

**University of Toronto  
Ontario Biology Competition**

**1996 Examination**

Time: 90 minutes

Number of questions: 60

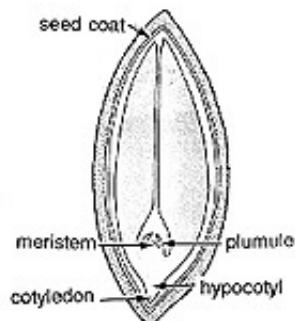
General Instructions

- 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?*

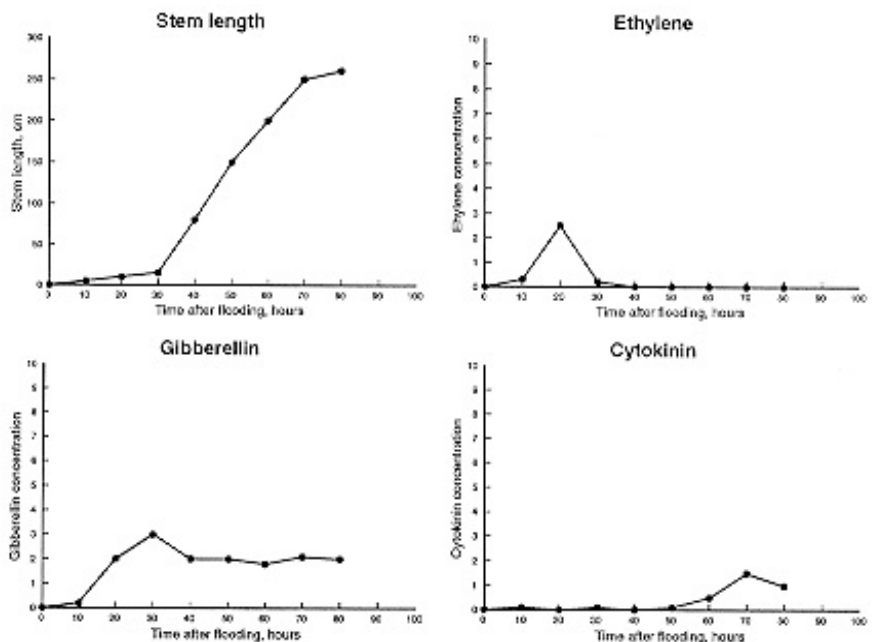
Since your score on the exam is based on the number of questions you answered correctly minus one-third of the number you answered incorrectly, it is improbable that guessing will improve your score (it is more likely to lower your score). (No points are deducted or awarded for unanswered questions.) 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. All cells have:
  - a. a cell wall and nucleus.
  - b. a nucleus and chloroplasts.
  - c. plastids and lysosomes.
  - d. a cell membrane and cytoplasm.
  - e. ribosomes and chloroplasts.
2. A scientist added a chemical (cyanide) to an animal cell to stop aerobic respiration. Which of the following is most likely to have been affected by this treatment?
  - a. Active transport of substances across the plasma membrane
  - b. Passive transport of substances across the plasma membrane
  - c. Diffusion of substances across the plasma membrane
  - d. The size of the ribosomes in the cytoplasm
  - e. The thickness of lipid bilayers
3. Which statement is **FALSE**?
  - a. If a lysosome bursts, its contents can seriously damage the cytoplasm of a cell.
  - b. Chloroplasts and mitochondria are each bounded by two membranes.
  - c. Macromolecules may be taken up into a cell by the process of endocytosis.
  - d. Protein molecules that are synthesized by rough endoplasmic reticulum are commonly modified in the Golgi apparatus.
  - e. In a hypertonic solution, a cell from a multicellular animal usually will swell and burst.
4. If you could suddenly remove all the protein molecules from the plasma membrane of a cell (without destroying the cell), which of the following would you expect to happen?
  - a. Transport of all molecules across the plasma membrane would stop.
  - b. Transport of most ions across the plasma membrane would stop.
  - c. The amount of cholesterol in the plasma membrane would decrease.
  - d. Amino acids would rapidly aggregate on the plasma membrane and replace the missing proteins.
  - e. Large macromolecules would diffuse out of the cell.
5. Which label on the diagram of a peanut (shown below) is **NOT** correct?
  - a. Cotyledon
  - b. Hypocotyl
  - c. Seed coat
  - d. Meristem
  - e. Plumule



