

**University of Toronto
National Biology Competition**

2008 Examination

Thursday, May 1, 2008

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 presents the levels of taxonomic classification from lowest (least inclusive) to highest (most inclusive)?
 - a. subspecies → genus → class → order → phylum
 - b. species → family → order → class → phylum
 - c. order → family → domain → phylum → kingdom
 - d. genus → phylum → class → order → taxa
 - e. class → order → phylum → family → domain

2. Although the forelimb of humans, cats, and bats show considerable differences in form and function, they are made up of the same basic bones. What does this suggest about the forelimbs of these organisms?
 - a. They are vestigial structures.
 - b. They have evolved due to convergent evolution.
 - c. They are derived from a common ancestor.
 - d. They are analogous structures.
 - e. They have different evolutionary origins.

3. Which feature do Hornworts (Anthocerophytes), Mosses (Bryophytes), and Liverworts (Hepatophytes) have in common?
 - a. The sporophyte generation is the dominant stage in their life cycle.
 - b. They all have roots.
 - c. They all produce seeds.
 - d. They are non-vascular plants and rely on the process of diffusion and osmosis to transport nutrients.
 - e. The sporophyte generation does not contain chlorophyll.

4. Which statement best describes the difference between exponential and logistic growth?
 - a. Exponential growth depends on birth and death rates; logistic growth does not.
 - b. Emigration and immigration are not important for logistic growth and are important for exponential growth.
 - c. Exponential growth depends on density; logistic growth depends on the carrying capacity.
 - d. Logistic growth reflects density-dependent effects of birth and death rates; exponential growth is independent of density.
 - e. Exponential growth follows a sigmoidal curve; logistic growth follows a linear function.

5. Tay-Sachs disease is an autosomal recessive disorder. Children with this disease generally die before their fifth birthday. The carrier frequency in Ashkenazi Jewish individuals is approximately 3%. If two individuals of Ashkenazi descent have a child with Tay-Sachs, what is the probability that their second child will be a carrier of the disease?
 - a. 0.5
 - b. 0.25
 - c. 0.03
 - d. 1
 - e. 0.0009

6. Plants have adapted to a diversity of environments including arid environments such as deserts. Which of the following traits is NOT an adaptation of plants to dry environments?
- A photosynthetic system which allows the stomata to open only at night.
 - Low stomatal density.
 - A thick waxy cuticle.
 - A large leaf size.
 - Modified stems or roots for water storage.
7. In the mammalian kidney, what is the primary function of the proximal tubule?
- To reabsorb urea from the filtrate by active transport.
 - To regulate urine concentration through the action of vasopressin.
 - To reabsorb creatinine and hydrogen ions from the filtrate through active transport.
 - To transport NaCl actively into the tubule to create the osmotic gradient required for the reabsorption of water.
 - To reabsorb ions and nutrients from the filtrate, such as glucose and amino acids, by active transport.
8. I have cell walls which include chitin, and I am a heterotroph. What am I?
- Mushroom
 - Yeast
 - Penicillium*
 - Escherichia coli* (*E. coli*)
 - Green algae
- i only
 - i, ii, and iii
 - ii and iii only
 - iii and iv
 - v only
9. Testosterone is a steroid hormone that can be used as a performance enhancing drug. Which of the following side effects would NOT result from testosterone abuse?
- A reduction in luteinizing hormone (LH) resulting in the disruption of the menstrual cycle in women.
 - A reduction in testosterone production leading to impotence and shrunken testes in men.
 - An increase in prolactin production which can lead to lactation.
 - A reduction in follicle-stimulating hormone (FSH) which can lead to sterility.
 - An increase in protein synthesis and acceleration of muscle growth.
10. When you become cold, your body has a number of control mechanisms to maintain homeostasis. Which of the following is NOT a physiological response to a drop in body temperature?
- Contraction of piloerector (hair) muscles.
 - Involuntary contraction of skeletal muscles (shivering).
 - An increase in fat metabolism.
 - Decrease rate of sweat production.
 - Vasodilation (increased diameter) of the blood vessels near the skin.

