University of Toronto
National Biology Competition
2025 Examination

Wednesday, April 16, 2025
Time: 75 minutes
Number of questions: 50

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.

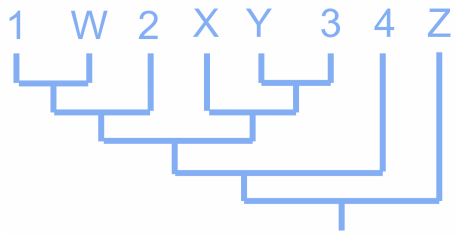
1. Jean-Baptiste Lamarck, a French naturalist who published a theory of evolution before Charles Darwin, argued the idea of inheritance of acquired characteristics. Which would be the best example of his concept?
   a) A jaguar loses a tooth, which impacts its ability to hunt, and decreases the number of offspring it has.
   b) A dog who was born with a fear of heights is more likely to have offspring that are scared of heights.
   c) A giraffe with disruptive camouflage is more likely to survive and reproduce.
   d) A parent who receives a vaccination for COVID-19 while breastfeeding can pass on this immunity to their child.
   e) A plant growing in an environment with high winds increases their stem thickness and will produce seeds that grow plants with thicker stems.

2. Which type of evidence helped contribute to Darwin's writing on evolution?
   a) Fossils of extinct species had similar characteristics to extant local species.
   b) Stromatolites show that life has existed for millions of years.
   c) Mendel's findings of heredity in peas also applied to beak shape and size which he observed in the finch species he found on the Galapagos Islands.
   d) Trees found in the South American temperate regions were more similar to trees in other European temperate regions than they were to those found in tropical regions of South America, due to adaptations to their environments.
   e) All of the above

3. Which of the following statements about microevolution is true?
   a) It only occurs within short time spans
   b) It is limited to evolution within micro-organisms
   c) It cannot cause the formation of new species
   d) It involves incremental changes within a population over time
   e) It is unrelated to Darwin's theory of natural selection

4. In lobsters, large males can intimidate other males away from females, whereas small lobsters are able to sneak up to females and mate undetected. This is an example of _____ selection and could lead to _____ speciation
   a) Disruptive, allopatric
   b) Disruptive, sympatric
   c) Directional, allopatric
   d) Stabilizing, sympatric
   e) Stabilizing, allopatric

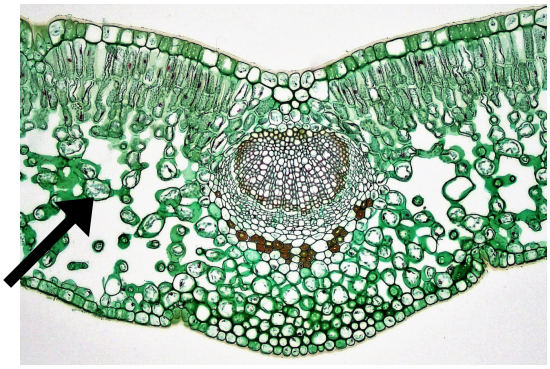
5. Which taxa is equally related to 1 and 2, more closely related to 3 than 4 and not sister taxa to 3?
   a) W
   b) X
   c) Y
   d) Z
   e) There is not enough information provided



6. Last year, more evidence was discovered for a new organelle that evolved through endosymbiosis, the nitroplast. Which of the following is a requirement for endosymbionts to be classified as an organelle?
   a) They have lost their own membranes
   b) They have lost their ribosomes
   c) They require proteins from the host cell
   d) They produce ATP
   e) They no longer have their own DNA

7. Which of the following organisms has historically been classified as a protist, but is not unicellular?
   a) Colonial cyanobacteria
   b) Morel mushrooms
   c) Bread mold
   d) Bull kelp
   e) Amoeba

8. What is the function of the gap shown in this leaf cross section?
   a) Regulates gas exchange
   b) Transport of water
   c) Transport of sugar
   d) D) Allows the movement of gases
   e) Reduce the weight of the leaf



