

**University of Toronto  
National Biology Competition**

**1999 Examination**

Time: 75 minutes

Number of questions: 50

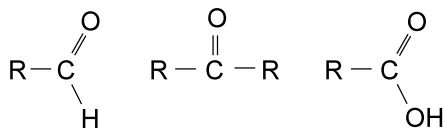
General Instructions

- 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?*

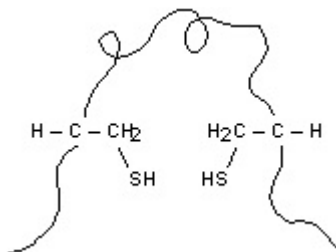
Since your score on the exam is based on the number of questions you answered correctly minus one-third of the number you answered incorrectly, it is improbable that guessing will improve your score (it is more likely to lower your score). (No points are deducted or awarded for unanswered questions.) 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.

- Under the electron microscope, you observe a cell with three different types of large organelles, each bounded by two membranes. The cell is most likely to be from:
  - a plant. \*\*
  - an animal.
  - a fungus.
  - a bacterium.
  - a virus.
- In a biology lab exam, a student is given two cultures of single-celled, colourless organisms. She is told that one culture is of an organism collected from the Pacific Ocean and one is of an organism collected from Lake Winnipeg, but neither culture is identified. A question on the exam asks the student to determine which organism came from which source. Which experiment would best provide the answer to the exam question?
  - Look to see which cells had flagella; the flagellated cells were from Lake Winnipeg.
  - Put some cells of each culture into a 3 M sucrose solution; the cells that shrank were from the Pacific Ocean.
  - Put some cells of each culture into a 3 M sucrose solution; the cells that shrank were from Lake Winnipeg.
  - Put some cells of each culture into distilled water; the cells that burst were from the Pacific Ocean. \*\*
  - Put some cells of each culture into distilled water; the cells that burst were from Lake Winnipeg.
- From left to right, identify the class of compounds most likely to contain the functional groups shown below.



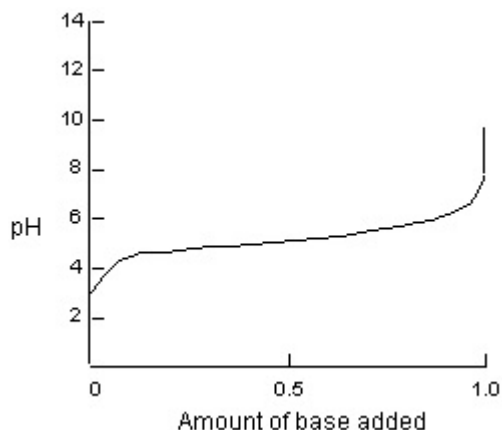
- Ketones, aldehydes, carboxylic acids
  - Aldehydes, ketones, carboxylic acids \*\*
  - Carboxylic acids, ketones, aldehydes
  - Aldehydes, carboxylic acids, ketones
  - Ketones, carboxylic acids, aldehydes
- Which statement about macromolecules is **FALSE**?
    - Monomers are the building blocks of polymers.
    - Both DNA and RNA are linear polymers of nucleotides.
    - A monosaccharide is a long-chain polymer formed of simple sugars. \*\*
    - Both cellulose and starch are polymers of glucose.
    - Triglycerides (or simple lipids) contain fatty acids and glycerol.

