



# Practice Test 1

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(Print) Number and Street

\_\_\_\_\_ City State Zip Code

**PHONE NO. :** \_\_\_\_\_  
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IMPORTANT: Please fill in these boxes exactly as shown on the back cover of your test book.

**2. TEST FORM**

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# AP<sup>®</sup> Biology Exam

## SECTION I: Multiple-Choice Questions

**DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.**

### At a Glance

**Total Time**  
1 hour and 30 minutes  
**Number of Questions**  
60  
**Percent of Total Score**  
50%  
**Writing Instrument**  
Pencil required

### Instructions

Section I of this examination contains 60 multiple-choice questions.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work. After you have decided which of the suggested answers is best, completely fill in the corresponding oval on the answer sheet. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely. Here is a sample question and answer.

#### Sample Question

Chicago is a

- (A) state
- (B) city
- (C) country
- (D) continent

#### Sample Answer

(A) ☒ (C) ☐ (D) ☐

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all the multiple-choice questions.

### About Guessing

Many candidates wonder whether or not to guess the answers to questions about which they are not certain. Multiple-choice scores are based on the number of questions answered correctly. Points are not deducted for incorrect answers, and no points are awarded for unanswered questions. Because points are not deducted for incorrect answers, you are encouraged to answer all multiple-choice questions. On any questions you do not know the answer to, you should eliminate as many choices as you can, and then select the best answer among the remaining choices.

**BIOLOGY**  
**SECTION I**  
**60 Questions**  
**Time—90 minutes**

**Directions:** Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding oval on the answer sheet.

Questions 1–5 refer to the following passage.

The following table lists the intracellular osmolality concentrations of four osmoconforming organisms that are known to mimic the osmotic conditions of their surroundings.

**Table 1. Osmolality concentrations of osmoconforming organisms**

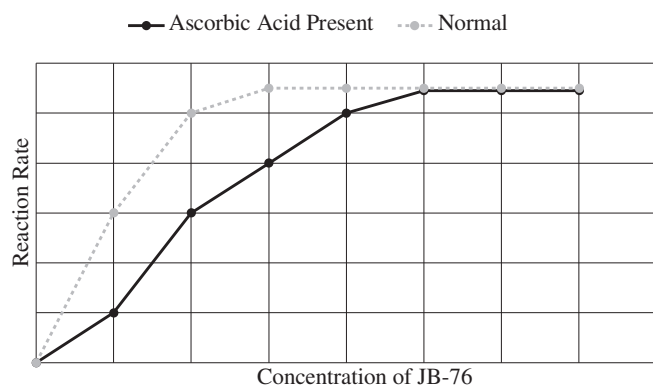
Organism 1	100 mOsm kg <sup>-1</sup>
Organism 2	400 mOsm kg <sup>-1</sup>
Organism 3	500 mOsm kg <sup>-1</sup>
Organism 4	150 mOsm kg <sup>-1</sup>
Organism 5	350 mOsm kg <sup>-1</sup>

- If a large amount of salt was added to the sealed tank where organism 4 was being kept, what would be the effect on the intracellular osmolality of organism 4?
  - Increase initially and then return to the initial state
  - Increase and maintain the increased state
  - Decrease and then return to the initial state
  - Decrease and maintain the decreased state
- Which of the following would likely have the largest direct effect on data in the table?
  - A mutation in a cytoskeleton protein
  - A mutation in a protein in the sodium-potassium pump complex
  - A mutation in a lipid in the outer chloroplast membrane
  - A mutation in a nuclear pore channel protein
- Which could decrease the osmolalities of the organisms?
  - Sodium is added to the sealed tank.
  - Chloride is injected into the organism.
  - Glucose is ingested by the organism.
  - Water is added to the sealed tank.
- Which of the following statements best describes the insides of these organisms compared to the environment in the tank when they reach osmoconformity?
  - Due to the influx of water into the organisms' cells, the organisms' insides are hypertonic when compared to the tank.
  - Compared to the tank, the loss of water out of the organisms' cells makes the organisms' insides hypotonic.
  - The organisms' insides are isotonic since the intracellular osmolality concentrations match the osmolality concentrations of the tank.
  - The flow of water into and out of the organisms' insides causes the cells to be retrotonic.
- A population of organisms that are not osmoconformers is dropped into the tank with Organism 1. The intracellular osmolality of Organism 1 begins to slightly decrease. Which of the following could explain this?
  - The new organisms were hypotonic compared to the tank and they lost water via osmosis.
  - The new organisms expelled waste products that increased the tank's osmolality.
  - The new organism competed with organism 1 for food and caused it to become active.
  - The new organism ingested large amounts of fluid and the tank fluid level decreased.

**GO ON TO THE NEXT PAGE.**

Questions 6–9 refer to the following passage.

The active site of the enzyme Ritzoline (RZN45) contains three positively charged lysine residues. When ascorbic acid is present, binding of JB-76, the substrate of RZN45, decreases. The reaction rate is affected by the presence of ascorbic acid as shown in the figure below. It is thought that a daily supplement of Vitamin C might aid those suffering from Ritzolier's Disease, which is caused by elevated levels of RZN45.

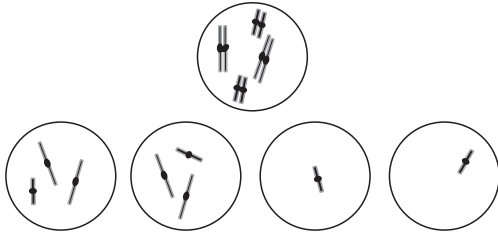


**Figure 1. Reaction rate based on ascorbic acid**

6. Which of the following is likely true?
  - (A) RZN45 and JB-76 have similarly charged amino acids at their active sites.
  - (B) Ritzoline is stabilized in the presence of Vitamin C.
  - (C) Ascorbic acid and JB-76 each have a pocket of negatively charged amino acids.
  - (D) JB-76 and ascorbic acid have an identical number of amino acids.
7. Which is the best explanation for the differing effects on reaction rate caused by ascorbic acid at low and high concentrations of JB-76?
  - (A) At high concentrations of JB-76, there are fewer free active sites for the ascorbic acid to bind to.
  - (B) At low concentrations of JB-76, there are fewer free allosteric sites for the RZN45 to bind to.
  - (C) At high concentrations of JB-76, there are more free allosteric sites for the ascorbic acid to bind to.
  - (D) At low concentrations of JB-76, there are more free active sites for the RZN45 to bind to.
8. A patient with Ritzolier's Disease would likely benefit from which of the following:
  - I. Injections of RZN45
  - II. Injections of JB-76
  - III. Injections of ascorbic acid
  - (A) I only
  - (B) II only
  - (C) III only
  - (D) II and III
9. If Figure 1 were to include additional data for higher concentrations of JB-76, how would the reaction rate change?
  - (A) The reaction rate would be lower than any reaction rate shown in Figure 1.
  - (B) The reaction rate would be higher than any reaction rate shown in Figure 1.
  - (C) The reaction rate would be equal to the highest reaction rate shown in Figure 1.
  - (D) The reaction rate would increase gradually for each concentration of JB-76 added.
10. The Galapagos Islands contain about 15 species of finches that vary in terms of beak size and strength. The differences are believed to have occurred as a result of allopatric speciation acting on the finch populations. Which of the following best explains how the finch populations developed different beaks?
  - (A) As finches migrated between islands, alleles were transferred between populations through the process of gene flow.
  - (B) Genetic drift occurred due to a hurricane near the islands causing a bottleneck effect.
  - (C) Through convergent evolution, the finches developed comparable features due to being exposed to comparable selective pressures.
  - (D) Geographic isolation between the different islands kept the populations from breeding with each other, and each population evolved separately.