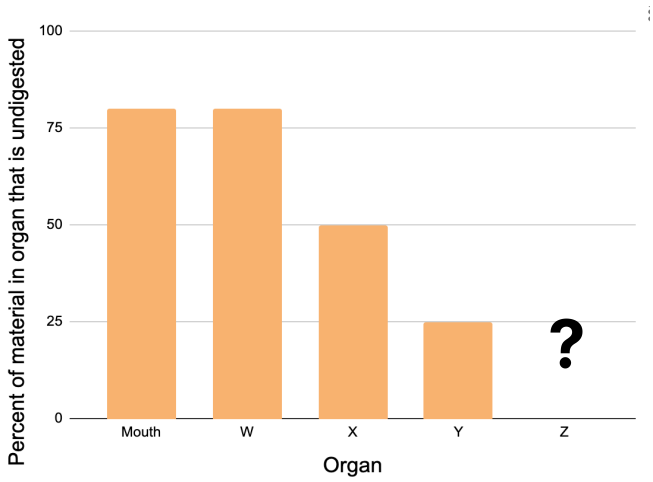
9. A thigmotropic response would be most beneficial for which plant and in which process in a three sisters garden?
   a) A bean plant for detecting and growing up structures, such as the corn stalk
   b) A bean plant for responding to the presence of nitrogen fixing bacteria
   c) A squash plant for determining when to close their stoma
   d) A corn plant as it detects which way is up for vertical growth
   e) A squash plant for facing its leaves towards the sun

10. ***8.2(a)*** What is the most likely mechanism by which *Verticillium dahliae,* a soil borne fungus, can cause vascular wilt in plants?
    a) The fungus grows into the phloem elements and blocks them
    b) The fungus grows into the xylem vessels and blocks them
    c) The fungus grows into the stoma and blocks them
    d) The fungus infects and damages the sclerenchyma tissue
    e) The fungus infects and damages the cuticle layer

11. 8.2 (b) Which of the following is true about phloem tissues?
    a) It contains tracheids with thickened walls to withstand high pressures.
    b) It contains stacks of vessels with perforated plates separating them.
    c) It contains sieve elements that are dead upon maturity.
    d) It contains companion cells that aid sieve elements by providing them with metabolites.
    e) Substances move through phloem via transpiration.

12. Which plant hormone stimulates the plant to respond to drought conditions by promoting stomatal closure?
    a) Gibberellins
    b) Ethylene
    c) Abscisic acid
    d) Auxin
    e) Cytokinins

13. This graph shows the percentage of undigested material in each organ (each organ is separated by a sphincter and presented in order of the alimentary canal, beginning with the mouth). Given this information, which organ is Z and how do you expect its value on the graph to compare to Y?
    a) Small intestine, lower
    b) Small intestine, higher
    c) Large intestine, lower
    d) Large intestine, the same
    e) Large intestine, higher



14. Bird digestive organs vary from those of mammals, with three specialized organs used for 1) chemical digestion, 2) mechanical digestion and 3) storage. Which organs perform each function, respectively?
    a) 1) Crop, 2) gizzard, 3) proventriculus
    b) 1) Gizzard, 2) crop, 3) proventriculus
    c) 1) Gizzard, 2) proventriculus, 3) crop
    d) 1) Proventriculus, 2) gizzard, 3) crop
    e) 1)Proventriculus, 2) crop, 3) gizzard

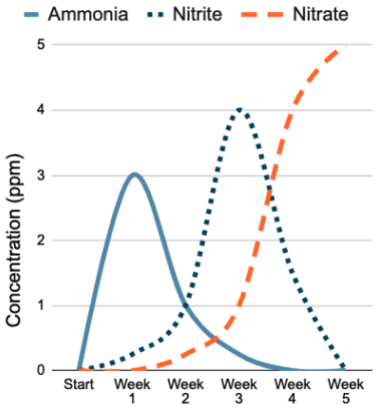
15. What is the location and function of lacteals?
    a) The small intestine, absorption of fats
    b) The spleen, filtration of red blood cells
    c) Mammary gland, secretion of milk
    d) In muscle tissues, secretion of lactic acid
    e) Within lymph nodes, filtration of waste