5. The diagram below shows a polypeptide chain and two adjacent cysteine groups. Which statement is **FALSE**?



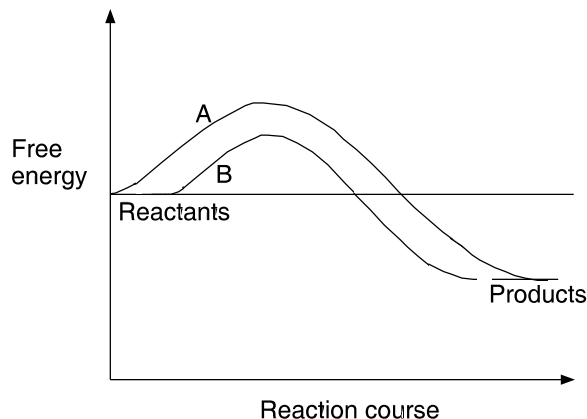
- The sulfhydryl groups on two cysteine side chains in a protein can react to form a covalent disulfide bridge.
  - When a cysteine residue is not part of a disulfide bridge, the side chain is hydrophobic.
  - Loss of hydrogen atoms from sulfhydryl groups of cysteine side chains in a protein results in a covalent bond that helps stabilize the proteins three-dimensional structure.
  - The methylene groups on two adjacent cysteine side chains in a protein can react to form hydrogen bonds that help determine how the protein folds. \*\*
  - The cysteine side chains are part of the protein's primary structure, which is determined by the precise sequence of amino acids in the unbranched polypeptide chain.
6. A scientist put some photosynthetic plant cells in a solution of inorganic minerals in the dark. He notices that after a few days, the cells could take up mineral A, but not mineral B. Control cells in the same nutrient solution but in the light continued to be able to take up both minerals. Which statement is the best conclusion from all of these observations?
- Photosynthesis uses light energy to directly transport minerals across the plasma membrane.
  - Mitochondria do not function in the dark.
  - Mineral A is taken up by diffusion and mineral B by endocytosis.
  - Mineral A is taken up by passive transport and mineral B by active transport. \*\*
  - Mineral A is taken up by active transport and mineral B by passive transport.
7. Of the five properties listed below, which are the most important in relation to the function of the plasma membrane in living cells?
- Selective permeability
  - Strength
  - Elasticity
  - Hydrophilicity
  - Fluidity
- i and ii
  - i and v \*\*
  - ii and iii
  - iii and iv
  - iv and v

8. The graph below shows the titration of acetic acid ( $\text{CH}_3\text{COOH}$ ). Which statement is **FALSE**?



- At the midpoint,  $[\text{CH}_3\text{COOH}] = [\text{CH}_3\text{COO}^-]$ .
  - At the midpoint, pH is about 4.8.
  - At the endpoint, all of the molecules of acetic acid have been titrated to the conjugate base, acetate.
  - The buffering range of acetic acid is between about pH 4.2 and pH 6.2.
  - The buffering capacity is most effective at pH values below 4 and above 6. \*\*
9. Which statement is **FALSE**?
- The Golgi complex forms vesicles that fuse to form the endoplasmic reticulum. \*\*
  - Cell walls generally contain high levels of carbohydrate.
  - If a lysosome bursts, its contents can seriously damage the cytoplasm of a cell.
  - Secreted proteins are initially formed by ribosomes attached to the endoplasmic reticulum.
  - The nucleolus is where ribosomes are assembled.
10. Which of the following is **NOT** a function of glycolysis?
- Production of ATP.
  - Production of NADH.
  - Production of  $\text{FADH}_2$ . \*\*
  - Formation of pyruvate.
  - Splitting the carbon skeletons of simple sugars.
11. The chemiosmotic hypothesis attempts to explain:
- the movement of water into the chloroplast and its use in photosynthesis.
  - the coupling of ATP formation to electron flow in an electron-transport chain. \*\*
  - the movement of lipid-soluble molecules through a membrane.
  - the movement of NADH from the cytoplasm into the mitochondrion.
  - the coupling of chemical gradients to osmosis.

12. The graph below shows two hypothetical reactions: reaction course A represents a reaction uncatalysed by an enzyme, whereas B represents an enzyme-catalysed reaction. Which statement is **FALSE**?