6. Which of the following changes would **DECREASE** the rate of water loss (transpiration) from the leaves of a sugar maple tree?
- Light breeze
  - Bright sunshine
  - An afternoon rain shower
  - A plentiful supply of soil water
  - High temperatures during the afternoon
7. Deep-water rice is an important crop in southeast Asia where water levels during the rainy season may rise by several metres within a short time. Deep-water rice has the ability to adapt to the rising water by growing quickly, thus keeping its "head" (flower stalk and upper leaves) above water. Examine the four graphs above and identify the hormone(s) that regulate(s) this rapid growth.

- Ethylene alone
- Cytokinin alone
- Gibberellin alone
- Ethylene and gibberellin
- Cytokinin and gibberellin

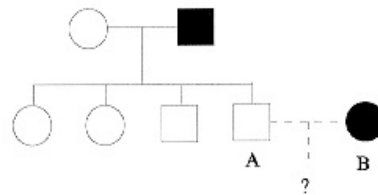


8. Cactus plants are adapted to the hot and dry deserts of North and South America. Which of the following characteristics would **NOT** help cacti to survive the extreme heat and low rainfall?
- A thick waxy cuticle
  - A stem with a high surface to volume ratio
  - Stomata that are closed during the day
  - Thin leaves with a large surface area
  - Water storage tissue

9. During the malting process, starch stored in the barley grain is broken down to sugars. These sugars provide the energy for anaerobic respiration by yeast cells during the beer making process. Which of the following observations indicates that the plant hormone, gibberellic acid, is required for this process?
- The yeast cells respire aerobically if  $O_2$  is bubbled through the brew.
  - Gibberellic acid promotes stem elongation.
  - Amylase enzyme converts starch to sugar.
  - The plant hormone, abscisic acid, prevents barley seed germination.
  - No alcohol is produced if the embryo is removed from the barley grain.
10. One of Mendel's laws states the following: Units of inheritance which control different aspects of the phenotype may be inherited independently. Which of the following true statements best restates this conclusion in modern terms?
- In the first stage of meiosis, the segregation of one pair of chromosomes does not affect the segregation of other chromosomes.
  - During fertilization, which sperm combines with which egg is a matter of chance.
  - In mitosis, there is no difference between the original DNA strand and the recently synthesized copy.
  - In the first stage of meiosis, chromosomes pair with their homologues.
  - Mutations are random events, which affect each locus independently.
11. Before beginning a genetic analysis how would you best ensure that you have homozygous genotypes?
- Mate close relatives for many generations.
  - Examine each individual very closely for signs of variation.
  - Start with individuals who are all homozygotes for recessive alleles.
  - Start with individuals from different species.
  - Start with individuals which look very different from other individuals.
12. In a population of humans, the frequency of a recessive allele causing a genetic disease is 0.01, or 1%. What proportion of the population would you expect to suffer from the disease?
- 0.0001
  - 0.001
  - 0.0025
  - 0.01
  - 0.25

13. In the pedigree shown below, individuals with the solid symbols suffer from a genetic disease caused by a recessive allele at an autosomal locus. You would counsel the couple marked A and B that the probability that each of their children will have the disease is:

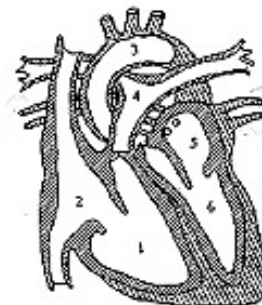
- 0
- 25%
- 50%
- 75%
- 100%



14. One day, you wake up with a sore throat and a runny nose. Your doctor takes a swab from your throat, sends it to a lab, and telephones you the next day to say that an antibiotic will not help you get better. Which of the following is the most likely reason for the doctor's statement?
- Having waited a day, it is too late to take an antibiotic.
  - You need an antiseptic, not an antibiotic.
  - You need to be vaccinated instead of taking an antibiotic.
  - You are infected by a virus.
  - An antibiotic only eliminates the symptoms of infection and does not cure the infection itself.
15. Which statement is **FALSE**?
- Viruses contain only DNA and protein.
  - All bacteria are prokaryotic.
  - All viruses are parasites.
  - Bacteria are involved in nitrogen processing in the soil.
  - Heterotrophic bacteria usually are photosynthetic.
16. You open your refrigerator to make a sandwich and find that the tomato that you put there 3 weeks ago has turned into a soggy, mushy mess. Your mother tells you that the tomato must have been infected with a bacterium. Which of the following procedures would be the best way to prove this?
- Take a bit of the mushy tomato and analyse it for DNA.
  - Examine the tomato tissue under the electron microscope and look for small cells with a cell wall, a plasma membrane, and no endoplasmic reticulum.
  - Put a piece of the mushy tomato (using aseptic techniques) on a culture medium and look for fluffy colonies of micro-organisms.
  - See if the mushy tomato takes up more oxygen than a healthy tomato.
  - Examine the tomato tissue under a light microscope and look for small polyhedral particles.

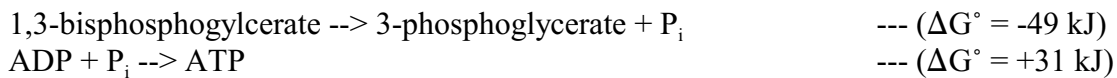
17. How is chyme (the semi-liquid stomach contents) treated in the stomach and small intestine?
- The compacted chyme is pushed into the small intestine only after the stomach has completed its action.
  - The chyme has a high pH in the stomach, but that is changed to a low pH in the intestine.
  - Most of the nutrients are absorbed from the chyme before the chyme is passed into the small intestine.
  - Small amounts of chyme are continuously released into the small intestine through the pyloric sphincter.
  - Sucrose and proteins are broken down in the stomach by the enzymes sucrase and trypsin.
18. Which statement is **FALSE**?
- The surface area of the absorptive surface of the small intestine of humans is well over 100 square metres.
  - Your large intestine contains many microorganisms that are beneficial to you because they produce useful vitamins.
  - In herbivores such as cows, the cellulose of plant cell walls is digested by cellulase produced by glands in the wall of the rumen.
  - Human saliva contains enzymes that begin the process of breaking down carbohydrates.
  - The liver produces bile, which helps in the digestion of fats by causing them to be dispersed as microscopic droplets.
19. If you arrange the following structures in the order in which they would be passed by an oxygen molecule during inspiration, which would be third?
- Bronchiole
  - Trachea
  - Alveolus
  - Epiglottis
  - Pharynx
20. Which of the following produces negative pressure within your thoracic cavity?
- Exhalation
  - Contraction of the diaphragm muscles
  - Relaxation of the muscles between the ribs
  - Contraction of the muscles in the wall of the stomach
  - Relaxation of the diaphragm muscles
21. What normally causes blood to move in the veins back to the heart?
- Contraction of precapillary sphincters
  - Contraction of nearby skeletal muscles
  - The closing of valves in the veins
  - Gravity
  - Energy stored in elastic fibres in the walls of the veins

22. Human males produce all the following hormones **EXCEPT**:
- Testosterone
  - Luteinizing hormone
  - Follicle stimulating hormone
  - Gonadotrophins
  - Progesterone
23. How are the time of ovulation and the onset of menstruation related in the human menstrual cycle?
- Both are triggered by high luteinizing hormone "spikes" (sharp increase in concentration).
  - Ovulation occurs approximately 7 days after the first day of menstruation.
  - Ovulation occurs approximately 14 days before the first day of menstruation.
  - Ovulation is triggered by copulation; menstruation is triggered by hormonal effect.
  - Ovulation is triggered by hormonal effect; menstruation is triggered by copulation.
24. The diagram below is of the adult human heart. The chambers or vessels that carry oxygenated blood include which of the following?