16. Which of the following is a correct comparison between arteries and veins?
    a) Arteries contain valves whereas veins do not
    b) Arteries are under lower pressures than veins
    c) Arteries have thicker walls than veins
    d) Arteries have wider lumens than veins
    e) Arteries always contain oxygenated blood, whereas veins do not

17. Ectopic pregnancies occur when a fertilized egg implants and begins to develop outside the uterus. Which of the following locations is least likely to be the site of ectopic pregnancy?
    a) The ovary
    b) The fallopian tube
    c) The abdominal cavity
    d) The cervix
    e) The urethra

18. To determine if an individual is allergic to a substance, doctors often use a skin prick test, where a small amount of the allergen is applied to the skin. If the person is allergic to the substance the skin may develop raised bumps. Which of the following best describes the immune response that causes this reaction?
    a) The antigens located on mast cells detect the antibodies on the allergen, releasing histamines which causes the blood vessels to dilate.
    b) The antigens located on mast cells detect the antibodies on the allergen, releasing histamines which causes the blood vessels to constrict.
    c) The antigens located on mast cells detect the antibodies on the allergen, releasing histamines which causes the lymph vessels to constrict.
    d) The antibodies located on mast cells detect the antigens on the allergen, releasing histamines which causes the blood vessels to dilate.
    e) The antibodies located on mast cells detect the antigens on the allergen, releasing histamines which causes the blood vessels to constrict

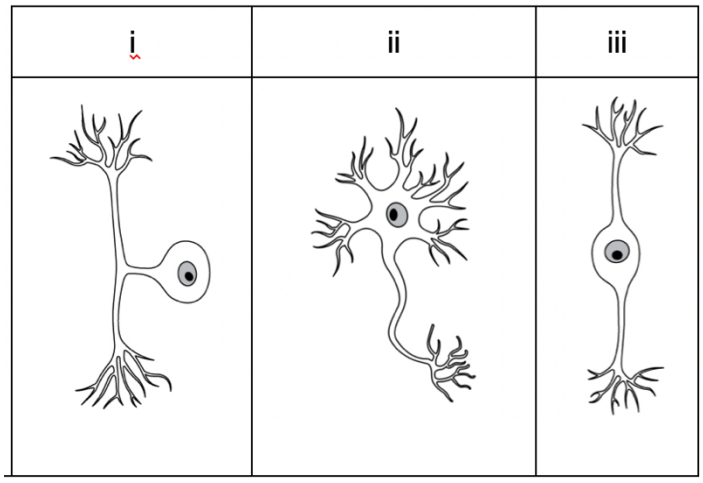
19. Aquarists manage waste level toxicity in their aquariums by encouraging the growth of beneficial bacteria. The graph shows the concentrations of these nitrogenous wastes over a period of time known in the hobby as “the cycle”. Which is the best explanation of what is happening?



a) The fish produce ammonia which breaks down naturally into nitrite then into nitrate over time.
b) The fish are producing ammonia initially, but as the beneficial bacteria build up in their stomachs, they start producing nitrite, and then nitrate instead.
c) Fish produce urea, which dissociates in water into ammonia, nitrate and nitrite.
d) The fish produce ammonia, which one type of bacteria can convert to nitrite, and then another can convert to nitrate.
e) The amount of nitrogen in the system is decreasing as the bacteria convert it to nitrogen gas which is released out of the water.

20. Which hormone is involved in a positive feedback loop?
a) Antidiuretic hormone
b) Oxytocin
c) Insulin
d) Thyroid stimulating hormone
e) Cortisol

21. What are the types of neurons shown in i, ii, and iii respectively?
a) i) Interneuron, ii) motor, iii) sensory
b) i) Motor, ii) sensory, iii) interneuron
c) i) Sensory, ii) interneuron, iii) motor
d) i) Interneuron, ii) sensory, iii) motor
e) i) Sensory, ii) motor, iii) interneuron



22. Which characteristic would be most helpful in determining if an organ has endocrine glands or exocrine glands?
    a) The presence or absence of ducts
    b) The size of the gland
    c) The types of cells present
    d) The presence of vascularization
    e) The shape of the gland

23. In an experiment, different fungi are placed on opposite sides of a Petri dish and their mycelium growth is measured after 7 days. The following growth diameters (in mm) were recorded for an unknown species of *Fusarium*. When grown in solo culture, *Fusarium* grows to 32 mm.

