

**University of Toronto
National Biology Competition**

2004 Examination

Thursday, April 29, 2004

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 is necessary for speciation to occur?
 - a. A large number of mutations accumulating within a population.
 - b. Reproductive isolation of two populations of organisms.
 - c. A reduction in the number of individuals in a population.
 - d. Matings between two populations of organisms produce offspring with low survivorship.
 - e. Populations are geographically separated from one another.

2. Which statement about a frameshift mutation is **CORRECT**?
 - a. It can only occur in non-coding regions of the genome.
 - b. It results in a protein sequence that is shorter in length.
 - c. It results in a protein sequence that is longer in length.
 - d. It is caused by the insertion or deletion of DNA.
 - e. It changes the sequence of amino acids in the resulting protein, but does not change the sequence of nucleotides.

3. Canadian health officials are considering different ways of preparing for a future world-wide epidemic of human influenza that could be derived from a form of the disease that infects birds (avian flu). Which of the following would **NOT** be useful in preventing a future influenza epidemic?
 - a. Inoculate healthy people with a vaccine against the pathogen.
 - b. Give infected people anti-viral drugs.
 - c. Give antibiotics to people with mild symptoms.
 - d. Distribute surgical masks to prevent the spread of the disease through moisture droplets released by coughing and sneezing.
 - e. Ask people with flu symptoms to stay at home.

4. Chromosome number is reduced during meiosis because the process consists of:
 - a. a single cell division without any chromosome replication.
 - b. two cell divisions without any chromosome replication.
 - c. two cell divisions and a single round of chromosome replication.
 - d. two cell divisions in which half of the chromosomes are destroyed.
 - e. four cell divisions with no chromosome replication.

5. Which statement about the properties of water and its role in biological systems is **FALSE**?
 - a. In a water molecule, hydrogen atoms are linked to the oxygen atom by polar covalent bonds.
 - b. The combination of hydrophobic and hydrophilic interactions of a protein with water can influence the shape of the protein.
 - c. The solubility of NaCl in water is a product of the interactions between the water molecules and the ions in the salt.
 - d. Water is a liquid at room temperature because of the hydrogen bonds that occur between individual water molecules.
 - e. Water boils at 100°C as a result of the breakage of the bonds between the hydrogen and oxygen atoms.

6. The banana plant is classified as a monocot because:
- the veins in its leaves are parallel, rather than netlike.
 - its gametes are formed in flowers, rather than cones.
 - its flower parts are produced in multiples of fours and fives.
 - the vascular bundles in its stem are arranged in a ring.
 - it lacks vascular tissue.
7. Which bodily process involves a positive feedback loop?
- Kidney function
 - Insulin secretion
 - Sweating
 - Muscle contraction
 - Childbirth
8. Which of the following was a central point in Darwin's theory of evolution by natural selection?
- The biological structures an organism is most likely to inherit from its parents are those that have become better suited to the environment through constant use.
 - Mutations occur to help future generations adapt to their environment.
 - Slight variations among individuals significantly affect the chance that a given individual will survive in its environment and be able to reproduce.
 - Genes change in order to help organisms cope with problems encountered within their environment.
 - More advanced organisms are less likely to go extinct.
9. Which organisms would be the most severely affected by the presence of pesticides that can become biologically magnified in a given ecosystem?
- Primary consumers, such as grasshoppers.
 - Primary producers, such as plants.
 - Top predators, such as hawks.
 - Secondary consumers, such as mice that feed on insects.
 - Decomposers, such as earthworms.
10. Which statement is **FALSE**?
- Members of the kingdom Archaea can survive in extreme environments, such as oxygen-free and extremely hot environments.
 - Cells are considered to be the basic units of life, thus viruses are often not considered to be living organisms because they have no cellular structure.
 - Protists are classified into major groups based on their type of nutrition, and include protozoa that ingest or absorb their food, and algae that carry out photosynthesis.
 - The haploid gametophyte is the dominant generation in the life cycle of non-vascular plants.
 - Cells of bacteria contain many chromosomes and reproduce by mitosis and meiosis.