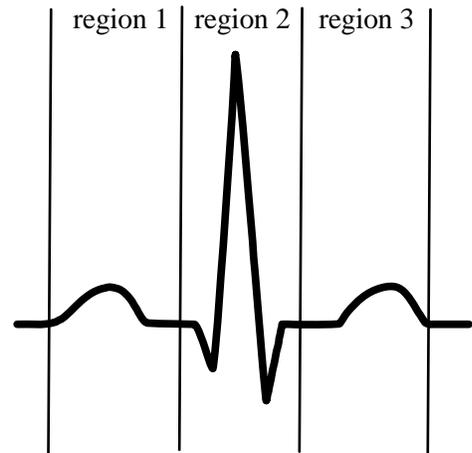
11. Duplicated chromosomes are generally NOT found during which stage of the cell cycle?
- G₂ phase
 - G₁ phase
 - Mitosis
 - S phase
 - Prophase
12. Bonding between amino acids can cause a polypeptide to form an alpha-helix or a pleated sheet. What is this configuration called?
- A secondary structure
 - A motif
 - A domain
 - A tertiary structure
 - A primary structure
13. The symptoms below may be exhibited by patients suffering various forms of endocrine imbalance. Which of these symptoms would you expect in someone suffering from hyperparathyroidism, a rare disease caused by overactive parathyroid glands?
- High levels of Ca²⁺ in the blood.
 - Muscle spasms.
 - Onset osteoporosis (a disease that causes weak bones).
 - The development of Grave's disease (symptoms include weight loss, rapid heart rate, and nervousness).
 - Reduced metabolic rate.
- i and ii only
 - i, ii, and iii only
 - i and iii only
 - iv and v only
 - v only
14. Most fruit flies (*Drosophila melanogaster*) have red eyes. A geneticist finds three separate mutants that have white eyes. She inbreeds the offspring of the mutants over several generations to produce three strains that only have white-eyed offspring. She then crosses the strains to produce an F₁ generation (see below), all of which have red eyes. From each F₁, an F₂ generation is produced; a ratio of nine red-eyed to seven white-eyed progeny is obtained in each case. How many loci are responsible for the white eyes of the three strains?
- 1 locus
 - 2 loci
 - 3 loci
 - 6 loci
 - No loci, as eye colour is affected by environmental conditions.

Cross type	F ₁	F ₂
strain 1 x strain 2	red	9 red : 7 white
strain 1 x strain 3	red	9 red : 7 white
strain 2 x strain 3	red	9 red : 7 white

15. Which statement about water transport in plants is FALSE?
- Root pressure alone is insufficient to explain water transport in plants.
 - Water moves from a cell with higher (less negative) water potential to a cell with lower (more negative) water potential.
 - The amount of water that can be transported by vessels is a function of the radius of the transport vessels.
 - The transport of water is carried out by the xylem which consists of sieve-tube cells and companion cells.
 - Water movement in the xylem is largely due to the cohesive and adhesive properties of water.
16. Some types of antiretroviral drugs used to treat HIV resemble a protein that is the substrate of the HIV protease. These antiretroviral drugs can bind to the active site of HIV protease making it unable to bind to its substrate. What can these drugs be classified as?
- Competitive inhibitors
 - Allosteric activators
 - Allosteric inhibitors
 - Cofactors
 - Enzymes
17. Which statement about cellular structures is CORRECT?
- Lysosomes are membrane-bound digestive vesicles that arise from the endoplasmic reticulum.
 - Ribosomes, smooth endoplasmic reticulum, and the Golgi apparatus are involved in protein production.
 - Animal cells are linked to the extracellular matrix through fibronectins, which are an integral part of the plasma membrane.
 - Mitochondria and chloroplasts are surrounded by two membranes and both have their own DNA that is commonly inherited through only one parent.
 - The nucleus is surrounded by a single membrane.
18. If an mRNA sequence is 5'-UCAGCCGUC-3' what is the sequence of the DNA template strand?
- 3'-TCAGCCGTC-5'
 - 3'-AGUCGGCAG-5'
 - 5'-GACGGCTGA-3'
 - 5'-TCAGCCGTC-3'
 - 5'-AGTCGGCAG-3'
19. Which statement about speciation is CORRECT?
- Genetic drift may counter speciation when incompletely isolated populations come together and intermediates begin to occur between them.
 - Speciation can occur instantaneously through polyploidy.
 - Hybrid inviability or infertility is a prezygotic isolating mechanism.
 - Sympatric speciation may occur through stabilizing selection.
 - The biological species concept provides a single definition of what constitutes a species for all living organisms.

20. Below is a diagram of an electrocardiogram (ECG). The vertical lines divide the ECG into regions 1, 2, and 3. What does the change of voltage in each of these regions indicate?

