

**University of Toronto
National Biology Competition**

2000 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.

1. Today there are many different breeds of dogs. What mechanism is responsible for most of this variation?
 - a. Inbreeding
 - b. Genetic drift
 - c. Natural selection
 - d. Artificial selection
 - e. Gene flow

2. In the evolution of life on Earth the early primitive cells that were present must have obtained their energy by:
 - a. glycolysis and fermentation.
 - b. aerobic respiration.
 - c. cyclic phosphorylation.
 - d. noncyclic phosphorylation.
 - e. oxidative phosphorylation.

3. The excessive use of antibiotics is a concern to the medical community. The concern is that antibiotics will no longer be as effective in treating disease because:
 - a. humans are evolving a resistance to some antibiotics.
 - b. viruses are not killed by antibiotics.
 - c. some bacteria are evolving resistance to antibiotics.
 - d. antibiotics are very expensive.
 - e. antibiotics cause mutations.

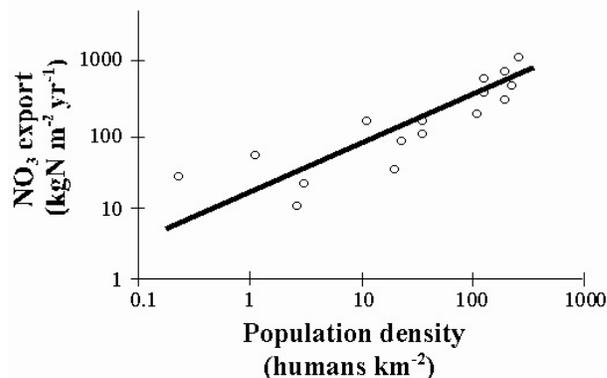
4. Which of the following "vegetables" is technically a fruit?
 - a. Potato
 - b. Lettuce
 - c. Broccoli
 - d. Celery
 - e. Green bean

5. The concentration of polychlorinated biphenyls (PCB, an organochloride contaminant) in many fish populations has been declining since a ban on their production was instituted in the late 1970s. PCBs remain a potential problem, however, because they are lipophilic and are known to biomagnify. Based on this knowledge, what type of fish is expected to be safest for human consumption (i.e., with the lowest concentration of organochlorides)?
 - a. Slow-growing fish species.
 - b. Piscivorous fish species (i.e., which eat other fish).
 - c. Benthivorous fish species (i.e., which eat invertebrates on the lake bottom).
 - d. Small (young) fish.
 - e. Fish species with high fat content.

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6. Which statement about chemical bonds is **CORRECT**?
- A covalent bond forms between a sodium ion and a chloride ion.
 - A hydrogen bond forms between water molecules.
 - A hydrophobic interaction links an oxygen atom to the hydrogen atoms in a water molecule.
 - A covalent bond links an iron atom to the protein haemoglobin.
 - An ionic bond binds complementary base pairs together in a double-stranded DNA molecule.
7. Which of the following statements about atoms are **CORRECT**?
- The atoms which make up an element are usually of the same kind.
 - An atom is identified by the number of its protons, which is called the atomic number.
 - Not all atoms of the same element have the same mass number.
 - Deuterium and tritium are isotopes of hydrogen; all three have the same atomic number, 1.
- i and ii
 - i, ii, iii, and iv
 - i and iii
 - ii and iv
 - iii and iv
8. Thyroid stimulating hormone (TSH), luteinizing hormone (LH), and oxytocin are all:
- released from the pituitary gland.
 - tropic hormones (act on other endocrine tissue).
 - steroid hormones.
 - sex hormones.
 - involved in the regulation of blood glucose.
9. Why is the global climate change that is predicted to occur in the next 100 years a concern for ecological communities?
- Primary production will decline markedly due to decreased atmospheric CO₂ concentrations.
 - The tundra of northern polar regions will disappear and be replaced by boreal forest.
 - Species will not be able to migrate quickly enough to follow the change in climate.
 - Ocean levels will increase substantially and flood a large portion of present continents.
 - Ultra-violet (UV) radiation will increase and have a severe impact (e.g., deleterious mutations) on communities worldwide.
10. Gas exchange in animals always involves:
- cellular respiration.
 - breathing movements.
 - active transport of gases.
 - control by the central nervous system.
 - diffusion across membranes.
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11. The graph below shows how much nitrate (NO_3^-) is exported from the continent towards the ocean by 16 major rivers in the world compared to the density of human populations living in those drainage basins (i.e., along these rivers). Nitrate exported through rivers causes eutrophication and has been implicated in the development of toxic algal blooms in marine coastal regions. What conclusion drawn from the graph is **CORRECT**?