11. A student decided to reduce her body fat by not eating any foods containing fat, but eating pasta and rice instead. Her friend gave her a list of five reasons (stated below) why this was not a good idea, but only one was correct. Which of the following was the correct reason?
- The body can use excess acetyl-CoA made from carbohydrates by glycolysis to make body fat.
 - Fats are essential for the process of aerobic respiration.
 - Without fatty acids produced from fats, there will be no acetyl-CoA to fuel the Krebs (citric acid) cycle.
 - An excess of carbohydrates leads to the production of lactic acid during glycolysis.
 - The amino acids in fats can be used to make proteins, which are needed to build muscles.
12. Which statement about the carrying capacity (K) of a population is **CORRECT**?
- At K, $dN/dt = 1$.
 - The growth rate of a population is at its maximum at $K/2$.
 - For each population the value of K does not change over time.
 - Populations experience the most rapid growth as they approach K.
 - Environmental resources are fully depleted at the carrying capacity of a population.
13. Population genetics can provide insight into all of the following, except:
- The frequency of a genetic disease in a population.
 - How long a disease is likely to persist.
 - How rapidly a disease can become established and spread in a population.
 - What genes are most likely to mutate and cause disease.
 - What disease-associated genes are being selected against in a population.
14. Which of the following are **NOT** associated with high levels of human chorionic gonadotropin (HCG)?
- A growing embryo.
 - High levels of progesterone.
 - An active corpus luteum.
 - Termination of ovulation.
 - High levels of luteinizing hormone (LH).
15. What is the cause of SARS (severe acute respiratory syndrome)?
- An influenza virus.
 - A coronavirus.
 - A virus similar to the virus which causes the common cold.
 - A bacterium.
- i only
 - i and iii
 - ii only
 - ii and iii
 - iv only

16. The second law of thermodynamics states that as entropy increases, free (usable) energy:
- is released as heat energy.
 - varies inversely with the absolute temperature.
 - increases.
 - decreases.
 - remains constant.
17. The movement of materials from one part of a plant to another is called translocation. Which statement about translocation is **FALSE**?
- Translocation of sugars occurs by simple diffusion.
 - Translocation requires energy provided by living cells.
 - Translocation of sugars occurs within cells called sieve tube elements.
 - Translocation moves sugars from regions of high concentration to regions of low concentration within the plant.
 - Translocation moves mineral nutrients from the root to the leaves.
18. Which statement about natural selection is **FALSE**?
- Natural selection can lead to adaptation.
 - Natural selection accounts for the resemblance between parent and offspring.
 - Natural selection causes allele frequencies in a population to change.
 - Natural selection is occurring today.
 - Natural selection is involved in the evolution of antibiotic resistance.
19. Which statement about cellular respiration is **FALSE**?
- All organisms perform cellular respiration.
 - Carbon dioxide is a product of the Krebs (citric acid) cycle.
 - Glycolysis and fermentation are carried out in mitochondria under anaerobic conditions.
 - Glycolysis results in the breakdown of glucose to pyruvate molecules.
 - The respiratory (electron transport) chain produces the most ATP molecules.
20. In humans, a widow's peak is caused by a dominant allele W , and a continuous hairline is caused by a recessive allele w . Short fingers are caused by a dominant allele S , and long fingers are caused by a recessive allele s . Suppose a woman with a continuous hairline and short fingers and a man with a widow's peak and long fingers have three children. One child has a widow's peak and short fingers, one has a widow's peak and long fingers, and one has a continuous hairline and long fingers. What are the genotypes of the parents?
- Female $wwSS$; male $WWss$.
 - Female $wwSs$; male $Wwss$.
 - Female $wwSs$; male $WWss$.
 - Female $WwSs$; male $WwSs$.
 - None of the above.