- When an enzyme changes the activation energy of a reversible reaction of the type  $x \xrightleftharpoons{k} y$ , both the forward and reverse reactions speed up.
  - The uncatalysed reaction (A) requires a higher activation energy than does the enzyme-catalysed reaction (B).
  - The change in free energy is the same for both reactions.
  - Adding an enzyme to mediate a reaction (B) does not alter the difference in free energy between the reactants and products; it only changes the activation energy and hence the rate constant.
  - Both reactions proceed to equilibrium at the same rate. \*\*
13. Which one of the following is an end product of the Calvin cycle, the dark reaction of photosynthesis?
- ATP
  - NADPH
  - A three-carbon sugar \*\*
  - Oxygen
  - Carbon dioxide
14. Some human cells divide approximately every 24 hours. You do some experiments to show that the  $G_1$  and S phases take up half of the cycle time. Further microscopic observations demonstrate that the mitotic phase is one hour long. How long does the post-synthesis “gap” take in this case?
- 1 hour
  - 6 hours
  - 9 hours
  - 11 hours \*\*
  - 23 hours

15. If cells in the process of dividing are subjected to colchicine, a drug that interferes with the functioning of the spindle apparatus, at which stage will mitosis be stopped?
- Anaphase
  - Prophase
  - Telophase
  - Interphase
  - Metaphase \*\*
16. Albinism (lack of skin pigmentation) is caused by a recessive autosomal allele. A man and a woman, both normal pigmented, have an albino child together. The couple then have a second child. What is the probability that the second child will be albino?
- 0
  - 25% \*\*
  - 50%
  - 75%
  - 100%
17. All of the following are used as evidence that genes are on chromosomes **EXCEPT**:
- The structure of DNA is a polymer of nitrogenous bases linked together by a “backbone” of alternating phosphates and sugars. \*\*
  - The correlation of the Mendelian law of segregation with the segregation of chromosomes in meiosis.
  - The correlation of the Mendelian law of independent assortment with the assortment of chromosomes in meiosis.
  - The correlation of Down’s syndrome in humans with an extra chromosome 21.
  - The sex linked inheritance of some forms of colour blindness in human males correlates with the inheritance of one X and one Y chromosome in males.
18. The relationship between genotype and phenotype is rarely simple. The term “pleiotropy” describes:
- when a heterozygote individual has a phenotype intermediate between those of the two types of homozygotes.
  - when a heterozygote exhibits phenotypes for both its alleles.
  - the ability of a single gene to affect multiple phenotypic traits. \*\*
  - when one gene affects the expression of another gene.
  - characters that vary continuously, indicating an additive effect of two or more genes on a single phenotypic character.
19. Which statement about meiosis is **FALSE**?
- The two meiotic divisions reduce the DNA content per cell to one half of the initial content.
  - Crossing over occurs in prophase of the second meiotic division. \*\*
  - In many species, the haploid products of meiosis proliferate by mitotic division.
  - In many multicellular organisms only one of the four products of meiosis is inherited.
  - There is no DNA replication between the first and second meiotic division.

20. Gene therapy for deleterious mutations in blood cells is becoming possible by introducing normal genes into blood cell precursors in the laboratory and re-injecting these cells into the patient. Which of the following would **NOT** be associated with this kind of gene therapy research?
- Attempting to place the normal gene in a vector which will help the gene integrate into a chromosome.
  - Utilising virus vectors which have had some of their own genes removed.
  - Utilising a suitably modified HIV virus.
  - Preventing transmission of the mutation to the next generation. \*\*
  - Finding gene transfer methods for treating other genetic disorders, such as cystic fibrosis.
21. If 35% of the bases of a DNA molecule are thymine, it follows that it also contains:
- 30% adenine.
  - 30% cytosine.
  - 15% guanine. \*\*
  - 35% uracil.
  - None of the above are correct.
22. Molecular biologists cracked the code of life in the 1960s, when a series of elaborate experiments disclosed the amino acid translations of each of the mRNA codons. How many triplet mRNA codons are there?
- 16
  - 20
  - 32
  - 64 \*\*
  - As many as there are amino acids, plus the initiation and termination codons.
23. You are asked to generate, within two weeks, a collection of recombinant plasmid clones that contain pieces of a large proportion of all human genes. What would be the fastest strategy?
- Digest human DNA with a restriction enzyme; digest the plasmid with two further restriction enzymes. Ligate the human and plasmid DNA and transfer DNA to bacteria.
  - Digest human and plasmid DNA with the same restriction enzyme. Ligate the human and plasmid DNA and transfer DNA to bacteria. \*\*
  - Digest human DNA extensively with a conventional endonuclease; digest the plasmid with a restriction enzyme producing "blunt ends." Ligate the human and plasmid DNA and transfer DNA to bacteria.
  - Transform human DNA to bacteria which contain a plasmid. Use a bacterial recombination system to integrate this DNA into the plasmids.
  - This cannot be done in two weeks or less.