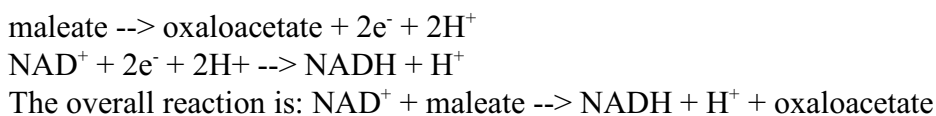
- 1 and 2 only
  - 1, 2, and 4
  - 3 only
  - 3, 5, and 6
  - 5 and 6 only
25. Which of the following is a "reduction" reaction?
- $\text{Na} + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{HO}^- + \frac{1}{2}\text{H}_2$
  - $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$
  - $\text{CH}_4 + \text{O}_2 \rightarrow \text{CH}_2\text{O} + \text{H}_2\text{O}$
  - $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
  - $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$
26. Consider the following:  $\text{H}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{HO}^- + \text{H}_3\text{O}^+$ . If such an aqueous solution contains  $10^{-6}$  mol/L of hydronium ion, what is the pH of the solution?
- $10^{-8}$  mol/L
  - 6
  - 6
  - 8
  - 6 mol/L

27. The requirement for stable hydrogen bonding between base pairs requires that, if one strand of double-stranded DNA consists of the sequence 3'-ATTCGTAC-5', the complementary sequence must be:
- 5'-UAAGCAUG-3'
  - 3'-ATTCGTAC-5' in the reverse direction
  - 3'-TAAGCATG-5'
  - 5'-TAAGCATG-3'
  - 5'-TAAGCATG-3' in the reverse direction
28. Coupled biochemical reactions are important in determining thermodynamic order within cells. Consider the following two reactions that occur simultaneously in cells:



Which of the following concerning the above partial reactions is **FALSE**?

- The energy change of the coupled reaction, or net reaction, is the sum of the energy changes of the two partial reactions and is  $\Delta G^\circ = -18 \text{ kJ}$ .
  - The coupled reaction is driven toward ATP, or occurs because the sum of the two free energy changes of the partial reactions is a negative value and yields energy to drive the reaction.
  - The overall reaction:  $1,3\text{-biphosphoglycerate} + \text{ADP} \rightarrow 3\text{-phosphoglycerate} + \text{ATP}$  is endergonic; it requires  $+18 \text{ kJ}$  and thus can not occur spontaneously.
  - The reactions occur during glycolysis.
  - ATP mediates the transfer of energy between exergonic reactions (that normally have relatively high free energies of phosphate transfer) and endergonic reactions.
29. Consider the following:



Which statement is **FALSE**?

- Maleate is oxidized to oxaloacetate.
- $\text{NAD}^+$  participates in a redox reaction.
- Maleate is reduced.
- $\text{NAD}^+$  is reduced.
- NADH can be used as a reducing agent for other synthetic reactions in the cell.

