The University of Toronto
National Biology Competition

2002 Examination

Time: 75 minutes

Number of questions: 50

General Instructions

C Do not open this booklet until you are instructed to do so.

C Print your name at the top of this booklet.

C 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.

C 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.

C 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.

C 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. The major function of the large intestine (colon) is:

   a. digestive breakdown of food.
   b. nutrient absorption of food.
   c. housing parasitic bacteria.
   d. secretion of bile and enzymes.
   e. reabsorption of water.

2. A film producer suggested the subjects below for a horror movie. His assistant (who had a degree in biology) pointed out that one of the potential "monsters" was scientifically impossible. Which one was it?

   a. A giant tree 30 metres high that could turn sunlight into chemical energy.
   b. A giant squid 3 metres long that could sink boats.
   c. A giant spherical single animal cell that could engulf people.
   d. A world-wide disease epidemic caused by bacteria.
   e. A plant cell that contained DNA in three different types of organelles.

3. The sea star *Pisaster ochraceous* is an abundant predator on the rocky intertidal communities along the Pacific coast of North America. The sea star feeds predominately on the mussel *Mytilus californianus*. In the absence of the sea star, the mussel is a dominant competitor, crowding out other species. Based on these observations, which statement relating to the number of species in the intertidal zone is most likely to be **CORRECT**?

   a. The number of species should be unaffected by the presence or absence of the sea star.
   b. The number of species present will be changed by the presence of the sea star, but the direction (that is, more or less species) cannot be predicted.
   c. The number of species present should be greater when the sea star is present than when it is absent.
   d. The number of species present should be less when the sea star is present than when it is absent.
   e. The mussel will go extinct in the intertidal zone when the sea star is present.

4. Centrioles:

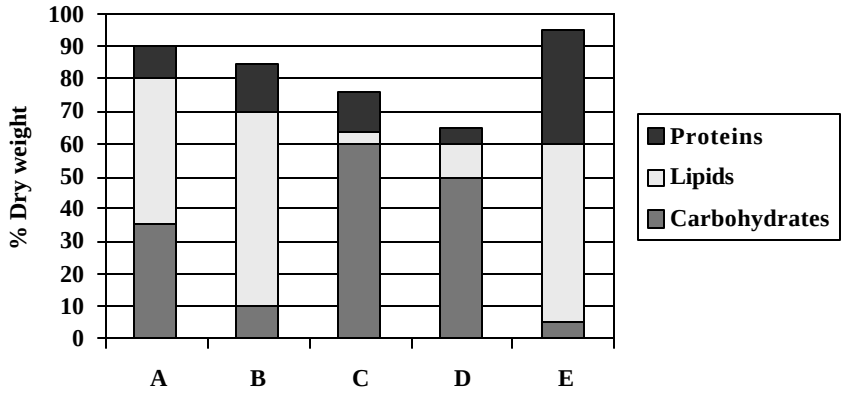
   a. hold sister chromatids together during metaphase.
   b. are duplicated before cell division.
   c. are only present during cell division.
   d. consist of DNA and histones.
   e. are found in plant cells.

5. In a hydrogen molecule, the two atoms are held together by:

   a. a shared pair of electrons.
   b. hydrogen bonds.
   c. van der Waal forces.
   d. ionic attractions.
   e. neutron gravity.

6. The graph below shows the percent content of proteins, lipids, and carbohydrates in the storage tissues of seeds from five different species. (Other seed components such as minerals are not shown.) Which storage tissue has the greatest lipid content?

a. Species A
b. Species B
c. Species C
d. Species D
e. Species E



7. A study of cliff swallows on Prince Edward Island found that the smallest and largest adult birds contribute relatively fewer offspring to the next generation than those birds that are closer to the average size. These findings suggest that:

a. this population is sexually dimorphic in body size.
b. artificial selection is acting on this population.
c. the mode of natural selection acting on this population is directional selection.
d. the mode of natural selection acting on this population is disruptive (or diversifying) selection.
e. the mode of natural selection acting on this population is stabilizing selection.