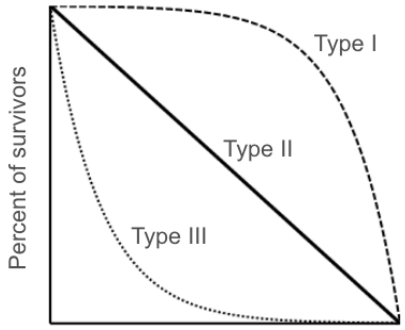
    Based on the results, which species does this Fusarium species have a relationship with that could be described as parasitic?
    a) Thielaviopsis basicola
    b) Chaetomium funicola
    c) Agroathelia rolfsii
    d) Penicillium chrysogenum
    e) There is not enough information to determine this.

Species present with Fusarium on dish	***Size* (mm)**
Thielaviopsis basicola	35
Chaetomium funicola	17
Agroathelia rolfsii	32
Penicillium chrysogenum	23

24. If a toxin that persists in the environment is taken up by primary consumers via phagocytosis and is not broken down by any organisms, which trophic level would have the highest concentration of the toxin after 100 years of exposure?
    a) Primary producers
    b) Primary consumers
    c) Secondary consumers
    d) Tertiary consumers
    e) Quaternary consumers

25. Which of the following scenarios would cause the conditions required for primary succession to occur?
    a) Wildfires
    b) Glacial retreat
    c) Blizzards
    d) Tsunamis
    e) Hurricanes

26. This graph shows three types of survivorship curves. What is the x-axis?
    a) Density
    b) Population size
    c) Carrying capacity
    d) Time
    e) Fecundity



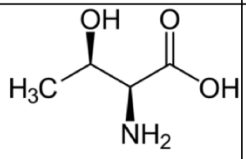
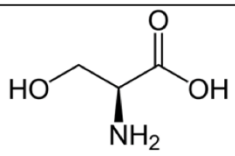
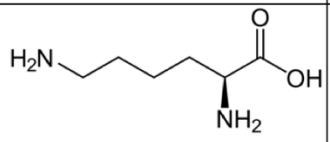
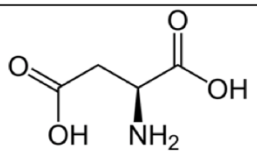
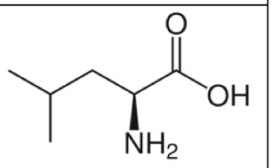
27. A human population has the following demographics: a stable birth rate of 3.0 children per woman, a relatively high average age of 50, and a stable death rate. The rate of emigration is low, but exceeds the immigration rate. Which is the most likely outcome over the next 50 years?
    a) The population size will gradually decline
    b) The population size will not change in size
    c) The population size will increase, regardless of the death rate
    d) The population size will increase, regardless of birth rates
    e) The population will grow at a rate equal to the birth rate

28. A blood cell has a large amount of rough endoplasmic reticulum and very few lysosomes. Which type of blood cell is it most likely to be?
    a) B cell
    b) Erythrocyte
    c) Macrophage
    d) Neutrophil
    e) Platelet

29. Which organelle can import protein directly from the cytosol, avoiding the need to rely on the endomembrane system for support?
    a) Golgi apparatus
    b) Lysosomes
    c) Peroxisomes
    d) Rough endoplasmic reticulum
    e) Vacuoles

30. The Rh factor on red blood cells is important for blood typing. Rh proteins form a complex that functions in both cell recognition and ammonia transport across the cell membrane. Which of the following best describes an Rh protein?
    a) Amphitropic protein
    b) Integral membrane protein
    c) Lipid anchored protein
    d) Peripheral membrane protein
    e) Surface membrane protein