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11. Figure 1 shows a cell at the onset of meiosis (just prior to initiation of prophase I) and the resulting 4 gametes achieved at the end of meiosis. Select the statement that is likely true.

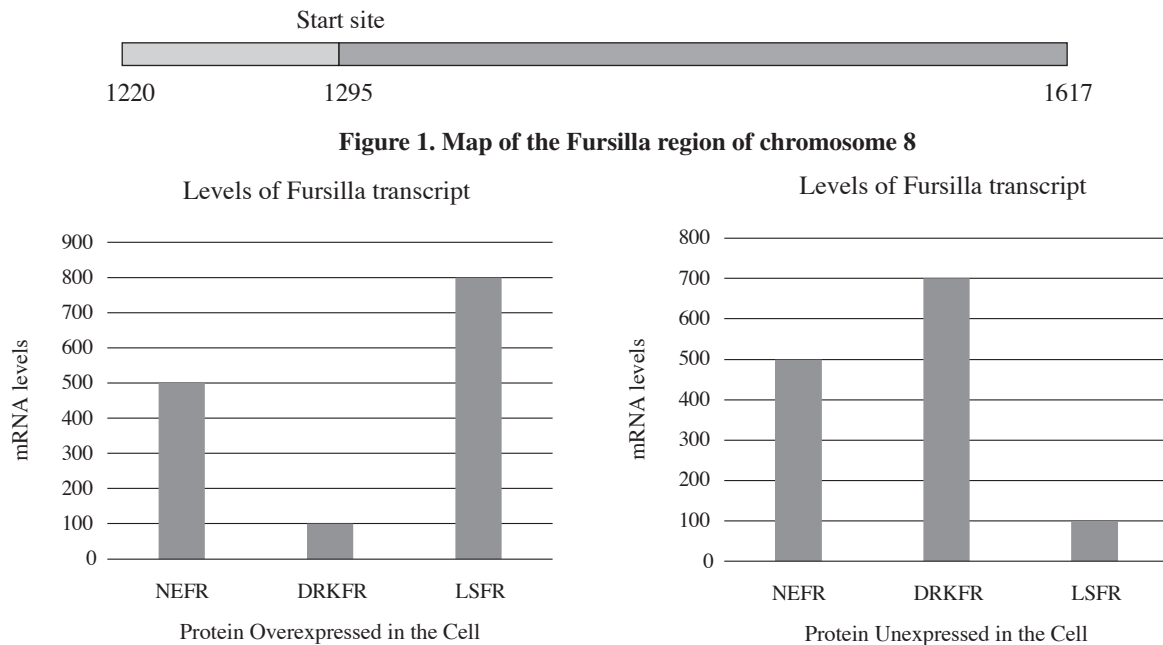


**Figure 1. Resulting gametes from meiosis**

- (A) Meiosis occurred as it should.  
 (B) There was a nondisjunction event in Meiosis I.  
 (C) There was a nondisjunction event in Meiosis II.  
 (D) Two Barr bodies were produced instead of four gametes.

Questions 12–16 refer to the following passage.

A gene responsible for production of hair pigment in dogs is called *Fursilla* (*frsl*). A map of the *Fursilla* locus is shown in Figure 1, below. When expressed, it results in darkly pigmented dog fur. When unexpressed, the hair is devoid of pigmentation and appears pure white. Expression of *Fursilla* (*frsl*) depends on the binding/lack of binding of several proteins: Nefur (NEFR), Lesfur (LSFR), and Dirkfur (DRKFR). Figure 2 shows the relative levels of *frsl* transcript as measured via RT-qPCR when each protein is overexpressed or unexpressed in the cell.



**Figure 2: Relative amounts of Fursilla transcript**

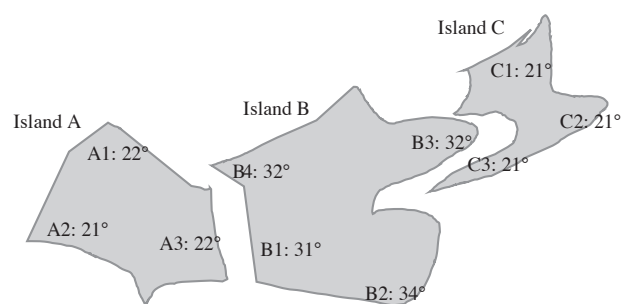
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12. Scientists identified a mutant allele of the Fursilla gene caused by a deletion of bases 1231-1295 on chromosome 8. What is the likely effect of this mutation?
- No transcription and no translation of Fursilla will occur.
  - Transcription will not occur, but translation will be unaffected.
  - Transcription of Fursilla will occur, but no translation will occur.
  - Both transcription and translation of Fursilla will be unaffected.
13. Which of the following would likely produce a dog with the darkest fur?
- High levels of LSFR and high levels of DRKFR
  - High levels of LSFR and low levels of DRKFR
  - Low levels of LSFR and high levels of DRKFR
  - Low levels of LSFR and low levels of DRKFR
14. Based on the data, which of the following most likely describes how the binding of proteins affects the production of Fursilla transcript?
- Because Fursilla transcript levels change when certain proteins are overexpressed or unexpressed in the cell, Fursilla must interfere with the other proteins.
  - Because Fursilla transcript levels stay the same whether NEFR is overexpressed or unexpressed, NEFR must bind inhibit the production of Fursilla transcript.
  - Because Fursilla transcript levels decrease when LSFR is unexpressed in the cell, LSFR must compete for the binding site or RNA polymerase.
  - Because Fursilla transcript levels increase when DRKFR is unexpressed in the cell, DRKFR must compete for the binding site of RNA polymerase.
15. An additional protein, Baldidog (BLD), was identified and found to interact with the DRKFR protein. When they bind together, it has been shown that they fit together because of:
- Complementary nucleotides sequences
  - Amino acid pockets with complementary conformations
  - Opposing regions rich in cytosines and thymines
  - Hydrophobic lipids and hydrophobic molecules
16. How would the overexpression of BLD affect the transcript levels of Fursilla?
- Fursilla transcript levels would increase.
  - Fursilla transcript levels would decrease.
  - Fursilla transcript levels would be unaffected.
  - Fursilla transcript would completely disappear.

17. Water molecules experience intermolecular forces when interacting with each other. Which of the following would most likely occur if water became a nonpolar molecule?
- Polar solutes would dissolve in water forming aqueous solutions of various concentrations.
  - The amount of liquid water on the planet would increase, and the amount of water vapor in the air would decrease.
  - The melting and boiling points of water would increase.
  - Solid water would be more dense than liquid water, so ice would no longer float.

Questions 18–21 refer to the following passage.

A chain of three small islands was found to be the home to a small species of mouse. The angle of jaw opening was found to vary significantly. The average size angle of the maximal jaw opening found in mice at 10 locations on the three small islands is shown in Figure 1, below.



**Figure 1. Angles of maximal jaw opening (in degrees) for mice found at various island positions**

18. Which of the following might account for the variations in maximal jaw angle?
- Different wind speeds on each island
  - Different heights of trees on each island
  - Different sizes of seeds on each island
  - Differences in altitude on each island
19. If the mice from Island A and the mice from Island B were placed together, what would likely happen?
- The mice would mate, but it is impossible to predict jaw angle.
  - The mice would mate, and the jaw angle would be approximately 27°.
  - The mice would mate, and the jaw angle would be either 21° or 32°.
  - The mice would not be capable of mating.

