

**University of Toronto  
National Biology Competition**

**2001 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.

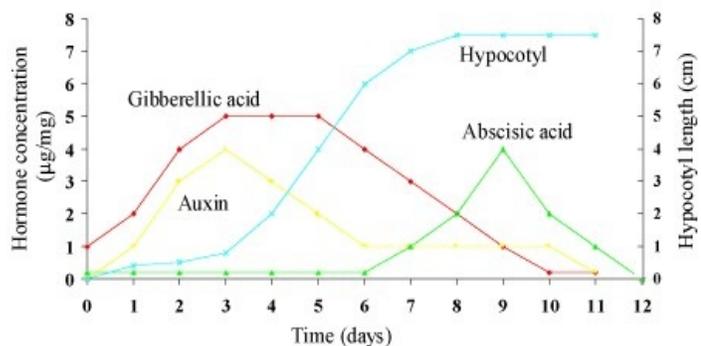
1. When a cell that was deprived of nutrients was given glucose, the pH within its vacuoles dropped. The best reason for this observation is that:
- a starved cell pumps protons across the plasma membrane to the cell exterior.
  - the dissociation of glucose in the vacuoles releases hydrogen ions.
  - protons leave the vacuole by passive transport.
  - protons enter the vacuole by passive transport.
  - protons enter the vacuole by active transport.
2. Individuals afflicted with haemophilia suffer from excessive bleeding due to the failure of the normal clotting mechanism. The disease is associated with a sex-linked recessive gene. Two brothers are haemophiliacs; their parents do not suffer from excessive bleeding. The probability that their sister inherited the gene for haemophilia is most likely:
- 0
  - 1/4
  - 1/2
  - 3/4
  - 1
3. If you arranged the units of life listed in the table below into a hierarchy, from smallest (least inclusive) to largest (most inclusive), which unit would be found three levels below a fish?

Organism	Community	Molecule
Atom	Population	Organ
Tissue	Cell	Biosphere

- Organ
  - Biosphere
  - Molecule
  - Cell
  - Population
4. Which of the following best describes Darwin's theory of the mechanism of genetic inheritance?
- Inheritance of acquired characteristics
  - Blending inheritance
  - Molecular inheritance
  - Particulate inheritance
  - Adaptive inheritance

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5. In the absence of oxygen, cells capable of fermentation:
- accumulate glucose.
  - no longer produce ATP.
  - accumulate pyruvate.
  - oxidize FAD.
  - oxidize NADH to produce  $\text{NAD}^+$ .
6. Which statement is **FALSE**?
- Cells that do not divide are usually arrested in the G2 phase.
  - Within the centrosome of an animal cell are a pair of centrioles.
  - The kinetochore is the point of attachment of the spindle fibre to the chromatid.
  - Anaphase begins the instant that the sister chromatids begin to separate.
  - A nucleosome consists of part of the DNA molecule wrapped around a group of histone molecules.
7. What is the difference between an acid and a base?
- An acid undergoes a reversible reaction, while a base does not.
  - An acid releases  $\text{OH}^-$  ions in solution, while a base accepts  $\text{OH}^-$  ions.
  - An acid releases  $\text{OH}^-$  ions in solution, while a base releases  $\text{H}^+$  ions.
  - An acid releases  $\text{H}^+$  ions in solution, while a base accepts  $\text{H}^+$  ions.
  - Acidic solutions have higher concentrations of  $\text{OH}^-$  than  $\text{H}^+$ , while basic solutions have higher concentrations of  $\text{H}^+$  than  $\text{OH}^-$ .
8. If the inner surface of the ileum in the human small intestine were smooth, rather than being folded and subdivided into villi, which statement would be true?
- The rate of absorption of digested food molecules would be higher, because the digested food would pass more easily through the digestive tract.
  - Digestion would not be as effective, because there would be fewer cells secreting trypsin (a protein-digesting enzyme).
  - Humans would have needed to evolve a much longer small intestine to absorb sufficient nutrients from their food.
  - Humans would not be able to survive, because the digestive tract would be more susceptible to damage.
  - Utilization of cellulose in the diet would not be possible, because the microorganisms that digest cellulose would have nowhere to live.
9. The total biomass in a terrestrial ecosystem will be greatest for which trophic level?
- Herbivores
  - Producers
  - Primary consumers
  - Tertiary consumers
  - Secondary consumers
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10. After pollination, which of the following events is crucial for fertilization to occur in flowering plants?
- Sperm swim to the egg and the polar nuclei.
  - Petals close around the reproductive parts.
  - Meiosis occurs within the pollen grain.
  - A pollen tube grows from the stigma to the ovule.
  - An insect delivers pollen to the stigma.
11. Plant hormones play a role in regulating seed germination. The graph below shows changes in hormone concentrations (left axis) and hypocotyl growth (right axis) over time for mung bean. Which hormone(s) most likely regulates hypocotyl (bean sprout) growth during mung bean germination?



