

**University of Toronto
National Biology Competition**

2007 Examination

Thursday, April 26, 2007

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. Which of the following processes absorb free energy (i.e., are endergonic)?
 - i. Nitrogen fixation
 - ii. Respiration
 - iii. Photosynthesis
 - iv. Maintenance of homeostasis
 - a. i only
 - b. i and ii
 - c. i, iii, and iv
 - d. ii and iv
 - e. iii and iv

2. What would result from a mutation that results in two purines to pair with each other (or two pyrimidines to pair with each other)?
 - a. The DNA molecule could no longer form a double helix.
 - b. The DNA helix would no longer have a constant diameter.
 - c. Replication of DNA would stop because a 3' hydroxyl group would no longer be available.
 - d. Ligase could no longer fulfill its function.
 - e. Ribose would replace deoxyribose in the DNA's backbone.

3. Which statement about taxonomic relationships is **CORRECT**?
 - a. A class can contain more than one phylum.
 - b. A genus can contain more than one order.
 - c. A family can contain more than one class.
 - d. An order can contain more than one family.
 - e. A genus can contain more than one family.

4. A naturalist studying competitive interactions between flower-visiting animals in a meadow observes that hummingbirds always prevent butterflies from feeding on blue flowers. What would most likely occur upon removal of hummingbirds from the meadow?
 - a. An increase in the fundamental niche of butterflies.
 - b. A decrease in the realized niche of butterflies.
 - c. No change in the niche breadth of butterflies.
 - d. A decrease in the fundamental niche of butterflies.
 - e. An increase in the realized niche of butterflies.

5. Which statement best describes why DNA replication is referred to as "semi-conservative"?
 - a. At each replication, each DNA molecule retains one strand intact and synthesizes the other strand from new material.
 - b. After one round of replication, half of the DNA contains the original material and half is made up of new material.
 - c. After two rounds of replication, all of the DNA contains a mixture of original and new material.
 - d. Within each strand, the number of purines equals the number of pyrimidines.
 - e. During replication, one strand acts as "leading" and the other as "lagging."

6. Which of the following pairs does **NOT** match?
- Tropical rainforest – high species diversity
 - Ozone shield depletion – increased radiation reaching the surface of Earth
 - Greenhouse effect – rise in atmospheric CO₂
 - Eutrophication – decreased net primary productivity
 - Acid rain – rain with pH < 5.0
7. Which of the following represents an important evolutionary adaptation that allowed angiosperms to predominate as the most abundant terrestrial plants on Earth?
- Triploid endosperm
 - Archegonia
 - Diploid gametophyte
 - Motile female gametes
 - Antheridia
8. Which statement about genetic disorders in humans is **FALSE**?
- The frequency of the allele for sickle cell anaemia is higher in native populations of wet, tropical countries because carriers have a better chance of surviving malaria.
 - Colour blindness is rare in females because the condition is recessively inherited and the gene is sex linked.
 - Down syndrome occurs when three copies of chromosome 21 are present.
 - Aneuploidies, such as Down syndrome, results from errors in DNA replication during the S phase.
 - Sperm containing a Y chromosome fertilizing an ovum (egg) that contains no sex chromosome results in a spontaneous abortion.
9. Which of the following is a characteristic of an open circulatory system?
- Heart
 - Arteries
 - Capillaries
 - Veins
- i only
 - i, ii, and iv
 - i and iii
 - i, ii, iii, and iv
 - ii and iv
10. Which metabolic pathway occurs in both fermentation and cellular respiration?
- Calvin (Calvin-Benson) cycle
 - Citric acid (Krebs) cycle
 - Glycolysis
 - Electron transport chain
 - Synthesis of water