**GO ON TO THE NEXT PAGE.**



20. Skeletons have been found that indicate that mice with jaw angles less than 30 degrees were once found on Island B. Which explanation best accounts for this.
- (A) A small jaw angle hinders the survival of mice on Island B.
- (B) A large jaw angle hinders the survival of mice on Island A.
- (C) A small jaw angle encourages the survival of mice on Island C.
- (D) A large jaw angle encourages the survival of mice on Island A.
21. Which of the following statements best supports that the jaw angle on Island B changed via punctuated equilibrium?
- (A) Fossil evidence has shown that over time the jaw angle on Island B slowly increased.
- (B) Fossil evidence has shown that the jaw angle of the mice on Island B increased very quickly.
- (C) Fossil evidence has shown that over time the jaw angle on Island B slowly decreased.
- (D) Fossil evidence has shown that the jaw angle of the mice on Island B fluctuates over time.
22. A scientist studying osmosis placed six similarly sized pieces of potato in sodium chloride solutions of different concentrations and then measured the percent change in mass.

**Table 1. % change in mass of potato samples**

Sodium chloride concentration	% change in mass
0.1 M	+17.5
0.3 M	+5.0
0.5 M	-7.5
0.7 M	-16.2
0.9 M	-26.1
1.1 M	-25.1

The percent change in mass is closest to 0% at which of the following approximate concentrations of the solutions?

- (A) 0.01 M
- (B) 0.25 M
- (C) 0.3 M
- (D) 0.45 M

Questions 23–26 refer to the following passage.

Proteins often need the equivalent of a shipping label so that they can be sent intracellularly or extracellularly to the correct location. These labels are typically found in three forms: signal sequences, target signals, or localization signals. A signal sequence is a stretch of hydrophobic amino acid residues that is only located within polypeptides destined to fold into EITHER extracellular proteins, intermembrane proteins that will anchor to the cell surface, or proteins that will be members of the secretory pathway that packs and ships things towards the cell surface. A targeting signal is a sequence that identifies the proteins of the secretory pathway. A localization signal is a sequence that labels proteins that are destined to go to specific organelles (that are not part of the secretory pathway). The table below shows seven eukaryotic proteins, and the sequences have been identified in each.

**Table 1. Sequences identified within eukaryotic proteins**

Protein	Signal Sequence	Targeting Signal	Localization Sequence
HRIET1	X	X	
HAZL2			
NUH8			X
K8TE	X		
TELEE	X	X	
TMSDG	X	X	
LNACT			X

23. Which of the following could be a description for HRIET1?
- (A) A protein found in the blood that plays a role in the immune system
- (B) A protein found in the Golgi apparatus that helps tether vesicles
- (C) A protein found in the nucleolus aiding in ribosome assembly
- (D) A protein found in the cytosol serving as a cytoskeletal anchor
24. One of the proteins was found to be a receptor for a large protein that is produced in the brain and travels through the blood until it can dock at the target cells that it stimulates. Which of the proteins is likely this receptor?
- (A) TMSDG
- (B) NUH8
- (C) HAZL2
- (D) K8TE

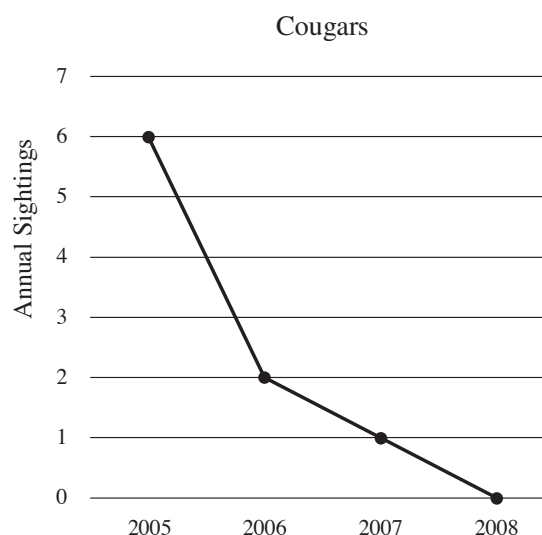
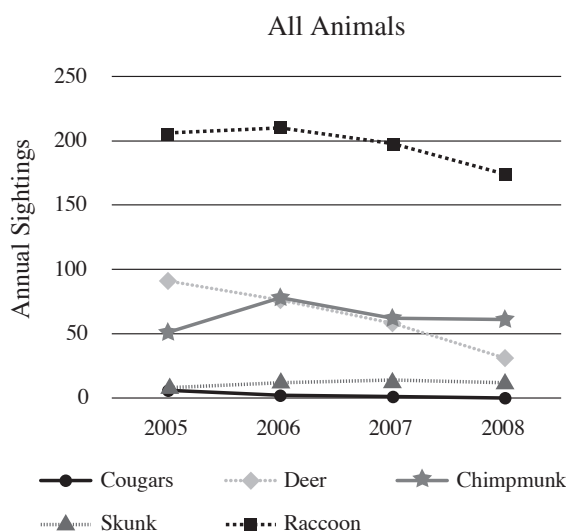
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25. Two proteins were identified in the electron transport chain. One was found to be active at the beginning of the chain, and the other was found to be active at the final stages of the chain. Which two proteins were these?
- (A) HRIET1 and HAZL2  
 (B) NUH8 and LNACT  
 (C) TELEEE and K8TE  
 (D) TMSDG and TELEEE
26. If a scientist was hoping to isolate and purify HAZL2, which of the following techniques would they use?
- (A) Collect only the nuclear fraction  
 (B) Collect only the cytosolic fraction  
 (C) Collect only the extracellular fraction  
 (D) Collect only the lipid membrane fraction

Questions 27–31 refer to the following passage.

In a heavily populated suburb, two cougars were once spotted roaming in a small field. Local wildlife experts, though not surprised, warned the public to be aware of their surroundings and to keep small pets protected. A group of local junior high school students were curious about the population of cougars in the area since no one they asked had ever seen one in the area. With the help of local wildlife enthusiasts and carefully placed motion-activated wildlife cameras, the group of students recorded sightings of animals in a local forest preserve for their entire four years of high school. The results are shown below.



27. Raccoons eat a diet rich in berries. Which statement is the most likely to describe the berry population?
- (A) A hard frost eliminated nearly all of the berries in 2007, but 2008 was a milder winter.  
 (B) A virus was introduced in 2006 that eliminated a fly using the berry bushes as a niche habitat.  
 (C) Cougars destroyed much of the berry habitat in 2005.  
 (D) The berry population remained steady, with a slight decrease due to lower rainfall in 2008.
28. Although the data is limited, which of the following populations is the most likely to be a primary food source for the cougars?
- (A) Skunk  
 (B) Deer  
 (C) Raccoon  
 (D) Chipmunk
29. Which change will cause fewer skunks to be sighted in the future?
- (A) An increase in the number of cougars  
 (B) An increase in the number of raccoons  
 (C) An increase in the number of deer  
 (D) It is impossible to make this determination

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30. It has been shown that the population size of chipmunks is directly tied to the number of acorns dropped. This can be scientifically summarized by which of the following statements?
- (A) Acorn number is a density-dependent population factor and affects the carrying capacity of the chipmunk population.
  - (B) Acorn number is a density-dependent population factor and does not affect the carrying capacity of the chipmunk population.
  - (C) Acorn number is a density-independent population factor and affects the carrying capacity of the chipmunk population.
  - (D) Acorn number is a density-independent population factor and does not affect the carrying capacity of the chipmunk population.
31. Which of the following populations does NOT demonstrate exponential growth?
- I. Cougar
  - II. Chipmunk
  - III. Deer
- (A) I only
  - (B) I and II
  - (C) I and III
  - (D) I and II and III
- Question 32–35 refer to the following passage.
- A certain gene has been identified on chromosome 2 in a species of butterfly. The mRNA transcript has been found to be 1578 base pairs in length. A portion of the transcript is shown below. The area shown in grey is part of a known ribosome binding site.