8. To study chromosomes of a single organism, geneticists cut images of stained chromosomes from a micrograph and arrange them to produce a karyotype. Which statement concerning karyotypes is **CORRECT**?

a. The length and shape of the chromosomes in a karyotype are the same.
b. Karyotypes are prepared from cells that are at any stage in the cell cycle.
c. Scientists examine the chromosomes under a microscope to determine the nucleotide sequence.
d. Normal individuals from the same species have the same number of chromosomes in a karyotype.
e. The sex chromosomes in a karyotype are also known as autosomes.

9. A wound making a hole through a person's chest will cause them difficulty in breathing mainly because:

a. it would damage the nerves to the diaphragm.
b. air breathed in through the mouth and nose would escape through the hole.
c. the hole would prevent the diaphragm from generating a negative pressure.
d. air would enter the lungs through the hole instead of the normal route through trachea and bronchi.
e. the expansion of the thoracic cavity would suck air in through the hole rather than expanding the lungs.

10. Which statement is **CORRECT**?

    a. Plastids are found in animal cells.
    b. Bacteria are the most abundant eukaryotic cells.
    c. Chromatin is found in the Golgi apparatus.
    d. Ribosomes are only found inside the nucleus.
    e. Plant cells contain mitochondria.

11. Which combination of characteristics of a vessel element are most important for water movement in the xylem?

    a. Rigid cell wall, cell dead at maturity, end walls absent.
    b. Rigid cell wall, reduction in size of plastids and mitochondria, end walls present.
    c. Rigid cell wall, living cell membrane, end walls absent.
    d. Flexible cell wall, nucleus anchored to the cell membrane, end walls present.
    e. Flexible cell wall, cell dead at maturity, end walls absent.

12. If the vagus nerves (main nerves of the parasympathetic nervous system) were cut, which of the following would be true?

    a. The heart would stop beating.
    b. The diaphragm would be paralysed.
    c. Adrenaline secretion by the adrenal gland would cease.
    d. None of a, b and c.
    e. All of a, b and c.

13. Barbie and Ken have their first child. Barbie knows her blood type is A, but Ken does not know his blood type. However, Ken knows that both his mother and father have type B blood. Their first child is a boy named Skip. Skip has type O blood. Barbie and Ken do not understand how this happened. Which of the following is the best explanation?

    a. Barbie's genotype is AA, and Ken's genotype is OO; thus, Skip expresses the O phenotype.
    b. Barbie's genotype is AO, and Ken's genotype is OO; thus, Skip expresses the O phenotype.
    c. Because Ken's parents are both type B, Ken cannot be Skip's father.
    d. Skip's blood type will need to be checked after his first month of life if Barbie and Ken want to know his blood type, as it takes about a month for the blood type to develop in a newborn child.
    e. Since Barbie has type A blood, there had to be a mix-up in the lab report, as Skip should also have type A blood.

14. Which statement about seed germination in a dicotyledon is **FALSE**?

    a. The radicle elongates first and absorbs water needed for germination.
    b. The chemical energy required for seedling growth comes from compounds stored in the cotyledons.
    c. The hypocotyl elongates and carries the plumule into the light.
    d. The plumule expands and functions in photosynthesis.
    e. The shoot apical meristem is formed after germination.

15. Which event most likely caused the near exponential growth of the human population?

    a. The bubonic plague.
    b. The industrial revolution.
    c. The development of agriculture.
    d. Adequate supplies of clean water.
    e. Global climate change.

16. When certain bacteria are treated with an effective antibiotic, some cells do not die. What is the best explanation for this occurrence?

    a. The antibiotic causes mutations for resistance to arise.
    b. Genes conferring resistance are already present in the population.
    c. The antibiotic prevents mutations for resistance from arising.
    d. The antibiotic reduces competition from other bacteria, increasing chances for survival.
    e. The antibiotic kills all of the resident bacteria, as well as resistant strains that may colonize.

17. During the first two weeks of the human menstrual cycle, artificially increasing blood levels of oestrogen and progesterone will:

    a. inhibit ovulation by reducing the release of LH and FSH from the pituitary.
    b. cause menstruation to start early.
    c. cause development of the ovarian follicle through binding to its receptors.
    d. prevent pregnancy by causing shrinkage and reabsorption of the uterine lining.
    e. stimulate secretion of milk by the lacteal glands in the breasts.