24. The term “translation” refers to:
- the excision and reintegration of a DNA fragment.
  - a specific type of DNA repair.
  - the synthesis of a polypeptide according to an RNA sequence. \*\*
  - the synthesis of RNA according to a DNA sequence.
  - the synthesis of DNA according to an RNA sequence.
25. A population is in genetic equilibrium when genotype and allele frequencies remain the same from one generation to the next. Genetic equilibrium will occur when:
- populations are small, thus more likely to be affected by genetic drift.
  - beneficial mutations arise.
  - there is no immigration and emigration. \*\*
  - there is mating between close relatives.
  - natural selection is acting on a particular phenotype.
26. In a population of diploid individuals that is in Hardy-Weinberg equilibrium, the frequency of a dominant allele for a certain hereditary trait is 0.3. What percentage of individuals in the next generation would be expected to be homozygous for the dominant trait?
- 9% \*\*
  - 14%
  - 42%
  - 49%
  - 90%
27. When Shakespeare was alive cobs of maize (corn) grew to about 15 cm in length, whereas today they can be almost twice this size. This is because:
- of the cooler temperatures and decreased rainfall experienced at that time.
  - agricultural fields in England were small at that time and thus nutrients were limiting.
  - recombinant DNA technology was not being practised at that time.
  - plant breeding using genetic principles was not introduced until the 20<sup>th</sup> century. \*\*
  - of the lack of genetic variation in maize from Mexico, where maize originated.
28. Many people were sceptical of the theory of evolution when Darwin first proposed it. Darwin received such sharp criticism because:
- the bones in the wings of bats, fins of porpoises, and legs of humans were known to be analogous structures.
  - he could not explain completely how evolution occurred because he did not know the mechanism of inheritance. \*\*
  - the fossil record indicated that there were links between birds and reptiles.
  - Earth was thought to be much older than it actually is.
  - he proposed that chimpanzees had evolved into humans.

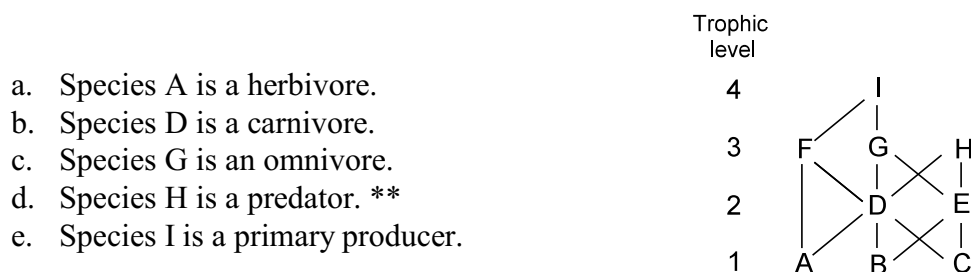


29. The sequence of events in geographic speciation is most likely to be:
- Genetic divergence → geographic barrier → reproductive isolation.
  - Geographic barrier → genetic divergence → reproductive isolation. \*\*
  - Reproductive isolation → genetic divergence → geographic barrier.
  - Geographic barrier → reproductive isolation → genetic divergence.
  - Genetic divergence → reproductive isolation → geographic barrier.
30. Elderly people are advised to get influenza (flu) vaccinations every year. Each year, a different type of flu vaccine has to be made. This is because:
- different viruses attack people of different ages, so each year as the population ages, a new vaccine must be produced.
  - antibodies to the flu vaccine do not survive very long in the blood.
  - vaccines are unstable and cannot be stored for more than one year.
  - the body learns to destroy the antibodies made against the vaccine, so a new type of vaccine is needed for each vaccination.
  - flu viruses change their genetic constituents so rapidly that vaccines against them rapidly become obsolete. \*\*
31. Which important aspect of the classification of all organisms is attributed to Carl Linnaeus?
- The use of Latin.
  - The use of branching diagrams (trees) to depict relationships among groups.
  - The use of two-part names (binomials). \*\*
  - The use of standardized common names.
  - The use of keys for identification.
32. It is generally agreed that prokaryotes constituted the first life on Earth. It is also generally accepted that the early eukaryotes were:
- photosynthetic.
  - chemosynthetic.
  - heterotrophs.
  - multicellular.
  - unicellular. \*\*
33. Which group of organisms has the largest number of described species?
- Arthropods \*\*
  - Vertebrates
  - Bacteria
  - Fungi
  - Flowering plants