- Large drainage basins export more NO_3^- .
- Small drainage basins export more NO_3^- .
- Drainage basins with higher population densities export more NO_3^- .
- Drainage basins with lower population densities export more NO_3^- .
- All rivers export equally large amounts of NO_3^- .



12. Which statement about proteins is **CORRECT**?

- The primary structure of a protein is composed of many branched chains.
- Proteins always contain an amino group at one end and the amino acid methionine at the other end.
- The formation of disulfide bridges between cysteine amino acids can modify a protein's primary structure.
- Charged amino acids are frequently found in the hydrophobic interior of a folded protein.
- The quaternary structure of proteins is the result of the interactions of two or more independent polypeptide chains.

13. One aspect of genetic engineering involves the modification of proteins to improve their function. Which statement would **NOT** be a logical goal for researchers in this field?

- Increase the hydrophobicity of a protein so that it will function in the aqueous environment of the cell cytoplasm.
- Improve the binding of a specific substrate to an enzyme.
- Modification of an enzyme active site to increase the rate of catalysis.
- Increase the stability of a protein so that it may function at a higher temperature.
- Change the amino acid content of the protein to improve its value as a more nutritious food for animals or humans.

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14. A scientist isolated pieces of plasma membrane from an animal cell and put them in an apparatus so that the membrane separated two reservoirs of distilled water. When she added a dilute solution of acetic acid to one side (side A) of the membrane, the pH of the solution on the other side (side B) did not change. She then ground up a culture of animal cells, filtered out the organelles and bits of membrane, and added this cell extract to side A. The pH of the solution in side B then dropped. What is the most reasonable explanation for the drop in pH in side B?
- The cell extract contained lipids that dissolved in the membrane.
 - The cell extract caused the acetic acid to dissociate.
 - Protons moved across the membrane by diffusion.
 - Protons moved across the membrane by passive transport.
 - Protons moved across the membrane by active transport.
15. Which of the following organelles from a living specimen can **NOT** be observed under the light microscope (using a x100 objective)?
- The nucleus of a plant cell.
 - Ribosomes in an animal cell.
 - Chloroplasts in a plant cell.
 - The nucleolus of an animal cell.
 - Mitochondria in a plant cell.
16. Some single-celled, non-photosynthetic organisms have a water expulsion vacuole that collects water from the cytoplasm and expels it from the cell. If you were trying to grow one of these organisms in the laboratory, which growth medium would be closest to its natural habitat? A dilute, aqueous, nutrient solution:
- supplemented with 1M NaCl.
 - supplemented with 1M sucrose.
 - supplemented with 1M glucose.
 - supplemented with 1M KCl.
 - with no supplements.
17. Jean Baptiste Lamarck published his theory of evolution in 1809, the year that Charles Darwin was born. Lamarck's theory of evolution has been rejected by modern biologists because:
- his theory provided a genetic mechanism for how evolutionary change occurred.
 - his theory was based on special creation.
 - the selection experiments he conducted on giraffe's necks involved artificial and not natural selection.
 - the characteristics an organism acquires during its lifetime cannot be passed on to its offspring.
 - his theory was only applicable to humans.