18. When an organism is temporarily deprived of oxygen it obtains its energy from:

    a. the citric acid (Krebs) cycle.
    b. the respiratory electron-transport chain.
    c. the oxidation of pyruvic-acid to acetyl-CoA.
    d. glycolysis and fermentation.
    e. none of the above.

19. Under certain conditions an animal cell released calcium into the surrounding liquid medium. When a chemical that interferes with mitochondrial function was added to the cell, the cell stopped releasing calcium. Based on these results, which statement is most likely to be **CORRECT**?

    a. Calcium was released from the cell by diffusion.
    b. Calcium was released from the cell by endocytosis.
    c. Mitochondria need calcium to function.
    d. The concentration of calcium outside of the cell was higher than the concentration immediately inside the cell.
    e. The concentration of calcium outside of the cell was lower than the concentration immediately inside the cell.

20. Drifting freely in the upper waters of the ocean, a diverse biological community exists, primarily consisting of microscopic organisms called:

    a. algae.
    b. detritus.
    c. benthos.
    d. bacteria.
    e. plankton.

21. DNA is observed in the nucleus and in mitochondria. The mitochondrial DNA in your cells is:

    a. a mixture of the mitochondrial DNA from your mother and father.
    b. a mixture of modified mitochondrial DNA from your mother and father.
    c. the same as your father's mitochondrial DNA.
    d. the same as your mother's mitochondrial DNA.
    e. transported from the nucleus during embryogenesis.

22. Which statement about the light reactions of photosynthesis is **FALSE**?

    a. Chlorophyll *a* is the only pigment that can absorb photons.
    b. Electrons from chlorophyll *a* are boosted to a higher energy level.
    c. As electrons are lost from chlorophyll *a* through the electron transport chain, they are replaced through the photolysis of water.
    d. The photolysis of water releases protons into the interior of chloroplast membrane sacs (thylakoids), thus generating a proton gradient that can drive ATP synthesis.
    e. Photophosphorylation results in the reduction of $NADP^+$ to NADPH.

23. What substances are required in minute quantities by an animal for growth and activity, but which the organism cannot synthesize?

    a. Fatty acids
    b. Proteins
    c. Vitamins
    d. Carbohydrates
    e. Triglycerides

24. Which of the following use their own metabolic energy to maintain a near constant body temperature?

    i. Fish
    ii. Birds
    iii. Reptiles
    iv. Amphibians
    v. Mammals

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

25. Below are measurements of various factors in the blood at the two ends of a capillary bed. What is the most likely location for the capillary bed?

Factor	*Arterial end*	*Venous end*
Urea	2.5 mM	2.5 mM
Glucose	4 mM	8 mM
pO_2	100 mm Hg	50 mm Hg
pCO_2	41 mm Hg	46 mm Hg
Hydrostatic pressure	14 mm Hg	8 mm Hg
Osmotic pressure	26 mm Hg	25 mm Hg

a. Lung
b. Kidney
c. Liver
d. Small intestine
e. Muscle

26. A man and a woman who both appear normal have a child together who has sickle cell anemia. Sickle cell anemia is an autosomal recessive trait. The woman becomes pregnant again and is told that she is carrying fraternal twins. What is the probability that both of the couple's twins will develop sickle cell anemia?

a. 1/16
b. 1/4
c. 1/2
d. 9/16
e. 3/4

27. In an experiment, the hypothalamus of a rat is artificially cooled to 2EC below normal body temperature. Which of the following would occur?

a. An increase in blood flow to the skin.
b. An increase in general metabolic activity.
c. Increased excretion of water by the kidneys.
d. Increased sweating.
e. Decreased activity of skeletal muscles.

28. In a comparison of amounts of urea in human urine, the largest amount of urea would be found with a diet very rich in:

a. animal fat.
b. simple carbohydrates (e.g., sucrose).
c. complex carbohydrates (e.g, starches).
d. protein.
e. fruits and vegetables.

29. Scientists estimate that there are approximately 30,000 to 50,000 genes in humans and an even greater number of proteins produced. This is because:

    a. the relationship between genes and proteins is not known.
    b. primary RNA transcripts can be alternatively spliced to make different mRNAs.
    c. DNA replication occurs throughout life, so that more genes are produced as a person gets older.
    d. both the coding and the template strand of a single gene is transcribed.
    e. the mRNA code is translated by the ribosome in the forward and reverse direction.