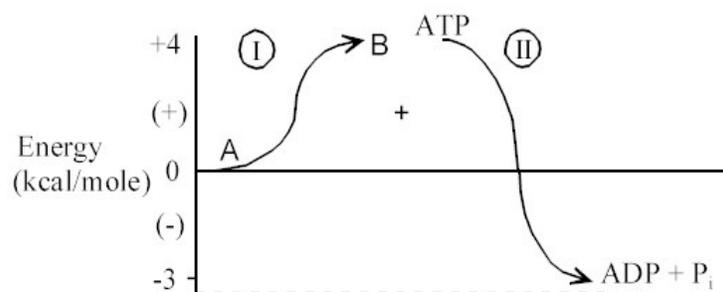
- Gibberellic acid alone
  - Auxin alone
  - Abscisic acid alone
  - Both auxin and gibberellic acid
  - Both auxin and abscisic acid
12. What is the most likely explanation for the observation that two individuals originating from the same clone look different?
- They developed in different environments.
  - They are differentially adapted to the same environment.
  - The clone from which they originated had more than one genotype.
  - They differ in heterozygosity.
  - They differ in homozygosity.
13. In the context of evolution, what is the most important source of new mutations?
- Exposure to x-rays.
  - Exposure to ultra-violet radiation.
  - Exposure to chemicals.
  - The mispairing of chromosomes during meiosis.
  - Errors during DNA replication.
14. Which statement is **CORRECT**?
- The vacuole is usually the largest organelle found in plant cells.
  - Plants do not have mitochondria.
  - Nuclei do not contain proteins.
  - The Golgi complex is primarily made up of microtubules.
  - The lysosome is only found in prokaryotic cells.

15. In a microbiology laboratory, the technician uses heat to sterilize the nutrient solution that is used to grow a fungus. When the heating system broke down, he sterilized the solution by passing it (in a sterile environment) through a sterile filter with a pore size of 0.2 micrometers. When the fungus was grown on the filtered nutrient solution it stopped growing and looked unhealthy within a few days. Which statement is the most likely explanation for the observed effect on the fungus?
- The nutrient solution contained a virus.
  - Heating makes the glucose in the nutrient solution more digestible.
  - Filtering removed one of the larger nutrient molecules.
  - The nutrient solution contained a bacterium that was pathogenic to the fungus.
  - Filtering changed the pH of the nutrient solution.
16. Which factor would contribute the most to increasing the rate of water movement upward in the xylem?
- The generation of root pressure.
  - The availability of soil water.
  - The rate of transpiration from the leaves.
  - The rate of carbohydrate loading.
  - The rate of auxin synthesis.
17. Two alternative alleles, the dominant  $A$  and the recessive  $a$ , are in equilibrium in a population. The frequency of  $A$  is 0.6. The percentage of individuals showing the dominant trait in the population should be:
- 36%
  - 40%
  - 60%
  - 75%
  - 84%
18. Fertile hybrids between different plant species are common in nature and form much of the basis for plant breeding in horticulture and agriculture. The plant species pairs involved in forming fertile hybrids are consistent with:
- both the biological and the morphological species concepts.
  - the biological but not the morphological species concept.
  - the morphological but not the biological species concept.
  - neither the biological nor the morphological species concept.
  - all of the species concepts that have been proposed.