18. Which statement about mitosis and the eukaryotic cell cycle is **FALSE**?
- Telophase is defined as the stage at which all the kinetochores arrive at the equatorial plate and the centromeres begin to divide.
 - Replication of DNA occurs during the S phase of the cell cycle, which is part of interphase.
 - At the onset of mitosis, the chromatin becomes highly organized as a result of supercoiling and compacting.
 - Mitosis refers only to the division of the nucleus, but is most often followed by cytokinesis, the division of the cell.
 - The transition of the cell from the G₂ phase to the M phase requires the action of cyclins.
19. Which statement about photosynthesis is **FALSE**?
- In green plants, both photosystems I and II are required for the synthesis of NADPH+H⁺.
 - The first stable product of photosynthesis in the majority of green plants (C₃-type plants) is 3-phosphoglycerate.
 - In normal aerobic environments and saturating levels of light, an increase in CO₂ concentration from 0.03% to 0.06% (300 ppm to 600 ppm) will result in an increase in the rate of CO₂ fixation by most green plants (C₃-type plants).
 - Photosynthesis is a redox process: H₂O is oxidized, CO₂ is reduced.
 - The enzymes required for CO₂ fixation in plants are located only in the grana of the chloroplast.
20. Feather colour in budgies is determined by two different genes that affect the pigmentation of the feathers: *Y_B_* is green; *yyB_* is blue; and *yybb* is white. Two blue budgies were paired for life. Over many years, they produced 22 offspring, five of which were white. What are the most likely genotypes for the parents?
- yyBB* and *yyBB*
 - yyBB* and *yyBb*
 - yyBb* and *yyBb*
 - yyBB* and *yybb*
 - yyBb* and *yybb*
21. A man is brought to court in a paternity case. He has blood type B, Rh positive. The mother has blood group B, Rh negative. The child's blood type is A, Rh negative. Which statement about the man is **CORRECT**?
- He is the father.
 - He might be the father.
 - He is not the father.
 - He might not be the father.
 - There is not enough information to make a decision.

22. A trait in a hypothetical diploid organism is inherited via a single gene with four different alleles. How many different genotypes would be possible in this system?
- 3
 - 6
 - 8
 - 10
 - 16
23. How are mature human sperm and ova similar?
- They are approximately the same size.
 - They are formed before birth.
 - They each have a flagellum that provides motility.
 - They are produced from puberty until death.
 - They both have the same number of chromosomes.
24. The frequency of crossing over between any two linked genes is:
- higher if they are recessive.
 - difficult to predict.
 - determined by their relative dominance.
 - the same as if they were not linked.
 - proportional to the distance between them.
25. Which statement concerning living eukaryotic cells is **FALSE**?
- Membranes control which hydrophilic organic molecules pass into or out of the cell.
 - Lysosomes and centrioles are each bounded by a single membrane.
 - Membranes are usually fluid at 37°C.
 - Membranes contain phospholipids and proteins.
 - Membranes are semipermeable.
26. There was great excitement around the world when the sheep "Dolly" was cloned using a nucleus derived from an adult cell of its "mother" which was then transplanted into an enucleated egg. There is also excitement when it is announced that genes causing human diseases, like muscular dystrophy, have been cloned. Which statement about these two examples of cloning is **CORRECT**?
- They both involve cutting a piece of DNA from the genome.
 - One involves the cloning of a nucleus and the other is the cloning of a piece of DNA.
 - They both produce products genetically identical to the original donor of cellular material.
 - They raise no ethical questions.
 - They are similar to deriving a bacterial clone from a single bacterial cell which divides to form a colony.