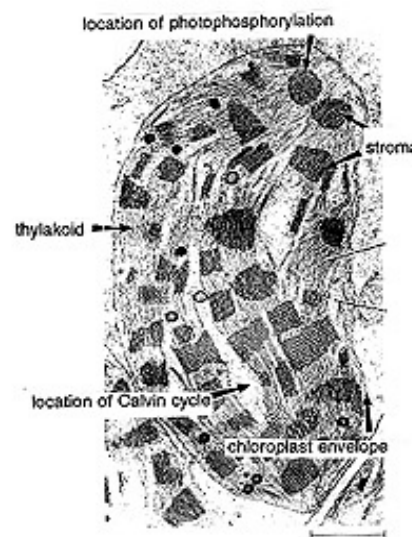


30. A plant cell was put into a solution of substance A at a concentration of 200 mmol/L. The rate of uptake into the cell was measured as 5 mmol per minute. When the cell was placed in a solution of substance A at a concentration of 400 mmol/L, the rate of uptake was 10 mmol per minute. When the experiment was repeated with substance B, the rate of uptake was 10 mmol per minute at both concentrations of the substance. Which of the following provides the best explanation of the results?
- Substance A appears to move into the cell by active transport, and B by diffusion.
  - Substances A and B appear to move into the cell by passive transport.
  - Substances A and B appear to move into the cell by active transport.
  - Substance A appears to move into the cell by diffusion, and B by active transport.
  - Substance A moves into the cell by active transport, and B by pinocytosis.
31. Which molecule releases the most energy during cellular respiration?
- Pyruvic acid
  - Glucose
  - Acetyl coenzyme A
  - Glyceraldehyde
  - Citric acid
32. With respect to the process of aerobic respiration, which statement is **CORRECT**?
- Entropy increases as the process takes place.
  - The reaction violates the second law of thermodynamics because the process is controlled by enzymes.
  - During the process, entropy is converted into free energy.
  - During the process, the free energy of the system increases.
  - During the process, the free energy remains constant.
33. Which statement is **CORRECT**? During aerobic respiration:
- the energy for oxidative phosphorylation comes from ATP.
  - the energy to make ATP comes from the potential difference in proton concentration across the inner mitochondrial membrane.
  - ATP is made by the transport of protons through a series of oxidation-reduction reactions, resulting in the transfer of electrons across the crista membrane of the mitochondrion.
  - a mole of glucose may yield from 40 to 50 moles of ATP.
  - glucose is first converted to pyruvic acid in the mitochondrion.

34. Long distance, competitive, runners are usually small and wiry and run more slowly than sprinters, who run much shorter distances and generally have a large bulk of muscle. Which of the following best explains the differences between the two types of runners?
- Long distance runners run more slowly because lactic acid quickly builds up in their muscles and causes fatigue. Sprinters do not run for long enough for lactic acid to build up in their muscles.
  - The large muscles of sprinters increases the oxygen supply to each muscle, preventing lactic acid from forming.
  - Sprinters do not run for long enough for sufficient lactic acid to build up in their muscles, therefore they can have large muscles for more power. By being lighter and running more slowly, long distance runners ensure that their muscles receive enough oxygen for aerobic respiration.
  - Sprinters run faster because their large muscles have more blood running through them to stop anaerobic respiration from taking place. Long distance runners run more slowly because they are using the energy from anaerobic respiration, which does not produce as much ATP as aerobic respiration.
  - Long distance runners burn more energy than sprinters, which makes it difficult for them to gain weight.

35. Which label on the photograph of a chloroplast shown above is **NOT** correct?

- Stroma
- Thylakoid
- Chloroplast envelope
- Location of photophosphorylation
- Location of Calvin cycle



36. Which statement about the Calvin cycle is **FALSE**?

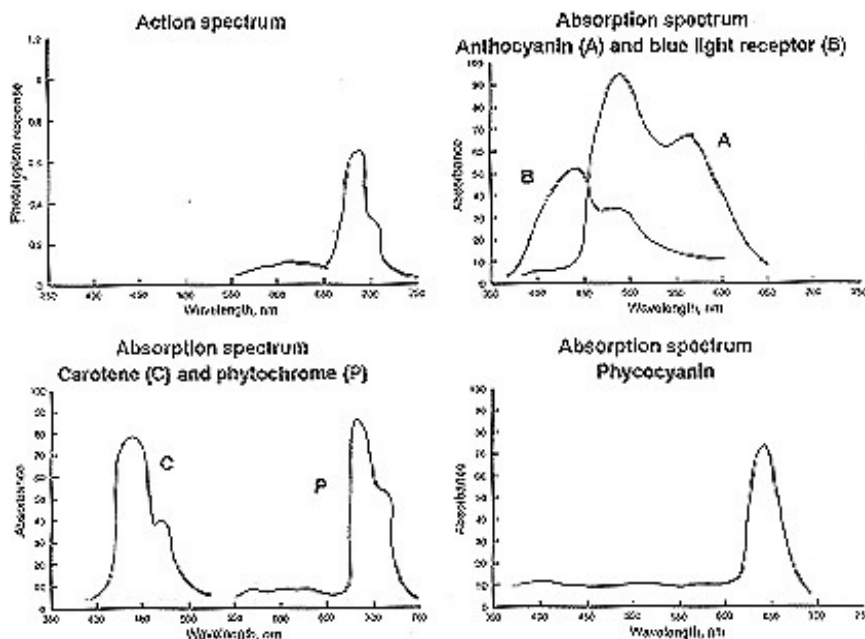
- $6\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}$
- The five-carbon sugar ribulose biphosphate is the acceptor molecule for  $\text{CO}_2$ .
- Two molecules of phosphoglyceraldehyde (PGAL) combine to form one molecule of glucose.
- Phosphoglycerate molecules are phosphorylated using ATP and then reduced to PGAL by NADPH.
- ATP from mitochondrial respiration is used to fix carbon and produce phosphoglyceraldehyde (PGAL).