5' **UUACGUGCAUGCGUA** GCUAGCUAGCUAUGCUAUCGCUUUAAGAGCAAAAAA 3'  
                                   15                                  30                                  45

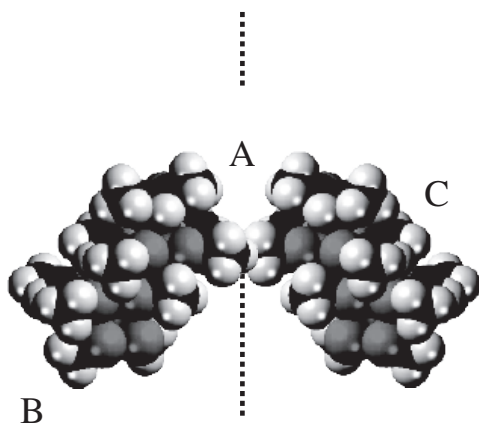
**Figure 1. Portion of the mRNA transcript of a species of butterfly**

32. If bases 0–15 were deleted, what would be the likely consequence?
- (A) No transcription would be allowed to occur.
  - (B) No translation would be allowed to occur.
  - (C) Neither transcription nor translation would occur.
  - (D) No consequence would occur as these bases are non-coding.
33. A transcript was identified in the nucleus that is similar to this transcript. How is it likely different from the mRNA transcript?
- (A) The nuclear transcript likely contained introns.
  - (B) The nuclear transcript likely contained exons.
  - (C) The nuclear transcript likely contained a poly-A tail.
  - (D) The nuclear transcript likely contained a 3' GTP-Cap.
34. RNA polymerase transcribes DNA into mRNA by matching base pairs of nucleotides. Which of the following would be the segment of DNA on the coding strand corresponding to bases 0–6 in Figure 1?
- (A) 5' AAUGCA 3'
  - (B) 5' TTACGT 3'
  - (C) 3' AATGCA 5'
  - (D) 3' TTUGCT 5'
35. Where on the strand shown in Figure 1 is a transcription factor likely to bind?
- (A) Bases 0 to 15
  - (B) Bases 20 to 25
  - (C) Bases -20 to -15
  - (D) None of the above
36. In a small ecosystem, it is estimated that producers equal approximately 2987 g/m<sup>2</sup> of biomass. What would be a good guess of how much biomass is found within secondary consumers?
- (A) 5974 g/m<sup>2</sup>
  - (B) 2987 g/m<sup>2</sup>
  - (C) 298.7 g/m<sup>2</sup>
  - (D) 29.87 g/m<sup>2</sup>

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Question 37–40 refer to the following passage.

The enzymatic catalysis of a reaction essential in the production of dog saliva is mediated by the protein ARKKKK60491. ARKKKK60491 is a homodimer, with each subunit being 337 amino acids. Figure 1, below, indicates a modular structure of the homodimer. Three positions are indicated on the model. Position A is the active site. Position B is a region known to have a large number of nonpolar residues. Position C is known to have a large number of charged residues.



**Figure 1. Modular structure of the homodimer**

37. A mutation is discovered in the gene for ARKKKK60491 that converts positively charged lysine residue into negatively charged glutamic acid residue. This single change directly impacts the location where the substrate to ARKKKK60491 attaches during catalysis. Which position is likely affected by this change?
- (A) Position A  
(B) Position B  
(C) Position C  
(D) None of the positions will be affected
38. Which of the following is Position B most likely to assist the protein with?
- (A) Stabilization of the substrate into the transition state during catalysis  
(B) Transportation of catalyzed cargo from the nucleus to the mitochondria  
(C) Creation of a homodimer through catalysis of homodimerization  
(D) Attachment to the membrane by embedding into the phospholipid bilayer
39. Which of the following statements best predicts the effect on the protein's structure if the subunits of the homodimer fail to attach?
- (A) The primary structure will change because the order of amino acids will differ.  
(B) The secondary structure will differ because hydrogen bonds will occur in different locations and the protein will fold into a different shape.  
(C) The tertiary structure will be destroyed because the side chain interactions will not occur and the protein will not fold into a 3-dimensional shape.  
(D) The quaternary structure will be destroyed because the different amino acid chains will not join together.
40. According to Figure 1, within the protein ARKKKK60491, which of the following locations contain polypeptide N-termini?
- I. Position A  
II. Position B  
III. Position C
- (A) I only  
(B) I and II  
(C) II and III  
(D) I and III

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Questions 41–43 refer to the following passage.

There are four major types of macromolecules, and each type has specific functions and characteristics. Proteins are made of amino acids and function as enzymes, receptors, hormones, signals, and receptors. Lipids are made of fatty acids and glycerol and function as membrane components and energy storage. Carbohydrates are made of monosaccharides and function as energy storage. Nucleic acids are made of nucleotides and provide genetic information for organisms.

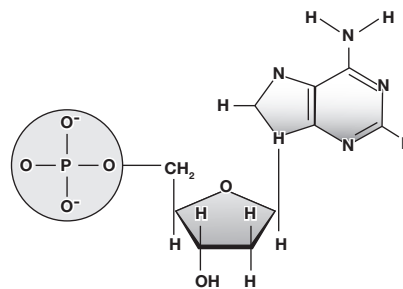


Figure 1. Structure of adenosine

41. Fats are a type of lipid that are generally soluble in organic solvents and generally insoluble in water. Which of the following questions will best guide the researchers to determine if a substance is a fat?

(A) At what temperature does the substance boil?  
 (B) What type of mixture does the substance form when mixed with water?  
 (C) Does treating the substance with acid affect its appearance?  
 (D) Have chemical reactions been recorded between the substance and other chemicals?

42. Sugars are a type of carbohydrate typically made up of hydrogen, carbon, and oxygen. The hydrogen:oxygen ratio is typically 2:1. Which of the following statements explains how carbohydrates function as a stored form of energy?

(A) Excess glucose is stored as glycogen in muscles and the liver.  
 (B) Glucose is broken down during photosynthesis to act as an energy source.  
 (C) Glycerol is released into the bloodstream when stored fat is used as an energy source.  
 (D) Glucagon is a hormone that stores excess energy in the pancreas.

43. All four types of macromolecules are organic compounds. Which of the following statements describes a difference between organic and inorganic compounds?

(A) Only organic compounds contain oxygen.  
 (B) Only organic compounds contain covalently bonded carbon atoms.  
 (C) Only organic compounds contain hydrogen bonds.  
 (D) Only organic compounds contain ionizing chemical groups.

44. Which of the following could NOT be represented by Figure 1?

(A) A monomer used to build a protein  
 (B) A nucleotide  
 (C) A reactant used to synthesize nucleic acids  
 (D) A chemical used to relay genetic information

Questions 45–49 refer to the following passage.