- Region 1 represents ventricular depolarization; region 2 represents atrial depolarization; region 3 represents atrial repolarization.
- Region 1 represents ventricular depolarization; region 2 represents ventricular repolarization; region 3 represents atrial depolarization.
- Region 1 represents atrial depolarization; region 2 represents ventricular depolarization; region 3 represents ventricular repolarization.
- Region 1 represents atrial depolarization; region 2 represents ventricular depolarization; region 3 represents atrial repolarization.
- Region 1 represents atrial repolarization; region 2 represents ventricular repolarization; region 3 represents atrial depolarization.



21. A/An _____ species has an effect on the structure and functioning of an ecosystem which is greater than expected based on its abundance.
- foundation
 - endemic
 - invasive
 - indicator
 - keystone
22. During meiosis, if there are 40 chromatids in a cell during prophase I, how many chromatids will there be in EACH daughter cell by the end of telophase II?
- 5
 - 10
 - 20
 - 40
 - 80
23. A biologist discovered a new species of microorganism in a soil sample taken from a marsh. The organism required hydrogen sulphide gas as a source of energy and released methane gas. In addition, the organism was unicellular and none of its organelles were bounded by membranes. The biologist also found that the RNA polymerase of this organism was more similar to yeast than to *E. coli*. To which group does the species belong?
- Animals
 - Bacteria
 - Fungi
 - Archaea
 - Plants

24. Several studies of genetic variation in the endangered African cheetah (*Acinonyx jubatus*) have been conducted. These studies have revealed that the species is monomorphic at all loci examined. What is the most likely cause of this low level of genetic variation?
- Artificial selection
 - Population bottlenecks
 - Founder effects
 - Inbreeding
 - Directional selection
25. Which statement about DNA replication in prokaryotes is CORRECT?
- DNA gyrase separates the two strands of DNA.
 - DNA ligase cleaves the DNA into Okazaki fragments.
 - DNA polymerase II synthesizes RNA primers.
 - DNA polymerase III synthesizes DNA from 3' to 5'.
 - RNA primers are removed by DNA polymerase I and replaced with DNA.
26. People on low carbohydrate diets derive their energy primarily from stored fats. Which of the following is the key metabolic pathway that allows for the production of cellular energy from lipids?
- The breakdown of lipids to glucose (glycolysis).
 - The breakdown of lipids to lactic acid (lactic acid fermentation).
 - The breakdown of lipids to acetyl-CoA (beta-oxidation).
 - The breakdown of lipids to alpha-ketoglutarate (deamination).
 - The breakdown of lipids to oxaloacetate (deamination).
27. Which of the following is NOT a function of the mammalian liver?
- The production of bile salts used to break up fat globules.
 - Detoxification of ingested poison.
 - Storage of fat-soluble vitamins A, D, E, and K.
 - The production of lipase used to breakdown lipids to fatty acids and glycerine.
 - Conversion of excess glucose to glycogen.
28. Where does glycolysis occur in cells?
- Cytoplasm
 - Intermembrane space of the mitochondria
 - Mitochondrial matrix
 - Chloroplast stroma
 - Thylakoid
29. In which type of cell would you expect to observe a large number of peroxisomes?
- Muscle cells
 - Osteocytes
 - Liver cells
 - Epidermal cells
 - Red blood cells

30. A botanist is having difficulty getting seeds to germinate. What hormone could she apply to the seeds to help induce germination?
- Auxin
 - Gibberellin
 - Abscissic acid
 - Ethylene
 - Juvenile growth hormone
31. A scientist observes a population of fish. She notes that females are grey while males have bright red and blue markings. She also finds that females are caught by predators less often than all males, but that males with dull colours are caught less often by predators than males with bright colours. What evolutionary process is likely responsible for the bright red and blue markings of males in this species?
- Sexual selection
 - Natural selection
 - Mutation
 - Genetic drift
 - Coevolution
32. Which of the following is a feature of the phospholipid bilayer of a cell membrane?
- Hydrophobic phosphate groups are found on the exterior of the bilayer.
 - Hydrophilic fatty acids are found in the interior of the bilayer.
 - Phospholipids in the bilayer often have non-polar molecules attached to the phosphate group.
 - Phospholipids in the bilayer have three fatty-acid tails which are hydrophobic.
 - Phospholipids in the bilayer are insoluble in water because of the large number of non-polar C-H bonds in their fatty-acid tails.
33. Which statement about respiration is FALSE?
- Oxidation of pyruvate produces acetyl-CoA (the two-carbon molecule) and is the link between glycolysis and the citric acid cycle (Krebs cycle).
 - During the citric acid cycle the four-carbon molecule oxaloacetate is added to acetyl-CoA to form citric acid.
 - The citric acid cycle produces NADH, FADH₂ and ATP.
 - The electron transport chain pumps protons out of the intermembrane space and into the mitochondrial matrix.
 - In eukaryotes, the actual yield of ATP through aerobic respiration is lower than the theoretical yield partly because mitochondria use the proton gradient for purposes other than ATP synthesis.
34. Which of the following is an isomer of glucose?
- Galactose
 - Maltose
 - Ribose
 - Glycogen
 - Deoxyribose

