sound of blood rushing into the atria.
- Sound of blood rushing into the ventricles.
- Sound of blood rushing into the aorta.

21. Why is a new strain of avian (bird) influenza that can cause serious illness in humans a concern to governments around the world?

- The bacterium that causes bird flu is resistant to most antibiotics.
  - The organism that causes bird flu may mutate so that it can spread from human to human.
  - The organism that causes bird flu is carried by wild birds and can be spread around the world as birds migrate.
  - The organism that causes bird flu can be spread by eating cooked chicken.
  - Vaccines will not work against the type of organism that causes bird flu.
- i, ii, iii, iv and v
  - i and v
  - ii and iii
  - ii, iii, and iv
  - iv and v

22. Which figure best represents an age structure diagram for a population undergoing very rapid population growth?



23. Which of the following organelles have evolved by endosymbiosis?

- i. Mitochondria
- ii. Chloroplasts
- iii. Peroxisomes
- iv. Ribosomes

- a. i only
- b. i and ii
- c. i, ii, and iii
- d. ii, iii, and iv
- e. ii and iii

24. If a molecule of mRNA, prior to splicing or polyadenylation, has 15% A, 20% G, 30% U, and 35% C, what is the composition of the double-stranded DNA that it was transcribed from?

- a. 15% T, 20% C, 30% A, 35% G
- b. 15% G, 20% A, 30% C, 35% T
- c. 22.5% T, 22.5% A, 27.5% G, 27.5% C
- d. 17.5% G, 17.5% A, 32.5% T, 32.5% C
- e. 25% A, 25% C, 25% G, 25% T

25. A patient is presenting with symptoms of gigantism. After a series of tests, you conclude that the patient most likely has a tumour on which of the following structures?

- a. Pituitary gland
- b. Adrenal gland
- c. Thyroid gland
- d. Hypothalamus
- e. Parathyroid gland

26. Which statement about oncogenes is **CORRECT**?

- a. Carcinogens are produced by oncogenes.
- b. Most human cancers are caused by oncogenes transferred by viruses.
- c. Oncogenes form proto-oncogenes after exposure to carcinogens.
- d. Oncogenes stimulate apoptosis (programmed cell death).
- e. Oncogenes produce proteins that are associated with cell division.

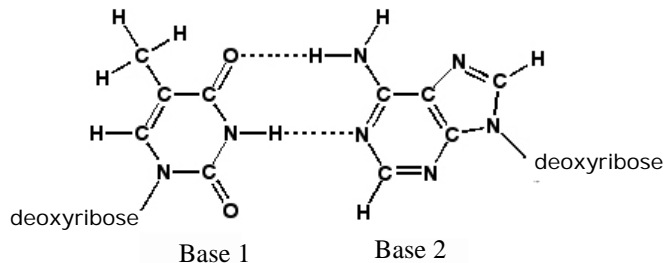
27. Which chemical bonds are considered the strongest, requiring the most energy to break?
- Ionic bonds
  - Hydrogen bonds
  - Van der Waals forces
  - Covalent bonds
  - Polar bonds
28. Which events occur during the light reactions of photosynthesis?
- Fixation of carbon dioxide, reduction of NADP<sup>+</sup>, formation of ATP.
  - Oxidation of water, reduction of NADP<sup>+</sup>, formation of ATP.
  - Oxidation of water, reduction of NADP<sup>+</sup>, hydrolysis of ATP.
  - Fixation of carbon dioxide, release of oxygen, synthesis of glucose.
  - Release of oxygen, fixation of carbon dioxide, hydrolysis of ATP.
29. You cut a live twig from a tree and examine the cut surface of the twig with a magnifying glass. You locate the vascular tissue and observe a growing droplet of fluid exuding from the cut surface. Where is this fluid most likely to be from?
- Phloem
  - Xylem
  - Cork
  - Pith
  - Broken vacuoles of cells
30. Which of the following would cause the kidneys to reabsorb more water?
- Increased blood volume
  - Increased cardiac output
  - Decreased blood pressure
  - Decreased anti-diuretic hormone (ADH) concentration
  - Decreased aldosterone levels
31. An electron microscope can visualize structures smaller than 100 nanometres (nm). Which structures could you only see with the aid of an electron microscope?
- A frog egg
  - A plant chloroplast
  - A virus particle
  - A protein molecule
  - Most bacteria
- i, ii, and v
  - ii and iii
  - iii and iv
  - iii and v
  - iv only



32. Which of the following contributes the most to global warming?
- Cattle digestion
  - Ozone depletion
  - Carbon monoxide emissions
  - Deforestation
  - Sulphur dioxide emissions
33. Stimulation by the parasympathetic nervous system promotes an increase in which bodily response?
- Heart rate
  - Breathing rate
  - Smooth muscle activity
  - Blood flow to skeletal muscles
  - Hepatic conversion of glycogen to glucose
34. What are the products of one molecule of glucose undergoing cellular respiration?
- Two molecules of pyruvate in the cytoplasm and two molecules of water in the mitochondrion.
  - Two molecules of pyruvate and two molecules of water in the cytoplasm.
  - Two molecules of pyruvate in the mitochondrion and two molecules of water in the cytoplasm.
  - One molecule of pyruvate in the mitochondrion and one molecule of water in the cytoplasm.
  - One molecule of pyruvate in the cytoplasm and one molecule of water in the mitochondrion.
35. Which of the following is **NOT** a cost (negative consequence) that can be associated with sexual reproduction?
- Enhanced transmission of sexually transmitted diseases.
  - A loss of reproductive potential because of the need to produce males.
  - An increased risk of population extinction.
  - Potential physical damage associated with mating.
  - Time or energy invested in locating a mate.
36. Which statement is **FALSE**?
- Carbohydrates always contain carbon, hydrogen, and oxygen.
  - Carbohydrates are assembled from units of fatty acids.
  - Carbohydrates can be used as an energy source for plant and animal cells.
  - Cellulose and starch are carbohydrates.
  - Sucrose is made from joining glucose with fructose.
37. In single-celled animals, which organelle is primarily responsible for digesting food particles?
- Golgi apparatus
  - Lysosome
  - Endoplasmic reticulum
  - Nucleus
  - Mitochondrion