The Dandranian Nettle is a plant native to the Eemagee nation. The nettle produces tiny flowers that come in two colors: white and pink. The petals of the flowers come in two varieties: ruffled or slotted. After years of studying them, it has been widely acknowledged that both traits follow classic Mendelian inheritance patterns of dominance. The table below shows floral phenotypes in a small garden in an isolated greenhouse, where the dominant phenotypes are the most plentiful and researchers assume the population is in Hardy Weinberg equilibrium.

Table 1. Population of various floral phenotypes

Phenotype	#
White	4900
Pink	400
Ruffled	700
Slotted	4600

45. A true-breeding white nettle is crossed with a true-breeding pink nettle. What will be the ratio of the offspring?

(A) 100% White  
 (B) 3 White: 1 Pink  
 (C) 1 White: 1 Pink  
 (D) 1 White: 3 Pink

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46. The F1 generation shown in Table 1 was crossed with a true-breeding pink nettle. What percentage of offspring would have pink flowers?
- (A) 0%
  - (B) 25%
  - (C) 50%
  - (D) 100%
47. A cross is performed between one nettle that is known to be heterozygous for both traits and a nettle that is pink and ruffled. Which of the following would lead researchers to believe the traits are linked?
- (A) Several white flowers are identified with ruffled petals.
  - (B) Nearly all white flowers also have slotted petals and nearly all pink flowers have ruffled petals.
  - (C) Petals are discovered that are both ruffled and slotted.
  - (D) Flowers are discovered that have two colors of flowers and two shapes of petals.
48. What frequency of the alleles in the greenhouse garden are recessive?
- (A) 0.14
  - (B) 0.27
  - (C) 0.38
  - (D) 0.56
49. What is the frequency of plants in the greenhouse garden that are heterozygous for the flower color trait?
- (A) 0.27
  - (B) 0.39
  - (C) 0.5
  - (D) 0.74

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Question 50–53 refer to the following passage.

G-protein coupled receptors (GPCRs) are a common type of protein receptor containing seven transmembrane segments and bearing intracellular and extracellular portions. The structure of a typical GPCR and its associated partners is shown below. GPCRs are coupled to G-proteins consisting of three subunits ( $\alpha$ ,  $\beta$  and  $\gamma$ ) that bind the nucleotides GTP or GDP on the intracellular side of the GPCR. The presence or absence of a ligand on the extracellular side of the GPCR determines whether GDP or GTP will bind to the intracellular G-protein. Extracellular ligand binding initiates GDP being exchanged for GTP and the separation of the G-protein. One subunit will travel to join with a secondary partner and will initiate a cascade of signaling effects within the cell. In the example shown below, the secondary partner is adenylyl cyclase and the signaling is cAMP upregulation.

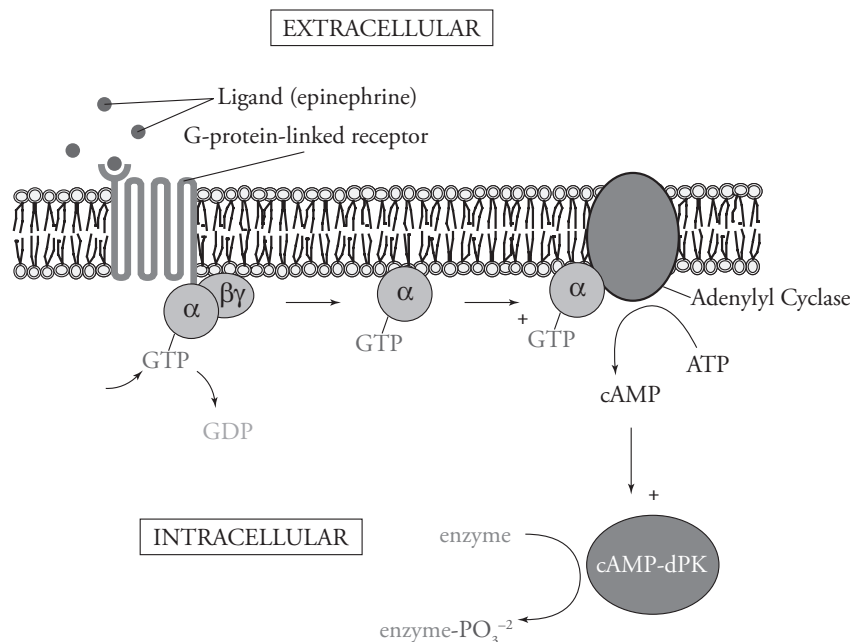


Figure 1. G-protein coupled receptor joining with adenylyl cyclase

50. A setup like a GPCR is unnecessary in which of the following situations?
- The signaling event is very specific
  - The ligand is a hormone traveling in the bloodstream
  - The effector molecules are located inside the cytoplasm
  - The ligand is a small nonpolar molecule
51. Based on Figure 1, which of the following is the first step in the activation of cAMP-dPK?
- The exchange of GTP for GDP
  - The binding of epinephrine
  - The separation of  $\alpha$ -GTP
  - Phosphorylation of intracellular enzymes
52. Which of the following situations is most similar to extracellular binding to a GPCR?
- A police officer pulling over a speeding car on the expressway
  - A celebrity chef visiting the kitchen of another restaurant
  - A driver giving their order to a person through a drive-up window
  - A taxi driver picking up a group of passengers
53. What does a GPCR's capability of making a ligand-induced conformational change allow?
- Binding of the ligand to the phospholipid head groups within the membrane
  - Communication between the outside of the cell and the inside of the cell
  - A solid attachment to the intermembrane region of the cell membrane
  - Intracellular binding of the GDP-associated G-protein complex

Question 54–58 refer to the following passage.

A small family farm has documented Tonduly carrot growth for a hundred years in a Midwest microclimate. The average lengths and masses of the carrots are shown in the table below. The same ecosystem was home to a species of vegetable weevil that attacks the carrots underground. Other than carrots, the weevils also preyed on radishes found in the ecosystem. This particular species of weevil spends its whole life beneath the soil, and the average depth at which these weevils were found each year is shown in the table below.

**Table 1. Average lengths and masses of carrots and depth at which weevils are found (by decade)**

Year	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
Average carrot mass (g)	61	62	61	65	58	61	60	62	65	61	59
Average carrot length (cm)	21.5	21.2	20.3	19.8	19.0	18.7	18.1	17.6	17.5	17.9	17.7
Average weevil depth (cm)	19.2	20.2	20.0	19.7	19.3	20.3	19.4	20.2	20.1	19.8	19.9