11. As part of a science competition, a student is asked to identify an unknown molecule as either DNA or RNA. Which of the following characteristics would be the strongest evidence that the unknown molecule is DNA?
- The presence of phosphate and sugar.
 - The absence of uracil.
 - The presence of thymine.
 - The presence of adenine, guanine, and cytosine.
 - The absence of a hydroxyl group on carbon 2 of the sugar molecule.
12. Which of the following signal transduction molecules is **NOT** bound to the plasma membrane?
- Cyclic AMP (cAMP)
 - Peptide hormone receptors
 - G proteins
 - Adenylyl cyclase
 - Phospholipase C
13. Which statement about cell division is **FALSE**?
- Mitosis can only occur after DNA has replicated in the S phase.
 - The amount of DNA in a nucleus at the end of mitosis is half the quantity of DNA in the preceding G₂ phase.
 - The number of sister chromatids determines how the number of homologous sets of chromosomes in a cell changes during mitosis.
 - Spermatozoa are permanently arrested in the G₁ phase and do not undergo mitosis.
 - Independent assortment takes place during metaphase I of meiosis.
14. A population of mountain goats originally inhabited the foothills of a mountain range. Over many thousands of years, increased competition by a lowland population of yaks drove the goat population to higher altitudes in the mountains. What change in haemoglobin is most likely to be associated with the goat population being physiologically adapted to higher altitudes?
- An increase in the number of heme groups.
 - Higher percentage of O₂ saturation for a given O₂ partial pressure.
 - Lower affinity for O₂.
 - Insensitivity to changes in blood pH levels.
 - Greater O₂ unloading at the tissues during strenuous activity.
15. A man and a woman have blood types A and B, respectively. Their first child had blood type AB, and the second child had blood type O. What correct prediction can be made about the blood types of subsequent children?
- Half will have blood type AB and half will have blood type O.
 - They will have blood type A and B only.
 - Each child has an equal chance of having blood type A, B, AB, or O.
 - Any blood type is possible, but A and B are much more likely.
 - None of the children will have blood type A.

16. In pheasant, males are larger and have more colourful plumage than females. Which of the following is most likely to account for these differences between males and females?
- Natural selection
 - Risk of predation
 - Mimicry
 - Sexual selection
 - Niche differences between the sexes
17. In the mammalian kidney, what causes water to be reabsorbed in the descending limb of the loop of Henle?
- Active transport of salt out of the tubule.
 - An increase in the osmolarity of the nephron fluid (filtrate).
 - Diffusion of salt out of the tubule.
 - High blood pressure.
 - Secretion of hydrogen ions from the renal medulla into the tubule.
18. Which of the following best describes the “flippers” found in seals, sharks, and penguins?
- Homologous structures resulting from divergent evolution.
 - Analogous structures resulting from divergent evolution.
 - Homologous structures resulting from convergent evolution.
 - Analogous structures resulting from convergent evolution.
 - Homologous structures representing a monophyletic grouping.
19. In frogs, only a few molecules of melanocyte-stimulating hormone (MSH) are required to trigger large changes in melanocytes (specialized skin cells that contain the dark brown pigment melanin). Which of the following provides the best explanation for this observation?
- The hormone amplifies the production of second messengers within the melanocyte.
 - The hormone is lipid soluble and readily penetrates the membranes of the melanocytes.
 - The hormone molecules persist for years and can repeatedly activate the same melanocyte.
 - The hormone is rapidly replicated within each melanocyte.
 - The hormone is specific to melanocytes.
20. Which of the following is a defining characteristic of chordates (although in most species, these characteristics can often only be seen in the embryonic or larval stage)?
- Pharyngeal slits
 - Digestive tract along entire length of body
 - Notochord
 - Post anal tail
- i, ii, and iv
 - i and iii
 - i, iii, and iv
 - ii and iii
 - ii and iv