19. Which of the following is incorrectly paired with its function?
- Epididymis: maturation and storage of sperm.
  - Prostate gland: secretes testosterone, a male sex hormone.
  - Fallopian tube: catches ova and conducts them towards the uterus.
  - Seminal vesicles: produce a sugar-containing fluid to nourish sperm.
  - Corpus luteum: produces progesterone, a female sex hormone.
20. What was the key evolutionary event that led to the diversification of plants on land?  
The evolution of:
- chloroplasts.
  - protected seeds.
  - tissues to store starch.
  - meiosis.
  - a water-conducting cell type.
21. Which statement about animal stem cells is **FALSE**?
- Stem cells are relatively undifferentiated cells that can divide to produce more differentiated tissue cells.
  - Stem cells can be found in tissues that need frequent cell replacement, such as skin, the inner lining of the intestine, and the blood system.
  - Dividing stem cells can produce cells that differentiate to replace cells lost to injury and age; for example, stem cells in bone marrow produce red and white blood cells.
  - Scientists are able to grow stem cells in the laboratory.
  - Recent studies have shown that stem cells from one kind of tissue cannot be made to differentiate into cells of another tissue.
22. What two characteristics make water different from most other compounds?
- Its solid state is less dense than its liquid state, and it takes up *large amounts* of heat to change to its gaseous state.
  - Its solid state is less dense than its liquid state, and it takes up *only small amounts* of heat to change to its gaseous state.
  - Its solid state is more dense than its liquid state, and it takes up *large amounts* of heat to change to its gaseous state.
  - Its solid state is more dense than its liquid state, and it takes up *only small amounts* of heat to change to its gaseous state.
  - Its solid state is just as dense as its liquid state, and it takes up no heat to change to its gaseous state.

23. In *Drosophila* the gene for brown eyes is recessive to its normal allele for red eyes; the gene for curled wings is recessive to its normal allele for straight wings. The two genes show independent assortment. Males heterozygous for both genes are mated to females that are heterozygous for the eye colour gene, but homozygous for the gene for curled wings. What proportion of the offspring should have normal red eyes and normal straight wings?
- 3/16
  - 3/8
  - 1/2
  - 3/4
  - 9/16
24. Some plants contain nitrogen-fixing bacteria (of the genus *Rhizobium*) in their root nodules. This relationship is known as:
- an amensalism (one participant harms the other).
  - a commensalism (one participant benefits but has no effect on the other).
  - a mutualism (both participants benefit).
  - interspecific (between species) competition.
  - competitive exclusion (competition between species for a limiting resource in which one species completely eliminates the other).
25. Populations of many species of small mammals – such as lemmings, voles, and snowshoe hares in Canada – undergo large population fluctuations on a predictable basis (e.g., every 3 to 4 years). Which of the following does **NOT** appear to play a role in these population cycles?
- Territorial (spacing) behaviour of adult members of these populations
  - Dispersal of individuals away from the area where they were born
  - Stress caused by the effects of living at high densities
  - High mortality caused by predators
  - Severe weather conditions
26. Natural selection is a process that may result in evolution. If evolution is to occur, which of the following must be true?
- Individuals within a species are variable.
  - Some of the variations within species are passed on to the offspring (i.e., they are inherited).
  - More individuals are produced than the environment can support; only a fraction of the offspring produced in each generation survive to reproduce.
  - The survival and reproduction of individuals are not random; the individuals who survive and go on to reproduce, or who reproduce the most, are those with the most favourable variations.
- i, ii and iii
  - i, ii and iv
  - i, ii, iii and iv
  - iii only
  - iv only

27. Cell division in plants is typically concentrated in meristems. In which of the following regions of the plant would cell division **NOT** occur?
- Shoot apex
  - Root apex
  - Embryo
  - Wood
  - Cambium between wood and bark
28. DNA fingerprinting has become a familiar forensic tool and has been cited in recent criminal trials. It is possible to do DNA fingerprinting with even a very minute sample of DNA because:
- DNA contains only four different types of nitrogenous bases.
  - there are large quantities of DNA in each cell of the body.
  - DNA determines a very specific polypeptide chain.
  - one can use the polymerase chain reaction.
  - gel electrophoresis is very effective.
29. Which statement about geographical speciation is **FALSE**? The diverging populations:
- initially belong to the same species.
  - become genetically differentiated from one another.
  - acquire some degree of reproductive isolation.
  - may respond to natural selection.
  - live in the same geographical region.
30. Coupled biochemical reactions are important in determining thermodynamic order within cells. The figure below shows two hypothetical reactions, I and II. Which statement about these reactions is **FALSE**?