37. Transport of the products of photosynthesis is thought to occur by pressure flow through the sieve tubes of the phloem from a *source* (such as the leaves where the products are produced) to a *sink* (such as a developing fruit where they are used or stored). Which of the following statements about phloem transport is **FALSE**?

- a. Water enters the sieve tubes by osmosis.
- b. Sieve tubes in a source have a low hydrostatic pressure.
- c. Water and solutes move through the sieve tubes along a pressure gradient.
- d. Solute are actively removed from the sieve tubes in the sink area.
- e. Solute are swept along by the bulk flow of water in the sieve tubes.

38. Using the four graphs above and your knowledge of the action spectrum of photosynthesis and the absorption spectra of chlorophyll *a* and chlorophyll *b*, identify the plant pigment responsible for phototropism.

- a. Anthocyanin
- b. Blue light receptor
- c. Carotene
- d. Phytochrome
- e. Phycocyanin

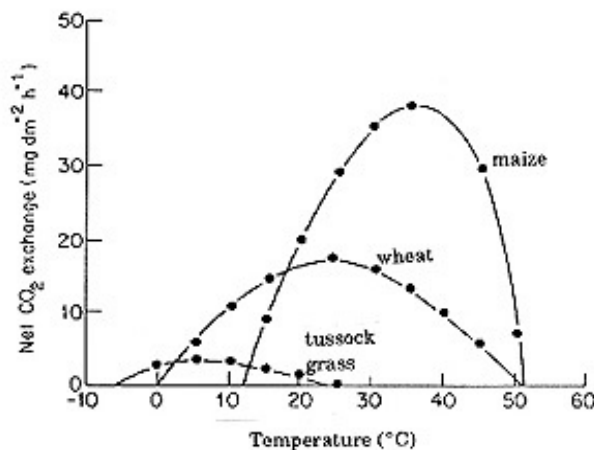


39. Which of the following gives sexual reproduction an advantage over asexual reproduction?

- a. It produces more offspring.
- b. It ensures the survival of the species.
- c. It increases the variation among the offspring of an individual.
- d. It preserves parental genotypes.
- e. It allows evolution due to sexual selection.

40. Typically, plant species are adapted for photosynthesis in a specific temperature range. Examine the above graph that shows the relationships between photosynthetic rate and temperature for the following species: alpine tussock grass (a  $C_3$  species); wheat from the temperate zone ( $C_3$ ); maize from the subtropics ( $C_4$ ). Which statement about these relationships is **FALSE**?

- Wheat is the species that has the highest rate of photosynthesis when temperatures are around  $25^\circ\text{C}$ .
- Maize shows maximum photosynthetic rates at  $38^\circ\text{C}$ .
- Wheat shows maximum photosynthetic rates at  $25^\circ\text{C}$ .
- In a region where mean temperatures were  $10^\circ\text{C}$ ,  $C_3$  species would have higher photosynthetic rates than  $C_4$  species.
- In the arctic tundra where mean daily temperatures might be as low as  $0^\circ\text{C}$ , the  $C_3$  tussock grass would have the highest rate of photosynthesis.



41. Normally, genetic information is passed from DNA to RNA to protein. Which recently discovered process can pass information in the other direction?
- Digestion by restriction enzymes
  - Polymerase chain reaction
  - DNA repair
  - Reverse transcription
  - Splicing of introns
42. The DNA of an organism has cytosine as 20 percent of its bases. What percentage of DNA bases would be thymine?
- 0
  - 10
  - 20
  - 30
  - 60
43. For a gene with the DNA sequence TACCCGGATTCA, and read from left to right, the anticodon of the transfer RNA that carried the last amino acid would be:
- TCA
  - UCA
  - AGU
  - ACT
  - AGT