31. Which of the following amino acids has a hydrophobic R group (i.e., side chain)?

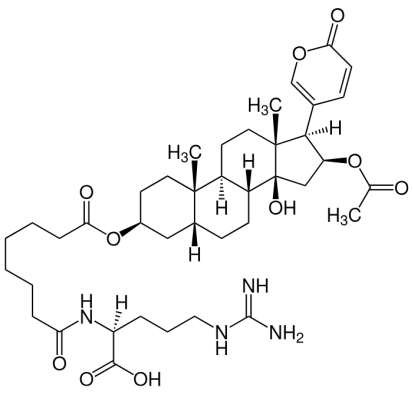
a. Threonine	b. Serine	c. Lysine	d. Aspartic Acid	e. Leucine
				

32. What type of covalent bond links monosaccharides together?
a) Peptide bonds
b) Hydrogen bonds
c) Phosphodiester bonds
d) Van der Waals bonds
e) Glycosidic bonds

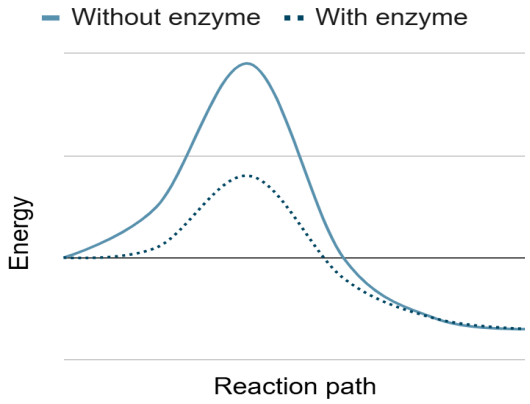
33. Despite calcium being present in high quantities in the soil, plants can sometimes suffer from calcium deficiency due to competition with another nutrient for uptake. Which nutrient is most likely involved in this competition?
a) Chloride
b) Iodine
c) Magnesium
d) Oxygen
e) Silicon

34. Which of the following pairs of compounds could form a buffer solution, when combined?
a) H_2CO_3 / $NaHCO_2$
b) H_2CO_3 / NH_3
c) H_3PO_4 / H_2CO_3
d) NH_3 / NH_4Cl
e) NH_4OH / NH_3

35. Bufotoxin, a toxin found in some amphibians, contains which types of biological molecules based on its known structure?
a) Chitin and glycogen
b) Chitin and protein
c) Glycogen and steroid
d) Glycogen and protein
e) Protein and steroid



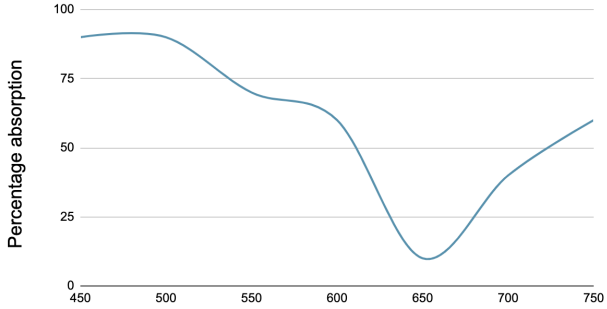
36. This graph shows the change in energy when a molecule of L-glucose is broken down without an enzyme and with an enzyme. Which of the following is most likely to change if the substrate is substituted with D-glucose?
    a) The activation energy of the enzyme- catalyzed reaction
    b) The activation energy of the uncatalyzed reaction
    c) The free energy change of both reactions equally
    d) The free energy change of the enzyme- catalyzed reaction
    e) The free energy change of the uncatalyzed reaction



37. Which of the following cellular processes is correctly paired with one of its products?
    a) Citric acid cycle - NAD+
    b) Electron transport chain - CO_2
    c) Glycolysis - ATP
    d) Fermentation - NADH
    e) Pyruvate processing - $FADH_2$