27. All fungi:
- are parasitic.
 - are capable of carrying out photosynthesis.
 - are heterotrophic.
 - live on dead organic matter.
 - are pathogens.
28. On the Galapagos Islands evolutionary divergence has resulted in 14 species of finches that are differentially adapted to feed on seeds, insects, and the buds of various plant species. This example of adaptive radiation occurred because the Galapagos Islands are:
- close enough to one another to favour considerable inter-island migration.
 - close to the mainland.
 - small, favouring divergence through genetic drift alone.
 - arid and stressful, resulting in many mutations.
 - sufficiently isolated from one another that inter-island migration rarely occurs.
29. NaCl is harmful to most crop plants. A scientist at the University of Toronto genetically modified a plant so that it could be grown in dry parts of the world where the available water has a high level of NaCl. This genetically modified plant copes with the high levels of NaCl by transporting salt into its vacuoles where it accumulates to abnormally high levels. Which feature would be observed in the genetically modified plant when compared to a non-modified plant?
- The leaves in the modified plant are more yellow in colour.
 - The modified plant has salt crystals on the surface of its leaves.
 - The cytosol (the material between the plasma membrane and the vacuole membrane, excluding the organelles) in the modified plant has a lower osmotic pressure.
 - The cytosol in the modified plant has a higher osmotic pressure.
 - The osmotic pressure is the same in both plants.
30. Which statement about ATP synthesis is **FALSE**?
- ATP is synthesized only in chloroplasts and mitochondria.
 - ATP synthesis in the chloroplast occurs in the thylakoid region of this organelle.
 - Proton motive force (proton gradient) drives the formation of ATP in mitochondria.
 - ATP synthases are protein complexes that allow protons to cross membranes.
 - Substrate level phosphorylation of ADP does not require ATP synthase to catalyse the reaction.
31. Dominant mutations are easier to detect than recessive mutations because they:
- are always lethal and so their appearance is unmistakable.
 - are expressed in both homozygotes and heterozygotes.
 - occur at a higher frequency.
 - are always neutral in their effect.
 - are always favoured by selection.

32. A man who carries an *X*-linked allele will pass it on to:
- all of his daughters.
 - half of his daughters.
 - all of his sons.
 - half of his sons.
 - all of his children.
33. The main feature of the "biological species concept" is its emphasis on the:
- large morphological differences between different species.
 - genetic variation within populations.
 - recognition of different species based on their ecological separation.
 - role of sexual reproduction in maintaining diversity within a species.
 - absence of gene flow between different species.
34. Which statement about genetically modified (GM) foods is **FALSE**?
- Scientists have used genetic modification, in various forms, as a means of improving crop yields, crop quality, and pest resistance for many years.
 - Genetic modification includes products made by artificial mutagenesis and by non-natural crosses between unrelated species.
 - A major difficulty in labelling foods as "GM-free" is that it is virtually impossible to measure genetically modified DNA or protein molecules in most foods made from GM crops.
 - The recent decision by McCain Foods to stop processing GM potatoes means that they will eventually use less pesticides to produce the potatoes that are required to make fries.
 - A major environmental concern with GM crops is that engineered genes will escape into the environment, resulting in the origin of "superweeds" (aggressive undesirable plant species).
35. Of the following taxonomic categories which is the most inclusive (i.e., is the highest in the hierarchy)?
- Order
 - Subspecies
 - Class
 - Genus
 - Family
36. Some viruses are surrounded by a membranous envelope which originates from the:
- plasma membrane of the host cell.
 - synthesis of proteins and lipids inside the virus.
 - synthesis of proteins in the virus and lipids in the host cell.
 - synthesis of lipids in the virus and proteins in the host cell.
 - nucleus of the host cell.

37. In plants, sieve areas are regions of the cell wall with pores that allow cytoplasmic continuity between adjacent:
- epidermal cells.
 - parenchyma cells.
 - phloem cells.
 - tracheids.
 - xylem vessels.
38. If the haploid number for a species is three, each dividing diploid cell during mitosis will have how many chromatids at anaphase?
- 3
 - 6
 - 9
 - 12
 - 18
39. A feature of fertilization that is only found in angiosperms is that:
- the sperm may be carried by wind to the female organ.
 - one sperm fertilizes the egg, while another combines with the polar nuclei.
 - a pollen tube carries a sperm nucleus into the female gametophyte.
 - a chemical attractant guides the sperm towards the egg.
 - the sperm cells have flagella for locomotion.
40. Which statement about mammalian heart function is **FALSE**?
- Contraction of the heart originates at the sinoatrial node in the right atrium.
 - The atrioventricular node propagates the contraction to the ventricles.
 - During atrial contraction venous blood flows into the right ventricle.
 - The pulmonary artery contains oxygenated blood.
 - The left side of the heart pumps only oxygenated arterial blood.
41. The main effect of cytokinins in plants is to:
- increase the length of internodes on flowering stems.
 - prevent the growth of lateral buds.
 - regulate opening and closing of stomata.
 - stimulate cell division.
 - improve the quality of fruits.