21. Which term best describes the relationship between the chemical reactions illustrated below?



- Coupled redox reactions
 - Chemiosmotic synthesis of ATP
 - Coupled electron transport reactions
 - Reversible reactions
 - Coupled phosphate transfer reactions
22. In carnations, genes that code for flower colour show an incomplete dominance relationship. Red flowers crossed with white flowers yield pink flowers. What is the expected distribution of progeny from a cross between a pink-flowered parent and a red-flowered parent?
- 1:1 ratio of red to pink
 - All red
 - All pink
 - 1:1 ratio of red to white
 - 1:2:1 ratio of red to pink to white
23. A drug company developed a new insecticide that is highly poisonous to mosquitoes carrying West Nile virus. Mass spraying of the insecticide over a 10 year period resulted in a significant reduction in mosquito populations over the first five years, and a gradual increase in mosquito populations over the next five years. What is the most reasonable explanation for the observed effect of the insecticide on mosquito populations?
- The insecticide caused favourable mutations in the mosquitoes that led to resistance.
 - Genetic variants of mosquitoes resistant to the insecticide survived and transmitted their resistance to their offspring.
 - Mosquitoes from other populations in other areas moved in and replaced the mosquitoes killed by the insecticide.
 - The insecticide induced antibodies to the insecticide in some mosquitoes and these antibodies were then transmitted to offspring.
 - The drug company reduced the amount of insecticide sprayed in the environment.
24. If you leave most foods outside of the refrigerator, they will rapidly become spoiled with growths of bacteria and fungi. However, most microorganisms will not grow on the surface of honey. What is the best reason for this?
- The sugars in honey are toxic to most microorganisms.
 - Microorganisms do not use sugars as an energy source.
 - Honey is hypotonic to the cells of the microorganisms, causing them to take up water and burst.
 - The sugars in the honey enter the microorganisms via passive diffusion and disrupt metabolic processes.
 - Honey is hypertonic to the cells of the microorganisms, causing them to lose water and plasmolyse (shrink).

25. Match the component or process in the left column with the proper compartment or membrane in the right column (e.g., the citric acid cycle occurs within the_____).

i. Citric acid (Krebs) cycle	p. Stroma of chloroplast
ii. RuBP carboxylase/oxygenase (Rubisco)	q. Matrix of mitochondrion
iii. Glycolysis	r. Thylakoid membrane
iv. Photosystem II	s. Cytoplasm

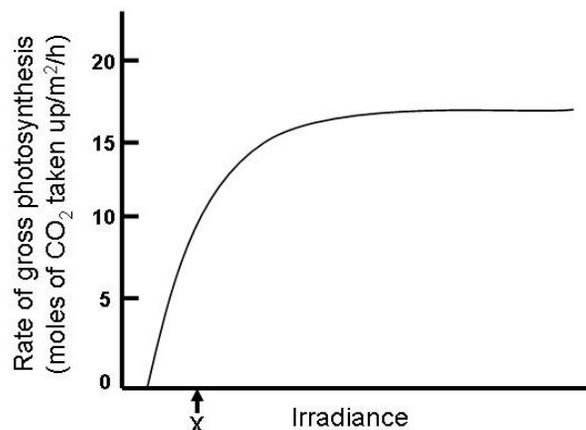
- a. i-q, ii-p, iii-s, iv-r
 b. i-q, ii-s, iii-r, iv-p
 c. i-r, ii-s, iii-p, iv-q
 d. i-q, ii-p, iii-r, iv-s
 e. i-p, ii-s, iii-q, iv-r
26. Which chemical bonds are involved in base pairing in DNA?
- a. Covalent bonds
 b. Ionic bonds
 c. Hydrogen bonds
 d. Van der Waals attractions
 e. Polar bonds
27. Which statement about thermogenesis is **CORRECT**?
- a. Aerobic metabolism by ectotherms produces no heat.
 b. Birds and mammals must contract their muscles to produce metabolic heat.
 c. All of the free energy released by mitochondrial oxidation is coupled to the production of ATP.
 d. In mammals, shivering is under voluntary control.
 e. Some mammals have tissues called brown adipose tissue (or brown fat) that are specialized for rapid heat production.
28. Which of the following conditions must apply for a behaviour pattern (such as eggshell removal behaviour in black-headed gulls) to evolve by natural selection?
- i. Individuals with the behaviour pattern must vary in their ability to produce offspring.
 ii. The behaviour pattern must be heritable.
 iii. Part of the variability in the behaviour pattern must be influenced by the environment.
 iv. Individuals must vary in the behaviour pattern.
 v. The behaviour pattern must confer greater fitness than other behaviour patterns.
- a. i, ii, and iv
 b. i, ii, and v
 c. ii, iii, and iv
 d. ii, iv, and v
 e. iii, iv, and v