21. A cell containing 40 chromatids at the start of mitosis would produce cells each containing how many chromosomes at the end of mitosis?
- 5
 - 10
 - 20
 - 40
 - 80
22. Some gas stations in Canada sell gasoline that contains ethanol. Which statement about ethanol is **FALSE**?
- Ethanol is a renewable resource.
 - The combustion of ethanol releases carbon dioxide and, therefore, contributes to global warming.
 - Ethanol does not release organic compounds into the air during combustion, whereas gasoline does.
 - During fermentation, yeast cells die when the ethanol they produce reaches a certain concentration.
 - Yeast cells produce ethanol inside their mitochondria.
23. What DNA sequence information is **NOT** present in a sequence of complementary DNA (cDNA)?
- Introns
 - Exons
 - 3' untranslated region
 - Promoter
- i and ii
 - i and iv
 - ii and iv
 - iii only
 - iv only
24. A red blood cell is in the artery leading to the small intestine of a human. How many capillary beds does it cross before it reaches the left ventricle of the heart?
- 0
 - 1
 - 2
 - 3
 - 4 or more
25. Which of the following pairs of organisms are most closely related to one another?
- Birds and mammals.
 - Mammals and crocodiles.
 - Frogs and birds.
 - Frogs and mammals.
 - Crocodiles and birds.

26. A biologist collects a sample of fish from a stream. The fish appear to be the same species, but when she measures the sample, she finds that their body sizes fall into two distinct groups: large and small. Which explanation is least likely to account for this observation?
- There are two species in the sample.
 - There is one species, but one size class is made up of males and the other is made up of females.
 - There is one species, but the small size classes are juveniles and the large size classes are adults.
 - There is genetic drift.
 - There is sexual dimorphism in body size.
27. Some of the essential elements required by living organisms are not readily available to them. For example, the conversion of _____ to a form useful to plants occurs as a result of the activity of bacteria.
- carbon
 - oxygen
 - nitrogen
 - phosphorus
 - hydrogen
28. The first functional electron microscope was built in Canada at the University of Toronto. Electron microscopes allow us to see cell components that are not visible under the best light microscopes. Which of the following cell structures can be seen only with an electron microscope?
- Ribosomes
 - Lysosomes
 - Peroxisomes
 - Mitochondria
 - Chloroplasts
29. The ratio of _____ in DNA is 1:1.
- guanine to adenine
 - adenine to thymine
 - cytosine to adenine
 - uracil to cytosine
 - uracil to thymine
30. You travel to Costa Rica as an eco-tourist and are amazed at the abundance of biological interactions that occur in the tropical rainforest. Which of the following interactions are **NOT** considered either competition, predation, or mutualism?
- Bats pollinating plants.
 - The transport of mites from flower to flower on the beaks of hummingbirds.
 - The digestion of cellulose by bacteria living in the guts of termites.
 - Army ants raid a bird's nest and consume the hatchlings.
 - A seedling which is intolerant of shade dies in the dark forest understory.