34. A mycorrhiza is a mutualistic association between a fungus and a plant's roots. Which statement best characterizes this association?
- The fungus provides nothing to the plant; the plant provides food to the fungus.
  - The fungus secretes toxins to kill the plant; the plant provides minerals to the fungus.
  - The fungus provides minerals to the plant; the plant secretes toxins to kill the fungus.
  - The fungus provides minerals to the plant; the plant provides food to the fungus. \*\*
  - The fungus provides minerals to the plant; the plant provides nothing to the fungus.
35. Which statement about water movement in plants is **FALSE**?
- It occurs from a region of low to high concentration. \*\*
  - It occurs in dead cells, called tracheids and vessel elements.
  - It depends on the cohesive properties of molecules.
  - It depends on the adhesive properties of molecules.
  - Water moves from the leaf to the atmosphere by diffusion.
36. It is common practice for farmers to pick tomatoes while they are green and to store them in a warehouse prior to shipment to the local grocery store. Prior to shipment, the tomatoes are treated with a growth regulator to induce ripening. Which growth regulator is used?
- Cytokinin
  - Auxin
  - Abscisic acid
  - Gibberellin
  - Ethylene \*\*
37. In which region of the vertebrate digestive tract does the majority of nutrient absorption into the blood stream occur?
- Stomach
  - Colon
  - Small intestine \*\*
  - Large intestine
  - Esophagus
38. The separation of oxygen from hemoglobin is enhanced near exercising muscle (this is known as the Bohr effect) and is caused by:
- oxygen binding to hemoglobin in the lung.
  - carbon monoxide binding to oxygenated hemoglobin.
  - carbonic anhydrase.
  - the interaction of lowered pH with oxygenated hemoglobin. \*\*
  - the interaction of carbon dioxide with oxygenated hemoglobin.

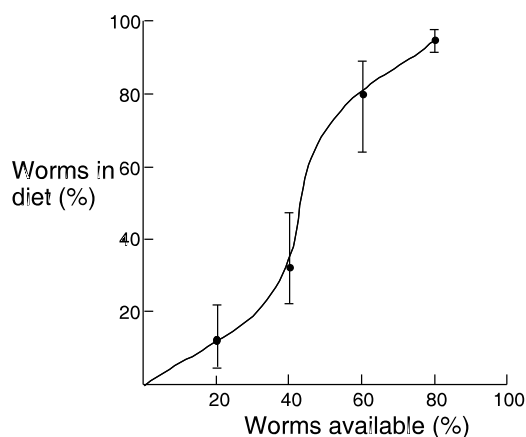
39. Beginning from the anterior (= superior) vena cava, what is the correct pathway of blood through the mammalian heart? (R = right, L = left)
- R atrium → R ventricle → pulmonary vein → lung circuit → pulmonary artery → L atrium → L ventricle → aorta.
  - L atrium → L ventricle → pulmonary artery → lung circuit → pulmonary vein → R atrium → R ventricle → aorta.
  - Aorta → L atrium → L ventricle → pulmonary vein → lung circuit → pulmonary artery → R ventricle → R atrium.
  - R ventricle → R atrium → pulmonary artery → lung circuit → pulmonary vein → L atrium → L ventricle → aorta.
  - R atrium → R ventricle → pulmonary artery → lung circuit → pulmonary vein → L atrium → L ventricle → aorta. \*\*
40. Which of the following is a “key event” in the evolution of vertebrates?
- Gut formation from the coelom
  - Formation of the neural crest \*\*
  - Spiral cleavage
  - Gastrulation following cell cleavage
  - Organogenesis to produce organs
41. Oogenesis is the process in the ovary that results in the production of female gametes. Which statement about oogenesis in humans is **FALSE**?
- Oogenesis begins at the onset of sexual maturity.
  - In oogenesis, unequal cytokinesis results in one single large daughter cell, which goes on to form the egg.
  - At birth, an ovary already contains all the cells it will ever have that will develop into eggs.
  - The process of oogenesis is completed when the egg cell is penetrated by sperm.
  - Oogenesis continues throughout the life of the individual. \*\*
42. As a nerve impulse passes along an axon:
- the membrane potential changes from positive to negative and then back again.
  - sodium ions flow out through ion channels and potassium ions flow in.
  - sodium channels open as the membrane potential becomes less negative. \*\*
  - the sodium-potassium pump moves sodium ions into the cell.
  - potassium channels close as the membrane potential becomes more positive.
43. A main function of the autonomic nervous system, which consists of the sympathetic and parasympathetic divisions, is to:
- act as an inhibitory system for skeletal muscle.
  - control the activity of a variety of secretory cells throughout the body. \*\*
  - communicate between the two halves of the brain.
  - control involuntary reflexes such as the knee-jerk response.
  - initiate the heart beat.