38. A company is interested in modifying a plant to perform photosynthesis at a higher rate. What would be the most accurate way of measuring photosynthesis in a modified plant compared to an unmodified control?
    a) Measure the change in plant mass
    b) Measure the change in soil mass
    c) Measure the chlorophyll content
    d) Measure the CO_2 consumption
    e) Measure the water lost due to transpiration

39. Certain species of algae can photosynthesize in deep waters, where it can get quite dark. In this area of the ocean different wavelengths of light can reach deeper than others leading to the evolution of new pigments to utilize the available light energy. On a diving adventure you collect a sample of one of these algae and measure the light absorption properties of its new photosynthetic pigment as shown on the right. What color would the algae appear when you observe it in your lab?
    a) Blue (460 - 500 nm)
    b) Green (500 - 570 nm)
    c) Yellow (570 - 590 nm)
    d) Orange (590 - 620 nm)
    e) Red (620 - 720 nm)



40. Which of the following is a reason a cell would fail to progress past the G1 checkpoint?
    a) The cell has not reached a critical size threshold
    b) The cell's telomeres are too short
    c) The chromosomes are not properly condensed
    d) All of the chromosomes have not been replicated
    e) The mitotic spindle has not been assembled

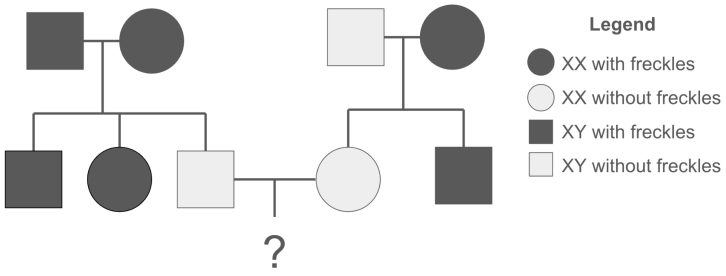
41. Five people were subjected to a breathalyzer test. None of them had consumed alcohol within the past 48 hours, yet one of them tested positive for ethanol in the blood. Which person is the most likely candidate?
    a) **Person 1:** Someone who has not eaten well in a week and is in ketosis.
    b) **Person 2:** Someone who had just sprinted to the testing center and whose body switched from aerobic respiration to anaerobic fermentation due to energy demands.
    c) **Person 3:** Someone with gut fermentation syndrome, a rare condition where gut flora ferments carbohydrates in the intestines, constantly producing small amounts of ethanol.
    d) **Person 4:** Someone who has a mutation in alcohol dehydrogenase, causing it to work more efficiently.
    e) **Person 5:** Someone who has recently undergone surgery and has metal implants in their body, causing interference with the breathalyzer test.

42. During meiosis, sister chromatids are separated in _____, while homologous chromosomes align at the center of the cell during _____.
    a) Anaphase I, Metaphase II
    b) Anaphase II, Metaphase I
    c) Metaphase I, Anaphase II
    d) Metaphase II, Anaphase I
    e) There is no correct answer, as homologous chromosomes only line up during mitosis.

43. Apple cultivars are propagated through a process called grafting, where branches from a tree are cut and attached to another tree. This method is preferred instead of growing new trees from seeds because apple trees have a "high degree of heterozygosity". Why does this make growing trees from seeds less desirable than grafting?
    a) Seeds carry more pathogens to the next generation of trees than grafts do.
    b) Seeds have a low germination rate due to having an odd number of chromosomes.
    c) Seeds have a low germination rate due to high genetic incompatibility.
    d) Seeds produce trees with different phenotypes, leading to inconsistent fruit quality.
    e) Seeds produce trees with more types of alleles, leading to off flavours.