31. A scientist added a solution of positively-charged ions to an animal cell and measured the concentration of the ions inside the cell 20 minutes later. If she repeated the experiment using a new cell and doubled the external concentration of the ions, the concentration inside the cell also was doubled. When she injected the living cell with a dye that specifically fluoresced when it bound to the ions, she saw that the cytoplasm fluoresced uniformly throughout the cell. What is the most likely explanation for how the ions were taken up into the cell?
- Via channel proteins in the plasma membrane.
 - Via carrier proteins in the plasma membrane.
 - By active transport.
 - By passive diffusion.
 - By endocytosis.
32. Which statement is **FALSE**?
- Catabolism refers to the metabolic breakdown of complex molecules into more simple molecules.
 - An exothermic reaction is one in which energy is released.
 - The term “activation energy” is used to describe the total amount of energy released by a reaction.
 - Enzymes are able to catalyse certain reactions by lowering the activation energy.
 - The synthesis of carbohydrates from CO_2 and H_2O by photosynthesis is an example of an endothermic reaction.
33. The following are parts of the gastro-intestinal (or digestive) tract. In which order would an indigestible food particle pass by them?
- Caecum \rightarrow pyloric sphincter \rightarrow cardiac sphincter \rightarrow bile duct opening \rightarrow ileum.
 - Cardiac sphincter \rightarrow pyloric sphincter \rightarrow bile duct opening \rightarrow ileum \rightarrow caecum.
 - Ileum \rightarrow cardiac sphincter \rightarrow caecum \rightarrow bile duct opening \rightarrow pyloric sphincter.
 - Pyloric sphincter \rightarrow cardiac sphincter \rightarrow ileum \rightarrow caecum \rightarrow bile duct opening.
 - Cardiac sphincter \rightarrow bile duct opening \rightarrow ileum \rightarrow caecum \rightarrow pyloric sphincter.
34. During phototropism, how does a plant stem bend and grow toward the direction of the light source?
- Cells on the shaded side of the stem synthesize more of the hormone abscisic acid (ABA).
 - Cell divisions on the lit side of the stem result in shorter cells.
 - Cell elongation on the shaded side of the stem is suppressed by the hormone ethylene.
 - Cells on the shaded side of the stem elongate more than those on the lit side.
 - Cells on the lit side of the stem synthesize more of the hormone auxin.
35. According to most conservation biologists, what is the greatest current threat to global biodiversity?
- Chemical pollution of water and air.
 - Depletion of the ozone layer of the stratosphere.
 - Insufficient programs to recycle non-renewable resources.
 - Alteration or destruction of habitats.
 - Global climate change resulting from human activities.

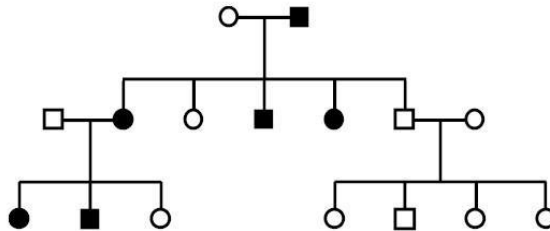
36. “Homeostasis” implies maintaining a constant condition in the body. Yet organisms have to change; for example, when they grow and develop, and when they respond to internal needs such as hunger and reproduction. Which one of the following would allow a controlled change in a system regulated by negative feedback?
- An increased gain in the feedback loop; that is, a larger response to any “error” (departure from the set-point).
 - A reversal of sign in the feedback loop to make it positive.
 - A change in the set-point of the feedback loop toward a new value.
 - An “opening” of the loop; for example, by blocking signals conveying error information.
 - A decrease in the rate with which the loop responds to errors.
37. Which statement about homologous genes is **CORRECT**?
- Homologous genes are those that have descended from a common ancestral gene.
 - Two genes can be 90% homologous.
 - Homology is equivalent to sequence similarity.
 - Two homologous genes cannot be found in the same individual.
- i only
 - i and ii
 - i, ii, and iii
 - ii and iv
 - iii and iv
38. Regions of the human body can be considered topographically as either “inside” or “outside.” For example, a water molecule in the brain is considered inside the body because it would have to cross at least one cell or tissue layer to reach the outside world. On the other hand, a water molecule in a tear duct, or in the nasal cavity, would be considered outside the body. In which of the following would a water molecule be inside the body?
- Lymph vessel
 - Bile duct
 - Urine in the bladder
 - Lung alveolus
 - Stomach
39. Spinach leaves are dark green because of the high concentration of chlorophyll pigments in their photosynthetic cells. Which statement about chlorophyll pigments is **FALSE**?
- They are located in the thylakoid membranes inside chloroplasts.
 - They are organized into reaction centres.
 - They absorb light energy that is passed from one chlorophyll molecule to another.
 - They absorb light energy that is then used to split water molecules into oxygen and hydrogen atoms.
 - They absorb the green wavelengths of light.