44. Some of the most effective antibiotics work by blocking the movement of the ribosome along prokaryotic mRNA. If the antibiotic erythromycin is administered, which of the following immediate effects would be expected in a bacterial cell?
- Inhibition of transcription of DNA to RNA
  - Inhibition of translation of RNA to protein
  - Inhibition of DNA replication
  - Inhibition of rRNA transcription only
  - Inhibition of amino acid synthesis
45. Assume that you are trying to insert a gene from human DNA into a plasmid and someone gives you a preparation of human DNA cut with restriction endonuclease A. The human gene you are after has sites on both ends for restriction endonuclease B. You have a plasmid with a single site for B, but not for A. Your best strategy would be to:
- insert the fragments cut with B directly into the plasmid without cutting the plasmid.
  - cut the plasmid with restriction endonuclease A and insert the fragments cut with B into the plasmid.
  - cut the plasmid twice with restriction endonuclease B and ligate the two fragments onto the ends of the human DNA fragments cut with restriction endonuclease A.
  - cut the human DNA again with the restriction endonuclease B and insert these fragments into the plasmid cut with the same enzyme.
  - cut the plasmid with restriction endonuclease A and insert the human DNA cut with A into the plasmid.
46. Darwin and Wallace convinced most of their contemporaries that evolution had occurred. They did this primarily by relying on evidence from which area of study?
- Palaeontology
  - Geographic distribution
  - Behaviour
  - Developmental biology
  - Comparative anatomy
47. Which of the following observations was **NOT** important in helping Darwin and Wallace develop their theory of natural selection?
- In most species more offspring are produced than can be supported by their environment.
  - The Earth, and life on Earth, is very old.
  - There is variability in populations.
  - Young tend to resemble their parents.
  - All cells contain DNA which transmits coded information to other cells.

48. Which of the following would **NOT** generally affect allele frequencies in a population?
- Non-random mating
  - Directional selection
  - Mutation
  - Immigration
  - Emigration
49. Which of the following would generally reduce the likelihood of speciation?
- Geographical isolation
  - Genetic variation in populations
  - Natural selection
  - Genetic drift
  - Immigration and emigration
50. In a population with two alleles for a particular locus,  $A$  and  $a$ , the frequency of  $A$  is 0.6. What would be the frequency of heterozygotes if the population was in Hardy-Weinberg equilibrium?
- 0.16
  - 0.24
  - 0.36
  - 0.48
  - 0.64
51. The human kidney:
- is responsible for the storage of nutrients such as glycogen.
  - concentrates the urine by actively transporting water out of the filtrate.
  - produces more dilute urine when the collecting ducts become less permeable to water.
  - responds to antidiuretic hormone by increasing urine output.
  - gets rid of urea from the body by secreting it into the descending arm of the loop of Henle.
52. Which of the following is **FALSE**?
- In vertebrate sensory neurons, nerve impulses normally travel both away from and toward the cell body.
  - The resting potential of a neuron is maintained by membrane "pumps" actively transporting sodium into and potassium out of the cell.
  - Neurons operate with two main types of electrical signal: slow graded potentials and fast action potentials.
  - Saltatory conduction involves nerve impulses "jumping" between regions of the axon where the myelin sheath is missing.
  - The "processing" of information by integration of synaptic activity occurs in the spinal cord as well as the brain.

53. Steroid hormones:

- a. pass easily through cell membranes to act in the nucleus.
- b. include testosterone, estrogen, and growth hormone.
- c. are only produced in the pituitary gland.
- d. stimulate liver cells to convert glucose to glycogen.
- e. are made of short chains of amino acids.

54. Insulin:

- a. was discovered by Banting and Best in the 1920s; both received the Nobel prize for their work.
- b. acts on the liver to cause the release of glucose when glucose is needed during exercise.
- c. was originally difficult to obtain because it is destroyed by protein-digesting enzymes from the pancreas.
- d. causes cell membranes to become impermeable to glucose.
- e. can cause diabetic coma by raising blood sugar levels higher than normal.