29. What process is used to transport glucose into animal cells?
- Active transport
 - Facilitated diffusion
 - Endocytosis
 - Osmosis
 - Exocytosis
30. A science student observed an animal cell under a light microscope using a 100X objective. Which of the following organelles could **NOT** be observed by the student?
- Lysosomes
 - Peroxisomes
 - Mitochondria
 - Ribosomes
 - Centrosomes
31. A geneticist produced four plants with sickle-shaped pods and seven plants with crescent-shaped pods by crossing two plants of the same species. A review of the literature revealed that pod shape in this plant species is controlled by a single, completely dominant gene. What is the most accurate conclusion that the geneticist can make about the genotype of the parental plants?
- One parent was homozygous dominant and the other was homozygous recessive.
 - Both parents were heterozygous.
 - One parent was homozygous recessive and the other was heterozygous.
 - Since this result fits neither a 3:1 nor 1:1 distribution further crosses are required to collect more data.
 - One parent was homozygous dominant and the other was heterozygous.
32. Why is photosynthetic CO₂ fixation dependent on light?
- ATP and NADPH are required for the regeneration of ribulose biphosphate (RuBP).
 - The conversion of RuBP and CO₂ to 3-phosphoglycerate (3PG) requires ATP.
 - Phosphoenolpyruvate (PEP) regeneration requires NADPH.
 - The movement of CO₂ from the air into the leaf requires ATP.
 - RuBP carboxylase requires a photostimulant to oxidize RuBP.
33. Which of the following is an example of a negative feedback system?
- The more you scratch, the more it itches, so the more you scratch.
 - As blood sugar levels increase, insulin is released, signalling cells to take up sugar.
 - During childbirth, the pressure of the baby's head on the cervix causes the release of a hormone signal that increases the strength of contraction in the birth canal.
 - Pressure on the car brake during a quick stop causes forward momentum on the driver, causing an increase in pressure on the brake.
 - Application of a depolarizing drug to a neuron brings the membrane to threshold potential which opens voltage-gated Na⁺ channels.

34. A scientist created a chemical that specifically inhibits mitochondrial electron transport. Which effect would be observed when the chemical is added to an animal cell?
- A stimulation of ATP synthesis.
 - An increase in the pH of the matrix.
 - A decrease in O₂ consumption.
 - A stimulation of proton pumping.
 - An increase in FADH₂ consumption.
35. An evolutionary biologist carefully studies two populations of orchids, one from New Brunswick and one from Nova Scotia. She wants to know whether the two populations belong to the same species or to two different species. What is the best way to determine if they are two different species?
- Show that they both have the same pollinator.
 - Grow orchids from the two populations in a greenhouse and show that they can interbreed.
 - Demonstrate that orchids from the two populations preferred different habitats.
 - Identify morphological differences between orchids from the two populations.
 - Map the distribution of the two orchids and find areas where they co-exist but do not interbreed.
36. A taxonomist found an organism while hiking through a tropical rainforest. Upon close examination, he determines that the organism has chitin and acquires nutrients through absorption. The organism most likely belongs to the _____?
- Protista
 - Bacteria
 - Animalia
 - Fungi
 - Plantae
37. Which statement about photosynthesis is **FALSE**?
- Plants and green algae use water as a source of electrons in photosynthesis.
 - Cyclic electron transport results in the production of oxygen.
 - RuBP carboxylase/oxygenase (Rubisco) can add O₂ to the Calvin (Calvin-Benson) cycle.
 - In the light, the pH of the stroma increases.
 - Photophosphorylation involves coupled reactions.
38. An ecologist randomly sampled a large population of deer mice and found that 910 were black and 90 were white. Black coat colour is controlled by a dominant allele and white coat colour is controlled by a recessive allele. Assuming that the population is in Hardy-Weinberg equilibrium, what is the number of heterozygous individuals in this population?
- 700
 - 300
 - 490
 - 210
 - 420

39. The graph below illustrates a light response curve for a C₄ plant such as sugarcane. If the rate of respiration is 15 moles of CO₂ evolved per m² per hour, what is the rate of net gas exchange at the rate of gross photosynthesis at the point of irradiance indicated by the symbol X?