38. Which of the following elements enters living organisms primarily from the atmosphere rather than from rocks or soil?
- Carbon
  - Calcium
  - Sulphur
  - Sodium
  - Phosphorus
39. Organisms that live in hypotonic aqueous environments must overcome which problem?
- Water and salt loss
  - Loss of water only
  - Acquisition of excess salts
  - Loss of salts only
  - Dilution and loss of salts
40. A scientist looking at a microscopic image of a frog embryo identifies the presence of both an archenteron and a blastocoel. What stage of development is the embryo currently experiencing?
- Cleavage
  - Neurulation
  - Fertilization
  - Gastrulation
  - Organogenesis
41. Coat colour in Labrador retrievers is controlled by two genes. The first gene controls coat colour, with black coat colour ( $B$ ) being dominant to brown coat colour ( $b$ ). The second gene controls the expression of colour, with the expression of colour ( $E$ ) being dominant to not expressing colour ( $e$ ). Failure to express colour results in a yellow Labrador retriever regardless of genetic coat colour (black or brown). A breeder repeatedly crosses a brown Lab and a yellow Lab. All of the resulting puppies are either black or yellow. The pair never produces any brown puppies. What are the genotypes of the parents?
- $bbee$  and  $Bbee$
  - $bbEE$  and  $Bbee$
  - $bbEe$  and  $Bbee$
  - $bbEe$  and  $BBee$
  - $BbEE$  and  $Bbee$
42. Imagine an animal that can alter its shape from a sphere to a ribbon. If this animal needs to conserve heat, it should form a:
- sphere, because this has a high surface area to volume ratio.
  - sphere, because this has a low surface area to volume ratio.
  - ribbon, because this has a high surface area to volume ratio.
  - ribbon, because this has a low surface area to volume ratio.
  - either a ribbon or sphere, because heat loss depends only on volume.

43. A man with blood type “A,” whose father was blood type “O,” married a woman of blood type “B” whose mother was blood type “O.” What are the possible blood types of their offspring?
- Only AB
  - Only A, B, or AB
  - Only A or B
  - Only AB or O
  - A, B, AB, or O
44. Which base pair is illustrated below?



	Base 1	Base 2
a.	guanine	cytosine
b.	thymine	adenine
c.	adenine	thymine
d.	cytosine	guanine
e.	thymine	guanine

45. A population of 100 diploid individuals is in Hardy-Weinberg equilibrium. If there are 16 individuals homozygous for the dominant allele, what is the frequency of the recessive allele?
- 0.16
  - 0.36
  - 0.40
  - 0.60
  - 0.84
46. Which statement about mitosis is **FALSE**?
- Homologous chromosomes synapse (pair) in prophase.
  - At anaphase the chromatids separate and migrate to opposite poles.
  - The enzymes needed for DNA synthesis increase in amount during G1.
  - At metaphase the spindle is complete and duplicated chromosomes line up at the equator.
  - The nuclear envelope is formed during telophase.

47. Which of the following is essential for speciation to occur?
- There must be a post-zygotic isolating mechanism.
  - Sub-populations must become geographically isolated from each other.
  - Formerly isolated sub-populations must never re-occur in the same place.
  - Gene flow between sub-populations must be restricted.
  - Hybrid offspring can be born, but are sterile 50% of the time.
48. Which statement is **FALSE**?
- Cristae of plant and animal mitochondria are involved in forming ATP.
  - In plants, sucrose is passed from the chloroplast to the mitochondrion, where it enters the citric acid (Krebs) cycle.
  - Plant mitochondria produce ATP that can be used to drive essential cell reactions.
  - In plants, chloroplasts use light energy to make carbohydrates, which are then used by mitochondria for cellular respiration.
  - In plants and animals, mitochondria can produce ATP only in the presence of oxygen.
49. Which statement about antibiotics and antibiotic drug use is **FALSE**?
- Most antibiotics are non-specific, also killing beneficial bacteria that normally occur in the body.
  - Antibiotic use can accelerate the evolution of antibiotic resistance in diseases such as tuberculosis.
  - Antibiotic-resistant bacteria can spread from one treated person to other persons who live in close proximity (for example, among family members).
  - Antibiotics accelerate the rate of mutation in the targeted bacteria, causing resistance to appear in the bacteria.
  - Antibiotic-resistance genes can move between different species of bacteria through a process called “horizontal gene transfer.”
50. How do sessile animals such as sponges and coral colonize new habitats?
- They have free-living larva.
  - They slowly spread along the substrate.
  - They send out spores, which drift on ocean currents.
  - The component cells separate, disperse, and then re-aggregate in new locations.
  - They rely on transport by other, mobile animals who carry them into new habitats.

End of exam.