54. Which carrot phenotype was selected for over time?
- (A) Thinner carrots  
(B) Longer carrots  
(C) Shorter carrots  
(D) Heavier carrots
55. If a weevil were introduced to the ecosystem that lived at a depth of 17 centimeters, how would the carrot length change in the coming years?
- (A) It would likely return to its original long size.  
(B) It would likely get longer than it has been in the past.  
(C) It would likely get shorter than it has been in the past.  
(D) It would not likely change at all with a weevil at 17 centimeters.
56. The average carrot consumer prefers long carrots. What should be done to promote the growth of longer carrots?
- I. Remove the weevil population  
II. Cross the longest carrot of each generation  
III. Introduce a different carrot predator that lives at 10 centimeters
- (A) I only  
(B) I and II  
(C) II and III  
(D) I and II and III
57. If true, which of the following would account for the average weevil depth changing to 17 centimeters in 2030?
- (A) The average carrot length changed to 15 centimeters.  
(B) The radishes completely disappeared from the garden.  
(C) Goats arrived to eat the tops of the carrot plants above the surface.  
(D) A small percentage of the weevil population died from a virus.
58. According to Table 1, which of the following traits is most linked to the carrot's fitness?
- (A) Weight  
(B) Length  
(C) Color  
(D) Flavor
59. A dance by the Lenoxian bird is one of the most highly complex mating rituals. Precision and flamboyancy are key to wooing a mate. The natural predator of the Lenoxian bird also enjoys the spirited dance and often strikes during the courtship ritual. Which of the following statements is likely true?
- (A) Sexual selection of the most exciting dancers is the driving selective pressure.  
(B) Selective pressure against the exciting dancers is the driving selective force.  
(C) The Lenoxian bird will soon become extinct if the predatory action does not cease.  
(D) There can exist a careful balance between multiple opposing selective pressures.
60. Antibiotic resistance occurs when drugs or chemicals used to treat an illness become less effective. Some varieties of *Neisseria gonorrhoeae* have become resistant to the antibiotic penicillin. Which of the following best explains how the bacteria became resistant?
- (A) The bacteria experienced hybrid vigor through gaining improved traits from their parents.  
(B) Through natural selection, bacteria with a random mutation that provided resistance survived and multiplied to create more bacteria.  
(C) The bacteria were influenced by other species in their environment through coevolution.  
(D) The bacteria evolved to fill different niches from other species in the environment through adaptive radiation.

**STOP**

**END OF SECTION I**

**IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS SECTION. DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.**



**BIOLOGY**  
**SECTION II**

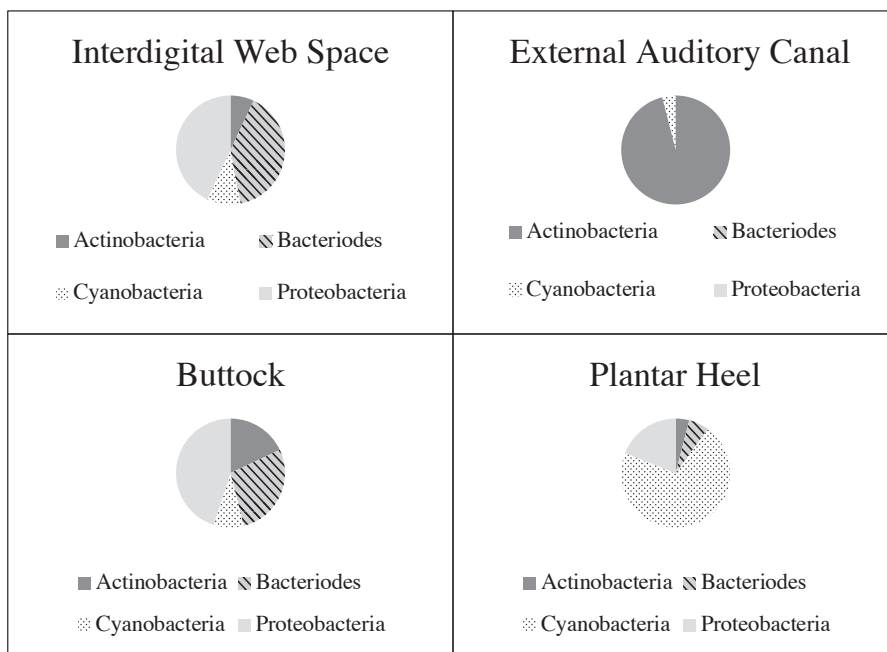
**6 Questions**

**Writing Time—90 minutes**

**Directions:** Questions 1 and 2 are long free-response questions that should require about 25 minutes each to answer and are worth 8–10 points each. Questions 3 through 6 are short free-response questions that should require about 10 minutes each to answer and are worth 4 points each.

Read each question carefully and completely. Write your response in the space provided following each question. Only material written in the space provided will be scored. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable unless specifically requested.

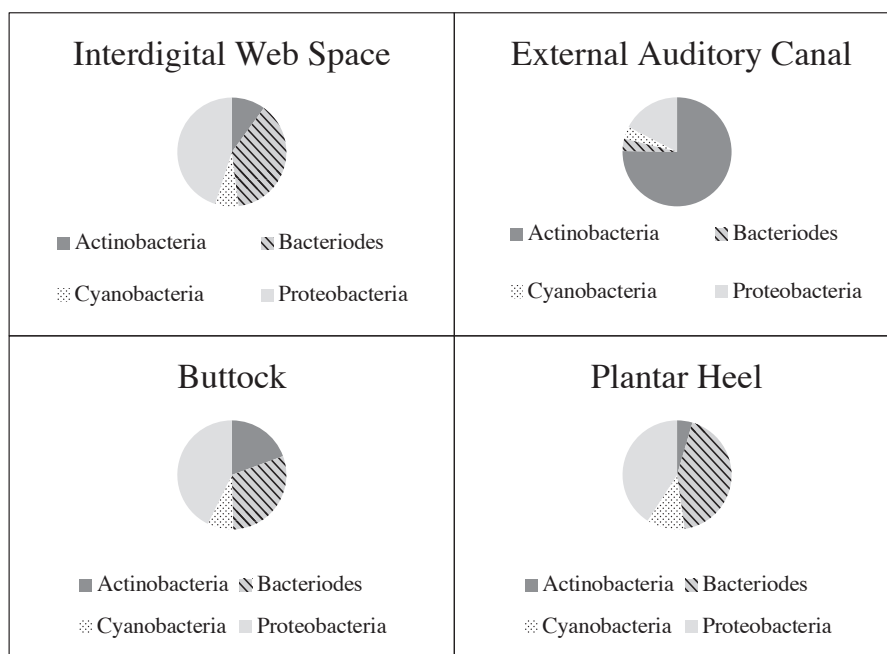
1. The microbiome is a collection of microbes, such as bacteria and viruses, that live in/on the human body. Sites of colonization include the skin, nasal passages, mouth, and gut. Links between the microbiome and many different conditions, such as allergies, obesity, depression, and many others have been suggested. During antibiotic use, the body can often suffer repercussions due to the destruction of the natural microbiome. The bacterial community composition varies greatly between body sites. Even among the skin microbiome, there is a great variety in the amounts and types of bacteria found in different locations.



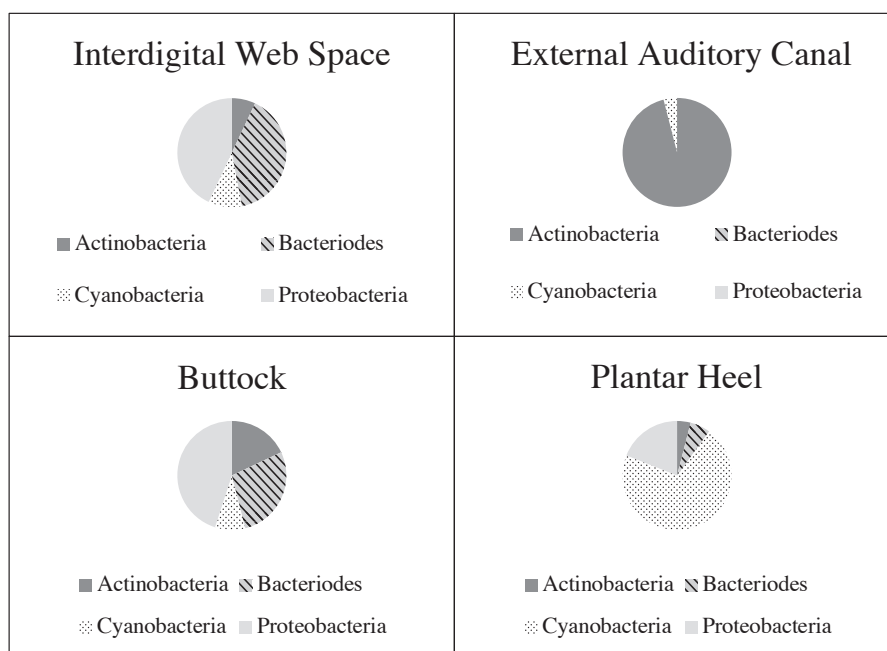
**Figure 1. Relative composition of bacterial communities found in each of four skin microbiomes**

An experiment was performed to assess the results of skin bacterial transplants to alternative sites of the body. A 2-inch square area of interdigital skin was swabbed with a sterile swab to collect bacteria. An additional swab was opened but not touched to the skin. Each swab was then rubbed on either an alternate skin site or the same type of skin site. After 7 days, the skin of the site of deposition was swabbed and plated on a dish to assess bacterial growth. The types of bacteria present were then cataloged.