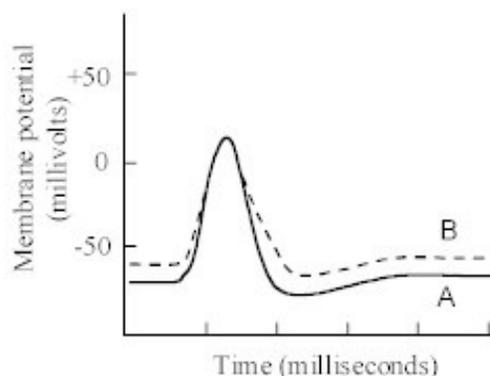
- The splitting of ATP to ADP + P<sub>i</sub> releases about 7.3 kcal/mole.
- The reaction of compound A to produce compound B requires an input of about 4 kcal/mole, which is provided by reaction II.
- Reaction I is exergonic, yielding 4 kcal/mole.
- The two coupled reactions release about 3.3 kcal/mole.
- To drive reaction I, the splitting of ATP to ADP + P<sub>i</sub> is always required.

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31. The content of a large vacuole in a eukaryotic cell has the same osmotic pressure as the surrounding cytoplasm, to prevent it from shrinking or bursting. If this eukaryotic cell is placed in a 3 M sucrose solution:
- the cell would burst.
  - the vacuole would expand and burst.
  - the cell and the vacuole would both shrink.
  - the cell would shrink but the vacuole would remain the same size.
  - nothing would happen, because a 3 M sucrose solution has the same osmotic pressure as the cell cytoplasm.
32. Which statement is **CORRECT**?
- Membranes of living organisms are in a fluid state, rather than in a gel state.
  - Membranes are semipermeable: large molecules such as proteins can easily move across them.
  - Hydrophilic organic molecules easily diffuse across membranes in eukaryotic cells.
  - In plants, the plasma membrane is known as the cell wall.
  - Rough endoplasmic reticulum is the name given to clusters of ribosomes attached to the cytoskeleton.
33. The sequence of steps in cellular respiration is:
- Pyruvate oxidation --> electron transport chain citric --> acid (Krebs) cycle
  - Pyruvate oxidation --> citric acid (Krebs) cycle --> electron transport chain
  - Citric acid (Krebs) --> cycle pyruvate oxidation --> electron transport chain
  - Citric acid (Krebs) --> cycle electron transport chain --> pyruvate oxidation
  - Electron transport chain --> pyruvate oxidation --> citric acid (Krebs) cycle
34. Which statement about the mammalian circulatory system is **CORRECT**?
- The average diameter of arteries is greater than that of veins.
  - The order of decreasing velocity of blood flow is: arteries > capillaries > veins.
  - The total surface area of the capillaries is considerably greater than that of all of the arteries, arterioles, venules, and veins combined.
  - In order to return blood to the heart, the blood pressure in veins is higher than it is in the capillaries.
  - The electrical activity that coordinates the beating of the heart originates in the atrio-ventricular node.
35. According to the latest estimates of the total number of human genes (based on the findings of the Human Genome Project) there are:
- less than 20,000 genes.
  - 30,000 to 50,000 genes.
  - 200,000 to 400,000 genes.
  - 500,000 to 1 million genes.
  - over 3 million genes.
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36. Which statement about the "foreign" genetic material in genetically modified (GM) crop plants or animals is **FALSE**?
- It must be inserted again in each generation.
  - It alters the phenotype of the GM plant or animal.
  - It may be subject to artificial selection by breeders and farmers.
  - It may be subject to natural selection by weather, pests, and diseases.
  - It may be transferred to related non-crop plants or animals.
37. Which statement about the two pathways of photosynthesis is **FALSE**?
- The first pathway (the light reactions) captures light energy and produces ATP and NADPH + H<sup>+</sup>.
  - The second pathway (the Calvin-Benson cycle) uses the products of the first pathway and CO<sub>2</sub> to produce sugars.
  - The second pathway is also known as the dark reactions because none of its reactions uses light directly.
  - The light reactions occur within chloroplasts; the Calvin-Benson cycle takes place in the cytosol.
  - Both pathways stop in the dark.
38. If it was possible to genetically engineer humans to be able to run long distances faster at high altitudes, which of the following would **NOT** help?
- Increasing the thickness of the cellular lining of the alveoli.
  - Increasing the amount of haemoglobin in each red blood cell.
  - Decreasing the binding affinity of oxygen and haemoglobin at very low oxygen partial pressures.
  - Decreasing the average size of the alveoli.
  - Increasing maximum cardiac output.
39. Which pattern of evolutionary change has **NOT** been recognized in portions of the fossil record that have been thoroughly sampled?
- Rapid change from one species to another over a short period of time (punctuation)
  - Rapid change from one family or order to another over a short period of time (saltation)
  - Stasis (equilibrium)
  - Gradual change
  - Fluctuating change
40. In the event of global warming which one of the following is most likely to occur?
- Existing plant and animal communities will move north in response to warming.
  - Agriculture in the Prairie provinces will be redeveloped on soils of the Canadian Shield.
  - The anticipated rise in sea level will be caused primarily by the melting of polar ice caps.
  - The decomposition of organic matter in the unfrozen surface layer of polar soils will increase.
  - Tundra vegetation will increase in area as soils dry out in polar regions.