35. A portion of a gene was sequenced in two individuals (see below). What type of mutation has occurred in individual two?

Individual one: mRNA: AUG ACU CAC CGA GCG CGA AGC UGA
 Protein: Met Thr His Arg Ala Arg Ser Stop

Individual two: mRNA: AUG ACU CAC UGA GCG CGA AGC UGA
 Protein: Met Thr His Stop

- Missense
 - Deletion
 - Silent
 - Transversion
 - Nonsense
36. You are growing a bean seedling in a windowsill. You find that the seedling begins to bend toward the direction of the window (the direction of the light). What is the cause of this growth pattern?
- An increase in turgor pressure in the cells on the shaded side of the stem resulted in a positive phototropic response.
 - Elongation of cells on the shaded side resulted in a positive phototropic response.
 - A higher rate of cell division on the shaded side caused a heliotropic response.
 - A weakening of the cell walls of the lit side, due to the presence of auxin, caused the stem to bend.
 - An increase in photosynthesis on the lit side of the stem resulted in formation of amyloplasts, which caused the stem to bend.
37. A population of Morning Glory has white, red and pink flowers. Crosses reveal that this polymorphism is controlled by one locus and two alleles. *WW* individuals have red flowers, *Ww* individuals have pink flowers, and *ww* individuals have white flowers. If the frequency of white-flowered individuals in the population is 0.09, what is the frequency of the pink-flowered individuals if the population is in Hardy-Weinberg equilibrium?
- 0.70
 - 0.49
 - 0.50
 - 0.16
 - 0.42
38. Although nitrogen makes up almost 80% of Earth's atmosphere, nitrogen gas cannot be utilized by plants as a nitrogen source. What biological process results in the conversion of nitrogen gas to a form useful to plants?
- The conversion of nitrogen gas to nitrite by bacteria in a process called nitrification.
 - The conversion of ammonium to nitrite by bacteria in a process called nitrification.
 - The conversion of nitrogen gas to ammonia by bacteria in a process called nitrogen fixation.
 - The conversion of nitrogen gas to ammonium by bacteria in a process called ammonification.
 - The conversion of nitrogen gas to nitric oxide by bacteria in a process called denitrification.

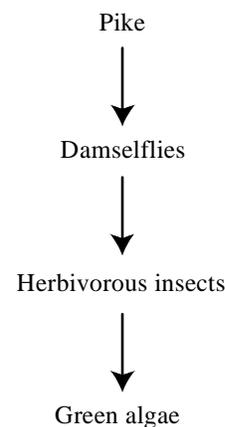
39. The *lac* operon, found in *E. coli*, codes for three enzymes that breakdown lactose. The three enzymes are coded by genes Z, Y, and A. The repressor of the *lac* operon is coded by gene I and is found at a separate locus. Lactose acts as an inducer by stopping the action of the repressor. In which of the following circumstances will the Z, Y, and A genes be expressed?

- i. If there is a mutation in gene I that prevents the repressor from binding to the operator.
- ii. If there is a mutation in gene I that prevents the inducer from binding to the repressor.
- iii. If there is a mutation in the promoter that prevents the RNA polymerase from binding.
- iv. If lactose is present.
- v. If lactose is absent.

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

40. The diagram at the right shows the feeding interactions between four species. Which statement about the species interactions is CORRECT?

- a. The damselflies are secondary carnivores.
- b. The algae are chemoautotrophs.
- c. If the pike were removed, the algae and damselfly populations would increase and herbivorous insects would decrease.
- d. The pike are on the first (bottom) trophic level.
- e. If the herbivorous insects were removed, the damselfly populations would decrease, while the pike and algae populations would increase.