40. A biologist studying a population of beetles observes that their average body size had increased over a number of generations. Which mechanism(s) can account for this observation?
- Natural selection.
 - A change in local environment.
 - Global climate change.
 - (a) and (b) only.
 - (a), (b), and (c).
41. For a trait that is controlled by two alleles at a single locus, the observed frequency of allele 1 in a population of diploid individuals is 0.8. If the population is in Hardy-Weinberg equilibrium what is the expected frequency of heterozygous individuals?
- 0.04
 - 0.16
 - 0.20
 - 0.32
 - 0.64
42. Most wild plants contain toxins that deter animals from eating them. A scientist discovered that a toxin produced by a certain plant was also toxic to the same plant if it was applied to the roots of the plant. As the first step in finding out why the plant was not normally killed by its own toxin, he fractionated some plant cells and found that the toxin was in the fraction that contained the largest cell organelle. He also found that the toxin was no longer toxic after it was heated. Which of the following statements are consistent with the scientist's observations?
- The toxin was stored in the central vacuole.
 - The toxin can cross the plasma membrane but not the membrane of the organelle in which it is stored.
 - The toxin was stored in the chloroplast.
 - The toxin is likely to be lipid-soluble.
 - The toxin may be an enzyme.
- i, ii, and v
 - i, iv, and v
 - ii and iii
 - iii and iv
 - iii and v

43. The virus that causes AIDS is currently evolving in human populations. Which of the following steps could be taken to stop the evolution of the AIDS virus?
- Reduce the general use of antibiotics among humans.
 - Treatment of infected patients with more effective antibiotics.
 - Increase the lifespan of infected patients through better care.
 - All of the above.
 - None of the above.

44. In the human pedigree below, the trait indicated in black is caused by what type of allele?

- Autosomal dominant
- Sex-linked
- X-linked dominant
- X-linked recessive
- Y-linked



45. Which statement is **FALSE**?

- Epinephrine (adrenaline) causes release of glucose from the liver.
- Rennin causes release of milk from mammary glands.
- Insulin causes uptake of glucose from the blood.
- Secretin causes release of bicarbonate from the pancreas.
- Thyroxin causes increased metabolic activity in muscles.

46. In an attempt to improve the efficiency of photosynthesis and increase crop yield, biotechnologists have focused their efforts on the process of carbon fixation. What is the most logical strategy that would improve this process?
- Genetically modify the plant to reduce the loss of CO_2 by eliminating respiration.
 - Genetically modify the plant to change it from one using C_4 carbon fixation to C_3 carbon fixation.
 - Modify the protein ribulose-bis-phosphate (RuBP) carboxylase to increase its affinity for CO_2 .
 - Genetically modify the plant to increase the rate of photorespiration.
 - Provide carbon to the plant in the form of glucose by adding it to the soil.

47. You are a doctor examining a patient who has some difficulty walking, and who complains about a weakness in the left leg. You find an absence of some reflex responses to stimuli applied to the left foot; the right foot is normal. Direct electrical stimulation to leg nerves causes normal muscle twitches in the left foot. Which is most likely to be the cause of the patient's condition?
- Degeneration of myelin sheaths of the motor neurons of the leg.
 - A back injury causing damage to the nerves entering the spinal cord.
 - Low production of the neurotransmitter acetylcholine.
 - A neck injury causing spinal cord damage.
 - Disease of the autonomic nervous system.

48. In populations that alternate between periods of asexual reproduction and periods of sexual reproduction, when is asexual reproduction most advantageous?
- When adults of both sexes are numerous.
 - When the weather is extremely cold.
 - When hybridization is possible.
 - When conditions are favourable and uniform.
 - When the population density is high.
49. What characteristic of adenosine triphosphate (ATP) makes it an important molecule in metabolism?
- ATP readily diffuses through mitochondrial membranes for use by other components of the eukaryotic cell.
 - Its hydrolysis requires free energy.
 - It is readily obtained from the environment.
 - It is extremely stable.
 - Its phosphate bonds are easily formed and broken.
50. Which cells are **NOT** normally involved in the functioning of the immune system in humans?
- White blood cells
 - Red blood cells
 - Lymphocytes
 - B cells
 - T cells

End of exam.