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**Figure 2. The results of rubbing a swab of interdigital skin on four skin sites**



**Figure 3. The results of rubbing a clean swab on four skin sites**

- (a) Bacterial communities containing different species of bacteria are no different than other communities with multiple species. **Explain** what factors contribute to a carrying capacity.
- (b) **Identify** the two important controls that are used in this experiment. In addition, the experiment includes a 7-day waiting period between when the bacterial transplant takes place. **Justify** why this is necessary.
- (c) **Interpret** the effect of the transplants between interdigital web space and the buttock, external auditory canal, and plantar heel areas.
- (d) If each deposition site is pretreated with known antibiotics, **explain** how this would likely affect the results.

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2. Researchers were interested in the effect of temperature on the respiration rate of crickets. Three chambers were prepared and kept at three different temperatures. A cricket was placed in each chamber. The CO<sub>2</sub> levels in the chamber were recorded at 0 minutes, 5 minutes, and 10 minutes to assess the changing levels of CO<sub>2</sub> over time. This process was repeated 50 times at each temperature. The results are indicated in Table 1.

**Table 1. Levels of CO<sub>2</sub> over time.**

	CO <sub>2</sub> levels( ppm $\pm$ 2 SE <sub>x</sub> )		
Temperature (°C)	0 min	5 min	10 min
20	1034 $\pm$ 26	1074 $\pm$ 251	2012 $\pm$ 71
35	1560 $\pm$ 55	1670 $\pm$ 120	1785 $\pm$ 100
50	2021 $\pm$ 35	2040 $\pm$ 55	2051 $\pm$ 5