41. When is the affinity of haemoglobin for oxygen increased?

- a. When carbon monoxide is present.
- b. When there are high levels of carbonic acid in the blood.
- c. At high temperatures.
- d. When one of the binding sites is occupied by oxygen.
- e. When carbon dioxide is bound to haemoglobin.

42. If you have blood type O and require a transfusion, what type of blood would result in agglutination of your red blood cells?

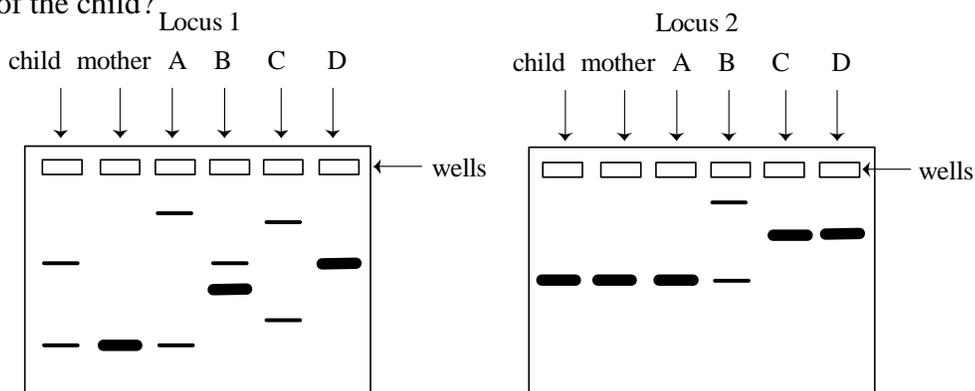
- i. Type A
- ii. Type AB
- iii. Type B
- iv. Type O

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

43. A disulfide bridge is formed by:
- a hydrogen bond.
 - a covalent bond.
 - an ionic bond.
 - van der Waals attraction.
 - hydrophobic exclusion.
44. Which of the following associations is the best example of commensalism?
- Bee pollinators feeding on nectar from a flower.
 - A hookworm growing in a dog.
 - Rhizobium* in a legume host.
 - A human infected with *Streptococcus*.
 - Clownfish living among the poisonous tentacles of sea anemones.
45. Which statement about ATP is FALSE?
- ATP is principally made within mitochondria of eukaryotic cells.
 - ATP is a compound that carries energy conserved during catabolic reactions.
 - Within cells, ATP has a negative charge and often has magnesium as its counterion.
 - ATP is often used in enzyme reactions that create new phosphate ester bonds in compounds.
 - ATP has phosphate groups with the highest bond energy of any compounds in the cell.
46. Which of the following membrane proteins rely only on passive processes to transport substances across the plasma membrane?
- Ion channel proteins
 - Carrier proteins
 - Peripheral proteins
 - Proton ATPase
- i and ii
 - i and iii
 - i and iv
 - ii and iii
 - ii and iv
47. Which statement about photosynthesis is FALSE?
- The photosynthetic electron transport chain and ATP synthase are located in the thylakoid membrane.
 - Rubisco (ribulose-1,5-bisphosphate carboxylase/oxygenase), the key enzyme involved in the Calvin cycle, can oxidize RuBP (ribulose-1,5-bisphosphate) which eventually results in the release of CO₂.
 - Chlorophyll a is the main photosynthetic pigment in plants and cyanobacteria and converts light energy to chemical energy.
 - The net equation for the Calvin cycle is $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$.
 - ATP synthase couples the formation of ATP to the passive diffusion of protons across the membrane.

48. Samples of DNA were obtained from a child, his mother, and four potential fathers (A, B, C, and D), and DNA fingerprinting was performed using two co-dominant loci. Based on the resulting gels (below) who is the most likely father of the child?

- Individual A
- Individual B
- Individual C
- Individual D
- None of the individuals.



49. What is responsible for the rapid depolarization of the axon (i.e., the rising phase of an action potential)?
- Voltage-gated sodium channels open allowing Na^+ into the cell.
 - Voltage-gated potassium channels open allowing K^+ into the cell.
 - The Na^+/K^+ pump actively moves Na^+ out of the cell and K^+ into the cell.
 - Voltage-gated Ca^{2+} channels open allowing Ca^{2+} into the cell.
 - Voltage-gated potassium channels open allowing K^+ ions out of the cell.

[Question #50 was removed from the exam at the time of grading.]

End of exam.