30. The observation that placental mice in North America are very similar in appearance to marsupial mice in Australia, even though they are not closely related to one another, is an example of:

    a. homology.
    b. analogy.
    c. divergent evolution.
    d. local adaptation.
    e. convergent evolution.

31. A typical animal hormone has different actions on different tissues because:

    a. the various target cells have different genes.
    b. hormones are directed to specific targets by the circulatory system.
    c. the receptors on different target cells are linked to different cell mechanisms.
    d. each different response is connected to a different receptor for the same hormone.
    e. enzymes alter the chemical structure of the hormone at different target tissues.

32. Cells have a resting membrane potential of approximately ! 60 mV. If a cell received a stimulus that opened Na^+ channels in the plasma membrane:

    a. K^+ ions would enter the cell against their chemical/concentration gradient.
    b. Na^+ ions would enter the cell down their electrochemical gradient.
    c. the membrane potential would change to ! 80 mV.
    d. Na^+ ions would leave the cell down their chemical/concentration gradient.
    e. K^+ ions would leave the cell down their electrical gradient.

33. Nitrogen is often in short supply in terrestrial ecosystems because:

    a. there is very little free nitrogen in the air.
    b. atmospheric nitrogen is primarily in the stratosphere and does not often come in contact with terrestrial ecosystems.
    c. nitrogen solubility in water is very low and therefore atmospheric nitrogen enters cells very slowly.
    d. atmospheric nitrogen varies widely from location to location, and thus there are frequently local shortages of nitrogen.
    e. atmospheric nitrogen cannot be used by most organisms and needs to be converted to useful forms by bacteria and cyanobacteria.

34. Which set of terms most accurately describes the pathway taken by a molecule of CO_2 from the atmosphere to the point where it enters the Calvin cycle?

    a. Stomatal aperture, intercellular space, mesophyll cell wall, chloroplast.
    b. Stomatal aperture, epidermal cell, mesophyll cell, chloroplast.
    c. Stomatal guard cell, intercellular space, mesophyll cell membrane, chloroplast.
    d. Stomatal guard cell, intercellular space, phloem sieve tube, chloroplast.
    e. Epidermal cell, palisade cell, spongy mesophyll cell, chloroplast.

35. Arrange the following steps involved in synthesis of a protein in the correct order.

    i. A complementary RNA copy of DNA is made.
    ii. The DNA double helix unwinds.
    iii. mRNA binds to ribosomes.
    iv. The amino acids of two adjacent tRNAs form a peptide bond.
    v. mRNA leaves the nucleus.
    vi. An anticodon of tRNA recognizes an mRNA codon.

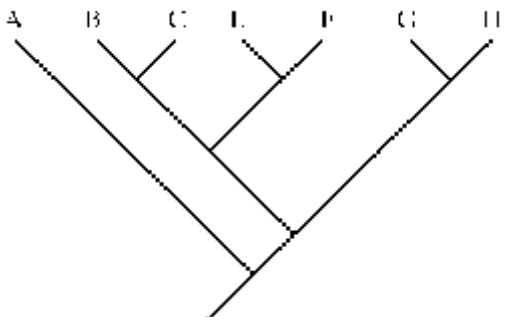
    a. i, ii, iii, v, vi, iv
    b. ii, i, iii, v, iv, vi
    c. ii, i, iii, iv, vi, v
    d. iv, v, ii, i, vi, iii
    e. ii, i, v, iii, vi, iv

36. If you cross a diploid individual that is homozygous recessive for a given trait with a heterozygous diploid individual, what is the probability of obtaining an offspring with the homozygous recessive phenotype?

    a. 0%
    b. 25%
    c. 50%
    d. 75%
    e. 100%

37. A lineage composed of two or more groups of organisms which includes the common ancestral group and all descendants is called a monophyletic group. The branching diagram (cladogram) below depicts the relationships of seven species. Which of the following is not a monophyletic group?

    a. B + C
    b. G + H
    c. B + C + E
    d. B + C + E + F + G + H
    e. A + B + C + E + F + G + H



38. A scientist put some single cells in a hypotonic (relative to the inside of the cells) solution. She noticed that the cells quickly burst. These cells were probably:

    a. bacteria.
    b. animal cells.
    c. viruses.
    d. cells killed by heat.
    e. plant cells.