44. Mendel's experiments with pea plants led to the Law of Independent Assortment. However, gene sequencing has shown that three of the genes responsible for the traits he studied are located on the same chromosome. What is the most likely explanation for Mendel's observation of independent assortment for these genes?
    a) Gene sequencing has a high error rate, leading to incorrect gene location results
    b) Multiple chromosomes have fused since Mendel's experiments
    c) The genes have translocated to different chromosomes since Mendel's experiments
    d) These genes are far apart on the chromosome
    e) The peas were polyploid, allowing two pairs chromosomes to assort randomly

45. Freckles in humans are determined by the *MC1R* gene, which follows Mendelian inheritance. A couple wants to know their chances of having a child together with freckles, so they create a pedigree showing the traits of their siblings and parents. Based on this information, what is the chance they will have a child with freckles?
    a) 0 %
    b) 25 %
    c) 50 %
    d) 75 %
    e) 100 %



46. In snapdragons, flower color is determined by one gene with two alleles: (*R)* resulting in red flowers and *(W)* resulting in white flowers. A botanist crosses a white-flowered plant with red-flowered plant. All the resulting offspring have pink flowers. If the pink plants are allowed to self-fertilize, what are the expected phenotypic ratios?
    a) 100% pink
    b) 50% red, 50% white
    c) 25% red, 50% pink, 25% white
    d) 50% red, 25% pink, 25% white
    e) 25% red, 25% pink, 50% white

47. The 2024 Nobel prize in Medicine and Physiology was awarded for the discovery of microRNAs that play a crucial role in regulating gene expression. One example is *lin-4*, a 22-nucleotide microRNA in *C. elegans* that regulates the expression of the LIN-14 protein, which is coded by the *lin-14* gene. This microRNA localizes to the cytoplasm and is too short to be translated. How does lin-4 regulate *lin-14*?
    a) *lin-4* binds to the *lin-14* gene promoter and inhibits transcription of *lin-14* gene
    b) *lin-4* binds to the *lin-14* gene promoter and promotes transcription of *lin-14* gene
    c) *lin-4* binds to the *lin-14* mRNA and promotes translation of *lin-14* mRNA
    d) *lin-4* binds to the *lin-14* mRNA and inhibits translation of *lin-14* mRNA
    e) *lin-4* binds to translation factors and promotes translation of *lin-14* mRNA

48. There are 61 mRNA codons that specify various amino acids. During translation, tRNAs recognize and bind to codons (reading from the 5' to the 3' direction in the mRNA) and carry the corresponding amino acid to be incorporated into the polypeptide chain. One would expect that cells would have at least 61 unique tRNAs, one for every codon that specifies an amino acid. However, in humans, only 30-40 unique tRNAs are required to translate mRNA. What is the explanation for this discrepancy?
    a) Only the first two positions of the codon are read by Watson-Crick pairing rules, while deviations are allowed in the third position
    b) Only the last two positions of the codon are read by Watson-Crick pairing rules, while deviations are allowed in the first position
    c) Only the first two positions of the codon are read by Watson-Crick pairing rules, while the nucleotide in the third position is redundant
    d) tRNAs can bind in either direction, effectively halving the number needed
    e) Only the last two positions of the codon are read by Watson-Crick pairing rules, while the nucleotide in the third position is redundant

49. Which of the following correctly represents the order of sequences in a prokaryotic mRNA molecule?
    a) 3' untranslated region → Protein-coding region → Shine-Dalgarno sequence → Stop codon
    b) Stop codon → Protein-coding region → 3' untranslated region → Shine-Dalgarno sequence
    c) Protein-coding region → 3' untranslated region → Stop codon → Shine-Dalgarno sequence
    d) Shine-Dalgarno sequence → Protein-coding region → Stop codon → 3' untranslated region
    e) Shine-Dalgarno sequence → Stop codon → Protein-coding region → 3' untranslated region

50. The 2024 Nobel prize in Chemistry was awarded for the development of an AI model called AlphaFold which can predict the 3D structures of proteins with unprecedented accuracy. This year, a new version of the AphaFold is being developed to determine how these proteins interact with metals, coenzymes and ligands. Which level(s) of protein structure will be impacted by these interactions?
    a) All four levels of protein structure
    b) Quaternary only
    c) Tertiary and Quaternary
    d) Tertiary only
    e) Secondary and Tertiary

THE END