41. Macromolecules are giant molecules formed by the joining of smaller molecules. The bonds that form between the units of macromolecules are:
- hydrogen bonds.
  - peptide bonds.
  - disulfide bonds.
  - ionic bonds.
  - covalent bonds.
42. Which of the following is **NOT** a function of the mammalian kidney?
- Water retention
  - Regulation of sodium in the blood
  - Excretion of toxins
  - Synthesis of urea
  - Water excretion
43. In what respects are the photosynthetic adaptations of  $C_4$  plants and CAM plants similar?
- In both cases, the stomata normally close during the day.
  - Both types of plants make their sugar without the Calvin-Benson cycle.
  - In both cases, an enzyme other than rubisco carries out the first step in carbon fixation.
  - Both types of plants make most of their sugar in the dark.
  - Neither  $C_4$  plants nor CAM plants have grana in their chloroplasts.
44. A scientist discovered that a protein associated with the plasma membrane of a cultured animal cell disappeared from the membrane soon after a hormone was added to the cell. After adding the hormone, if she disrupted the cell and centrifuged it, the protein did not stay in solution but went to the bottom of the centrifuge tube. After adding the hormone, if she disrupted the cell and dissolved all membranes with a detergent before centrifuging, the protein remained in solution. Which statement best explains her results?
- The protein was a peripheral membrane protein that came off the membrane after hormone treatment.
  - The hormone caused the cell to make endocytotic vesicles that specifically formed at sites in the plasma membrane that contained the protein.
  - The hormone destroyed the protein.
  - The hormone bound to the protein to make the protein heavier.
  - The hormone caused the plasma membrane to break into fragments, causing the cell to make new plasma membrane without the protein.

45. Which of the following is **NOT** involved in DNA replication?
- Helicase
  - RNA primase
  - Reverse transcriptase
  - DNA ligase
  - DNA polymerase
46. If an adult human female took a drug that inhibited the release of LH (luteinizing hormone), which of the following would **NOT** occur?
- The menstrual cycle.
  - Release of an ovum from a mature follicle.
  - Secretion of FSH (follicle stimulating hormone) from the pituitary.
  - Secretion of estrogen by the follicle cells.
  - Secretion of GnRH (gonadotropin-releasing hormone) from the hypothalamus.
47. How does a noncompetitive inhibitor inhibit binding of a substrate to an enzyme?
- It binds to the substrate.
  - It binds to the active site.
  - It lowers the activation energy.
  - It increases the change in free energy ( $\Delta G$ ) of the reaction.
  - It changes the shape of the active site.
48. The figure below shows two nerve action potentials recorded intracellularly in response to stimulating an axon. What experimental manipulation would most likely have caused the change from curve A (solid line) to curve B (dashed line)?



- A decrease in stimulus intensity.
  - A decrease in sodium concentration in the extracellular fluid.
  - A decrease in the potassium concentration inside the neuron.
  - The presence of a low concentration of tetrodotoxin, a sodium-channel blocker.
  - An increase in intracellular calcium concentration.
49. Thermoregulation in mammals is a balance between heat gain and heat loss. All of the following can affect both heat gain and heat loss **EXCEPT**:
- Activity of the sweat glands.
  - Thickness of the fat layer under the skin.
  - Air movement near the body surface.
  - Blood flow in the skin.
  - Colour of the body surface.

50. Which statement is **FALSE**?

- a. Nondisjunction refers to the failure of a pair of chromosomes to segregate during meiosis.
- b. Karyotype refers to the number, forms, and types of chromosomes in a cell.
- c. Autosomes are cytoplasmic organelles that contain DNA and are capable of self-replication.
- d. Prophase refers to the onset of nuclear division.
- e. Centromere refers to the region where sister chromatids join.