39. Carbonic acid and sodium bicarbonate act as buffers in the blood. When a small amount of acid is added to this buffer, the H^+ ions are used up as they combine with the bicarbonate ions. When this happens, the pH of the blood:

    a. becomes basic.
    b. becomes acidic.
    c. does not change.
    d. is reversible.
    e. ionizes.

40. Assume that a population of diploid individuals is in Hardy-Weinberg equilibrium for a trait controlled by one locus and two alleles. If the frequency of the recessive allele is 0.8, what is the frequency of heterozygous individuals?

    a. 0.04
    b. 0.20
    c. 0.16
    d. 0.32
    e. 0.64

41. Which cellular structure is **NOT** surrounded by a membrane?

    a. Chromosome
    b. Mitochondrion
    c. Vacuole
    d. Endoplasmic reticulum
    e. Lysosome

42. Which statement about plasma membranes is **CORRECT**?

    a. Membrane glycoproteins usually have their carbohydrate groups facing the cytoplasm.
    b. The hydrophilic portion of phospholipids is orientated towards the inside of the phospholipid bilayer.
    c. Specific integral membrane proteins are always orientated in one specific direction in the plasma membrane.
    d. The phospholipid composition of the inner and outer layer of the phospholipid bilayer is usually the same.
    e. Integral membrane proteins are attached by non-covalent bonds to the outer face of the plasma membrane.

43. Oceanic islands are often called "natural laboratories for evolutionary studies." This is because they:

    a. are isolated from other land masses.
    b. are geologically very young.
    c. have low speciation rates.
    d. are ecologically very similar.
    e. always have small numbers of species on them.

44. Which of the following conditions would yield the highest rate of photosynthesis (as measured by the release of O_2)?

	Light		Concentration of atmospheric CO_2
	Photon flux density (light intensity)	Range of wavelength (light quality)	
a.	2000 µmol m^{-2} s^{-1}	400 to 700 nm	350 ppm
b.	2000 µmol m^{-2} s^{-1}	100 to 400 nm	350 ppm
c.	2000 µmol m^{-2} s^{-1}	100 to 400 nm	250 ppm
d.	1000 µmol m^{-2} s^{-1}	500 to 600 nm	100 ppm
e.	1000 µmol m^{-2} s^{-1}	400 to 700 nm	100 ppm

45. Which of the following is **NOT** found in the phylum Chordata?

    a. Bilateral symmetry.
    b. An external skeleton.
    c. A dorsal hollow nerve chord.
    d. Gill slits at some stage during development.
    e. A notochord at some stage during development.

46. Molecules resulting from the hydrolysis of a dipeptide are:

    a. two sugars.
    b. an amino acid and an alcohol.
    c. an acid and an amine.
    d. a sugar and an amino acid.
    e. two amino acids.

47. Which statement about enzymes is **FALSE**?

    a. They function best at a particular pH.
    b. All enzymes are catalysts.
    c. They function best at specific temperatures but break down at high temperatures.
    d. They undergo a major chemical change after reacting with their specific substrate.
    e. They are essential to the metabolism of cells for the conversion of energy.

48. The living organisms in the domain Archaea that live near volcanic vents in the ocean floor are examples of:

    a. chemoautotrophs.
    b. chemoheterotrophs.
    c. photoautotrophs.
    d. photoheterotrophs.
    e. geotrophs.

49. Which one of the following statements that contrast mitosis and meiosis is **CORRECT**?

    a. Cells divide by cytokinesis only in mitosis.
    b. DNA is replicated before the start of meiosis only.
    c. Spindles consisting of microtubules form only in mitosis.
    d. Centromeres are present only in mitosis.
    e. Exchange of genetic material occurs only in meiosis.

50. Chlorofluorocarbons react with the ozone in the atmosphere, thus exposing the Earth's surface to increasing levels of _____ radiation.

    a. infrared
    b. cosmic
    c. ultraviolet
    d. magnetic
    e. atomic

End of exam.