44. Some athletes take “steroids” in an attempt to enhance their physical performance. This can lead to decreased sperm production and even sterility. What is the most likely explanation for this effect?
- Interference in the proper negative feedback control of testosterone by luteinizing hormone. \*\*
  - Increased stimulation of the anterior pituitary to produce luteinizing hormone.
  - Excessive growth of testicular tissue.
  - Suppression of the natural production of thyroxin due to the destruction of thyroid tissue.
  - Excessive diversion of protein and other metabolites from the gonads to muscle tissue.
45. If you were outside for a long time on a hot, dry day, without anything to drink, which of the following would happen?
- The production of thyroxin by your thyroid gland would increase.
  - The osmotic pressure of your blood would decrease.
  - The re-absorption of fluids from your kidney tubules would decrease.
  - The concentration of urea in your urine would decrease.
  - The secretion of anti-diuretic hormone from your pituitary gland would increase. \*\*
46. In which ecosystem would you find the highest biodiversity?
- Freshwater marsh \*\*
  - Prairie grassland
  - Tundra
  - Boreal forest
  - Cultivated field
47. The diagram below shows the feeding interactions between nine species (A to I) of a food web with four trophic levels. Which statement about this food web is **CORRECT**?



48. What is the “carrying capacity” of a population?
- The rate at which the density of individuals increases over time.
  - The maximum number of individuals which can be supported in a given environment. \*\*
  - The proportion of individuals which are most responsible for population growth.
  - The minimum number of individuals necessary to avoid extinction of the population.
  - The number of individuals available to support higher trophic levels.

49. Which of the following is **NOT** a major cause of species extinction today?
- Introduction of diseases
  - Global climate change \*\*
  - Hunting
  - Habitat destruction
  - Introduction of predators
50. An experiment was conducted to determine the feeding preference of guppies. Four treatments were conducted where guppies were offered different mixtures of worms and flies: from a mixture of 20% worms (and 80% flies) to a mixture of 80% worms (and 20% flies). The stomach contents of the guppies were compared to determine what they actually ingested. The results are shown below (circles = mean values, vertical bars = total ranges). What can be concluded from these results?



- Guppies prefer worms.
- Guppies prefer flies.
- Guppies prefer the least abundant food available.
- Guppies prefer the most abundant food available. \*\*
- Guppies do not have a feeding preference.

End of exam.

- Time permitting, please answer question #51.

51. Which statement best describes you? (choose only one)

- I have already completed senior-level biology in secondary school.
- I am now studying senior-level biology in a **non-semestered** school.
- I am now studying senior-level biology in a **semestered** school.
- I will take senior-level biology in secondary school next year.

- Thank you for participating in the 1999 U of T National Biology Competition!
- Competition results, including scholarship information and certificates, will be received by your school in early June.
- Cash prizes will be sent to participating schools later in June.