42. In the following list, which term is **LEAST** related to the others?
- Duplication
 - Inversion
 - Translocation
 - Nondisjunction
 - Deletion
43. In the central nervous system the amount of voltage change required to open enough sodium channels to initiate a nerve impulse is referred to as the:
- refractory potential.
 - threshold potential.
 - action potential.
 - polarization potential.
 - resting potential.
44. Which statement about glycolysis is **FALSE**?
- During glycolysis, glucose is metabolized to pyruvate with the formation of ATP and $\text{NADH}+\text{H}^+$.
 - The initial step in glycolysis requires the phosphorylation of glucose by the enzyme phosphoglucomutase.
 - The conversion of phosphoenolpyruvate to pyruvate is catalysed by the enzyme pyruvate kinase and results in the formation of ATP.
 - The end product of glycolysis, pyruvate, can be used by yeast to produce ethanol during fermentation.
 - Glycolysis occurs outside the mitochondria.
45. The Swift Fox is a small mammal (about the size of a cat) that once lived throughout the prairie grasslands of central Canada. However, due to a number of factors including hunting, it had completely disappeared from Canada by the late 1970s. In an attempt to restore this species, foxes from American populations have been released in Canada. However, the number of Swift Foxes in Canada still remains low. Which factor is most likely **NOT** contributing to this?
- Much of the fox's original grassland habitat has been replaced with agriculture, which has reduced the quality and quantity of habitat for the foxes and the availability of suitable prey.
 - The foxes released in early reintroductions did not survive well, likely due to a lack of knowledge of sources of food and den locations, or because the American foxes were not adapted to the longer Canadian winters.
 - Coyotes, which are increasing in numbers, are feeding on the foxes, or competing with the foxes for available resources.
 - Swift foxes are still being trapped for their pelts (fur), as they have been since the early 1800s.
 - Swift foxes may have been the unintended victim of trapping and poisoning campaigns directed at other mammals, such as coyotes, wolves, and ground squirrels.

46. Carbonic anhydrase is an enzyme in red blood cells that catalyses a reaction between carbon dioxide and:
- bicarbonate.
 - carbonic acid.
 - haemoglobin.
 - oxygen.
 - water.
47. A certain type of grass has a diploid chromosome number of 8. A similar species of grass has a diploid chromosome number of 10. Interspecific hybridization between the two species results in sterile hybrids that can, nonetheless, reproduce vegetatively. The diploid chromosome number of these hybrids would be:
- 9
 - 16
 - 18
 - 20
 - 36
48. Various regions of the three embryonic germ layers in vertebrates develop into organs and tissues in the adult. Which match is **FALSE**?
- Mesoderm - notochord
 - Endoderm - lungs
 - Ectoderm - liver
 - Mesoderm - muscular system
 - Ectoderm - eye
49. Which characteristic is shared by ammonia, urea, and uric acid?
- They are all nitrogenous wastes.
 - They all need large amounts of water for excretion.
 - They all require about the same amount of energy to produce.
 - They are all equally toxic.
 - They are all produced in the kidney.

50. You are studying two populations of a species of aquatic insect in two different ponds. Both populations go through several generations each summer. The per capita food supply is the same in both ponds throughout the year and it is evenly distributed throughout the water column. You find that the population in pond A is increasing in numbers at a faster rate than the population in pond B. Which observation is most likely **NOT** contributing to this pattern?
- Individuals in pond A have more offspring than individuals in pond B.
 - Individuals in pond A have smaller offspring than individuals in pond B.
 - Individuals in pond A mature at a younger age than individuals in pond B.
 - There is a predator that rarely preys on this species but it is enough of a threat that it scares this species of insect into hiding in the vegetation at the very edge of the pond; this predator only lives in pond B.
 - Individuals in pond B have shorter life spans than individuals in pond A.