- 15 moles of CO₂ evolved per m² per hour.
- 5 moles of CO₂ evolved per m² per hour.
- 0 moles of CO₂ taken up and evolved per m² per hour.
- 5 moles of CO₂ taken up per m² per hour.
- 10 moles of CO₂ taken up per m² per hour.



40. An individual's fitness is best measured by:

- its ability to compete with other individuals for key resources.
- its resistance to disease and parasites.
- its ability to survive relative to other individuals.
- how early it can begin to reproduce.
- its relative contribution to the gene pool of the next generation.

41. Which statement about protein synthesis is **CORRECT**?

- A mutation that suppresses the formation of small nuclear RNA (snRNA) would increase the average size of mRNAs.
- Transcription factors act at the level of the ribosome during protein synthesis.
- Introns contain tRNA sequences that fuse with rRNA to form spliceosomes.
- Redundancy of the genetic code means that a single codon can code for more than one amino acid.
- Inosine can bond with uracil but not with adenine or cytosine.

42. In a laboratory experiment, a scientist applies a drug that opens sodium channels to a neuron. Two millilitres of the drug barely brings the membrane to threshold potential, at which time the scientist removes the drug by washing it away. After the neuron returns to stable resting potential, 10 ml of the same drug is applied. Which statement about the experiment is most likely to be **CORRECT**?

- The first application of the drug will not produce an action potential, as it is washed away quickly.
- No action potential will be produced because opening sodium channels will hyperpolarize the membrane.
- The action potential produced by the second application of the drug will be much greater than the first.
- The second application will not produce an action potential because the neuron is still in its refractory period.
- Both applications will produce action potentials of similar magnitude.

43. Which animal would produce a nitrogenous waste product with the lowest solubility in water?
- Butterfly
 - Shark
 - Frog
 - Polar bear
 - Freshwater fish
44. In the fruit fly *Drosophila melanogaster*, the white-eye allele is X-linked and recessive. What would be the outcome of a cross between a white-eyed female and a red-eyed male?
- The result would depend on the genotype of the parents.
 - All females will be red-eyed and all males will be white-eyed.
 - All males will be white-eyed and females will have a 1:1 red-eye to white-eye distribution.
 - Any combination of sex and eye colour is possible.
 - Female to male distributions and red-eye to white-eye distributions will be 1:1, independent of one another.
45. In terrestrial plants, most of the water used in photosynthesis is acquired from the soil and transported to the leaves. Which of the following best describes the pathway that a molecule of water would follow upon entering the root?
- Cortex → endodermis → xylem → epidermis
 - Xylem → epidermis → cortex → endodermis
 - Epidermis → cortex → endodermis → xylem
 - Endodermis → epidermis → xylem → cortex
 - Cortex → xylem → epidermis → endodermis
46. Which statement best explains why bumblebees do not require respiratory pigments?
- They have a small surface area to volume ratio.
 - They have low metabolic rates.
 - They have a counter-current gas exchange mechanism.
 - They have an open circulatory system.
 - They have a system to deliver air directly to tissues.
47. A study of a freshwater community revealed the following food chain:
- Phytoplankton → zooplankton → perch → trout → osprey
- The amount of energy in phytoplankton in this community is 1,000,000 joules. How much of this energy would most likely appear in the tertiary consumer given a 10% efficiency transfer between trophic levels?
- 100,000 joules
 - 10,000 joules
 - 1,000 joules
 - 100 joules
 - 10 joules

48. What elements are directly responsible for separating chromatids at the beginning of anaphase in mitosis?
- Centrioles
 - Centromeres
 - Kinetochores microtubules
 - Nuclear membranes
 - Nucleoli
49. In large aquatic systems, such as the Great Lakes of North America, environmental contaminants like DDT would be most concentrated in which animal?
- Herring gull eggs
 - Zooplankton
 - Perch (medium-sized fish)
 - Minnows (small-sized fish)
 - Zebra mussels
50. Certain indigenous tribes in the Amazon tip the darts of their blowguns with poison derived from frogs. These frogs are often brilliantly coloured and easy to spot in the forest. What is this an example of?
- Batesian mimicry
 - Warning colouration
 - Müllerian mimicry
 - Cryptic colouration
 - Secondary defence

End of exam.