55. Which sequence best describes a simple reflex arc such as the knee-jerk reflex?

- a. sensory neuron --> interneuron --> motor neuron --> effector cell
- b. sensory neuron --> interneuron --> interneuron --> motor neuron
- c. sensory neuron --> motor neuron --> interneuron
- d. sensory neuron --> effector cell --> motor neuron
- e. sensory neuron --> motor neuron --> effector cell

56. An excess supply of which of the following nutrients is the most common cause of eutrophication in freshwater lakes in Canada?

- a. Phosphorus
- b. Calcium
- c. Sulfur
- d. Potassium
- e. Nitrogen

57. Because of interest in the global carbon (C) cycle and the greenhouse effect, ecologists are estimating how much C is in each biome and whether the sizes of these C pools are changing. The organic matter (humus and dead plant tissues) in the soils of the boreal forest biome forms one of the largest pools of C in the biosphere. On average, boreal forest soils contain  $15,000 \text{ g}\cdot\text{C}\cdot\text{m}^{-2}$ , a higher value than occurs in other types of forest. However, the primary production of the boreal forest is only  $350 \text{ g}\cdot\text{C}\cdot\text{m}^{-2}\cdot\text{yr}^{-1}$  on average, a low value compared to other types of forests. This pattern occurs primarily because:
- high rates of herbivory in the boreal forest lead to low levels of forest productivity.
  - the slow weathering of bedrock under boreal forest soils releases large quantities of C into the soil. This C would be lost in hotter climates.
  - low rates of herbivory in the boreal forest mean that most leaves, branches, and roots are added to the soil when they die. Temperate and tropical forests, in contrast, have high rates of herbivory.
  - the cold, wet soils of the boreal forest restrict decomposition more than they restrict the photosynthesis of plants.
  - periodic fires destroy large areas of boreal forest and keep primary productivity low, while leaving most of the soil C intact.
58. Many of the world's fisheries are severely depleted. The goal of sustainable harvesting in a fishery is to harvest only a constant proportion of the total population, for instance 30%. Unfortunately, the harvest size has often gone up or stayed constant even as the total population size has crashed. Here is simple model of a fishery:

$$H = N \times E \times G$$

H = harvest size (number of fish caught)

N = total population size (number of fish)

E = the harvest effort (the number of days spent fishing times the number of boats fishing; in other words, the units of E are boat-days)

G = efficiency (the proportion of N caught per boat per day)

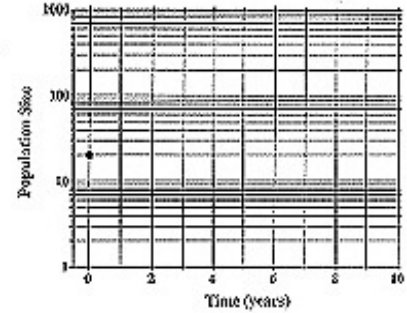
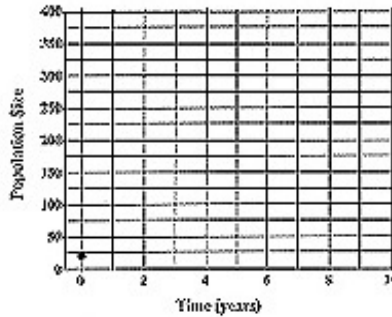
Which management approach is most sustainable and will **NOT** cause the population to crash in the long run?

- As N decreases, increase G by using either sonar to find the fish more easily, nets with smaller mesh sizes, or other advances in technology.
- As N decreases, increase E by allowing more boats to fish or more days of fishing.
- As N decreases, increase H.
- As N decreases, set a level for H and keep it fixed at that level.
- As N decreases, either E or G can change, but their product must remain constant.



59. We have introduced an animal species to an island where it undergoes exponential growth in this new unexploited, resource-rich environment. The initial population size (year 0) is 20 individuals (point shown on graphs). After 4 years the population size is 80 individuals. What is the population size after 10 years, assuming that exponential growth has continued?

- The population will be at its carrying capacity, but too little information about the biology of the species is given to determine what that value is.
- About 140 individuals
- About 170 individuals
- About 400 individuals
- About 640 individuals



60. In freshwater lakes, the dissolved nutrients are mixed and redistributed primarily by:

- fish.
- high and low tides.
- the spring and fall turnover.
- the thermocline.
- wave action along shorelines.