- (a) **Describe** how CO<sub>2</sub> is a measure of respiration. **Explain** why temperature might affect the rate of respiration.
- (b) On a set of axes, **construct** an appropriately labeled graph to demonstrate the CO<sub>2</sub> levels with changing temperature. Please include all temperatures, timepoints, and error bars.
- (c) **Identify** which temperature led to having the highest respiration rate in the crickets.
- (d) **Predict** what would happen to the CO<sub>2</sub> levels in the crickets with an additional 5°C increase above the highest temperature. **Justify** your prediction with evidence from the data.
3. A researcher was trying to determine why a strain of influenza spreads more easily than other strains. She suspected that the answer might lie in the Influenza Neuraminidase (NA) protein. NA is an enzyme known to play a role in releasing viral particles during viral spread. It functions by cleaving an attachment between viral particles and the cell membrane. The researcher evaluated the enzyme activity of each of the strains and found them to be quite different. She then compared the NA protein from the rapidly spreading strain of flu (NA<sub>H</sub>) with the NA protein from another strain of flu (NA<sub>A</sub>). The sequences were similar, but there were some differences in the amino acid sequence.

```

NAA 1-MNPNQKITTIGSICMVGIVSLMLQIGNMISIWVSHSIQTGNQHQAEPISN-----TNFLTEKAVAS
NAH 1-MNPNQKITTIGSICLVGLISLILQIGNIISIWVSHSIQTGSQNHTGICNQNIITYKNSTWVKDTTS

NAA VTLAGNSSLCPISGWAVHSKDNSIRIGSKGDVFVIRVVPFISCSHLECRTFEFLTQGALLNDKHSNGTV
NAH VILTGNSSLCPIRGWAIYSKDNSIRIGSKGDVFVIREVPFISCSHLECRTFEFLTQGALLNDKHSNGTV

NAA KDRSPHRTLMSCPVGEAPSPYNSRFESVAWSASACHDGTSLWLTIGISGPDNGAVAVLKYNIGIITDTI
NAH KDRSPHRTLMSCPVGEAPSPYNSRFESVAWSASACHDGMGLWLTIGISGPDNGAVAVLKYNIGIITETI

NAA KSWRNINILRTQESECACVYVGSCTFVRTDGPSNWQAS YKIFKMEKGKVVKSELEAPNYHYEECS CYP
NAH KSWRKINILRTQESECACVNGSCTFIMTDGPSDGLAS YKIFKIEKGKVTKSELNAPNSHYEECS CYP

NAA DAGEITCVCRDNWHGSNRPWVSFNQNLQYQIGYICSGVFGDNPRPNDGTGSCGPVSPNRAVGVKGFS
NAH DTGKVMCVCRDNWHGSNRPWVSFDQNLQYQIGYICSGVFGDNPRPEDGTGSCGPVYVDGANGGVKGFS

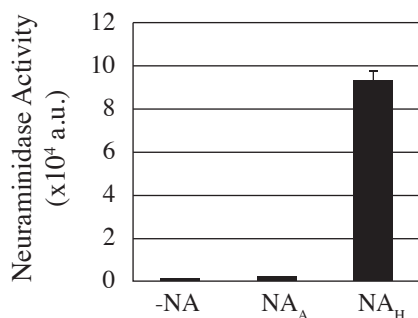
NAA FKYNGVWIGRTKSTNSRSGFEMI WDPNGWTGTDS SFVQDVAITDWSGYSGSFVQHP ELTGLDC
NAH YRYNGVWIGRTKSHSRSGFEMI WDPNGWTE TDS KFSVRQDVVAMTDWSGYSGSFVQHP ELTGLDC

NAA IRPCFWVELIRGRPKESTIWTS GSSISFCGVNSDTV GSWPDGAELPFTIDK-449
NAH MRPCFWVELIRGRPKESTIWTS ASSISFCGVNSDTV DWSWPDGAELPFSIDK-454

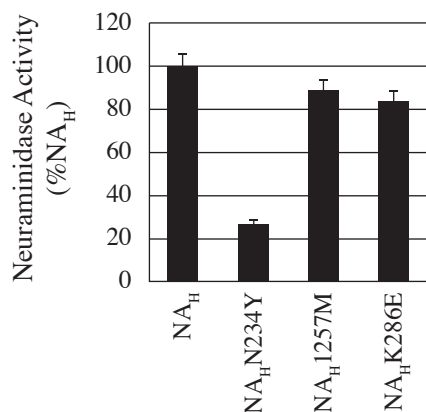
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**Figure 1. Amino acid sequence alignment between NA<sub>H</sub> and NA<sub>A</sub>**

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**Figure 2. Neuraminidase enzyme activity**

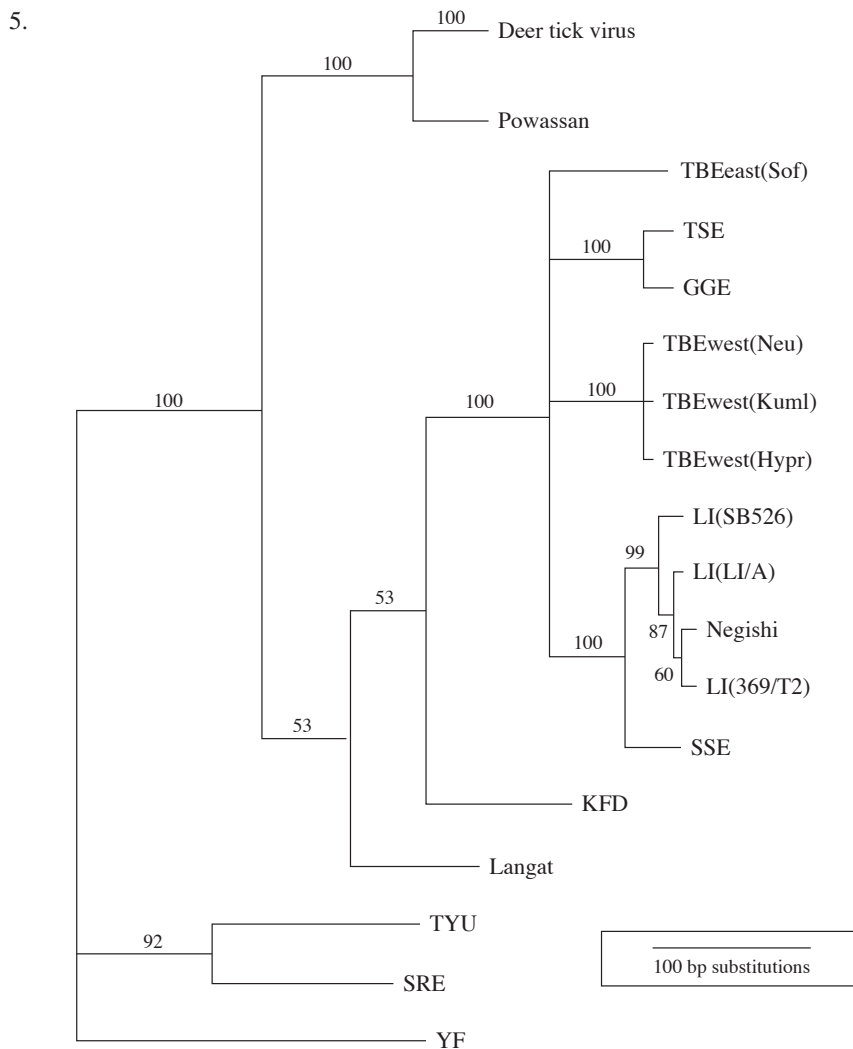


**Figure 3. Neuraminidase activity of NA<sub>H</sub> and NA<sub>H</sub> with mutations**

Point mutations were introduced in the nucleic acid sequence to modify the sequence of NA<sub>H</sub> to make it more like NA<sub>A</sub>. The enzyme activity was assessed.

- (a) **Explain** how changing a single nucleotide can change the sequence of the protein.
  - (b) Given what is known about the neuraminidase enzyme, **describe** what is measured to provide the results in Figure 2 and Figure 3.
  - (c) Will an NA<sub>H</sub> virus with an N234Y substitution be a rapid spreading or slow spreading virus?
  - (d) **Justify** your prediction.
4. The school is growing tomatoes using a hydroponics system. Hydroponics is a way of growing plants in a controlled system without traditional soil containing nutrients. Instead, nutrients that would be supplied by soils are added to water tanks at specific concentrations before the solution is pumped onto the plant root systems. This type of system allows for increased control over nutrient levels and allows for reduced water usage compared to outdoor crops because of minimal evaporation. An out-of-control thermostat in the science wing of the school resulted in a temperature that is known to increase thylakoid permeability to H<sup>+</sup> ions.
- (a) **Identify** which cellular process thylakoids are associated with.
  - (b) **Explain** why ions in the hydroponic tank cannot pass into the roots by simple diffusion.
  - (c) **Predict** the immediate effect this would have on the cell's ability to produce reactants necessary for carbon fixation.
  - (d) **Justify** your prediction.

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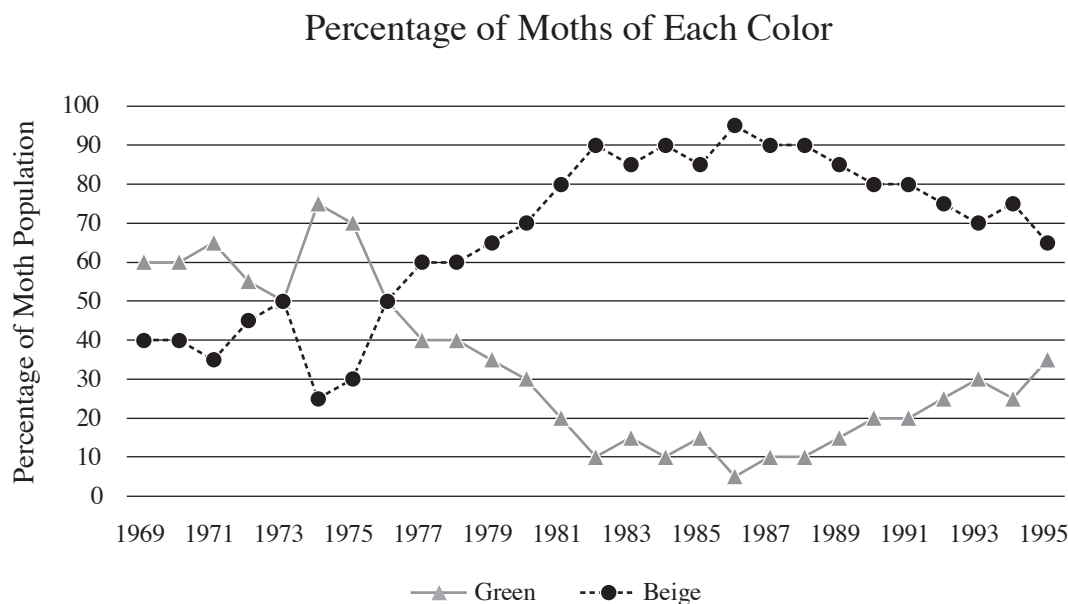
**Figure 1. Phylogenetic tree illustrating the relationship of deer tick virus to other tick-borne encephalitis group viruses**

In Figure 1, the values above branches indicate bootstrapped confidence values. Branch lengths are proportional to percent similarity in viral envelope gene sequence. TBE: tick borne encephalitis; TSE: Turkish sheep encephalitis; GGE: Greek goat encephalitis; LI: louping ill virus; SSE: Spanish sheep encephalitis; KFD: Kyasanur Forest disease virus; TYU: Tyuleniy virus; SRE: Saumarez Reef virus.

- Describe** what is represented by a node in a phylogenetic tree.
- Identify** two of the viruses that are LEAST similar to GGE.
- In 50 years, new data have identified that TBWest(Hypr) is no longer in circulation, but it seems to have evolved in two directions: TBWest1 and TBWest2. Using the empty tree below, correctly **indicate** TBWest(neu), TBWest(Kuml), TBWest1m, and TBWest2.
- This phylogenetic tree was created using nucleotide sequences. If protein sequences were used instead, **explain** why this might increase the similarity between the viruses?

**GO ON TO THE NEXT PAGE.**

6. In a city in Australia there is a population of moths that live in the grass, rarely taking flight except for short journeys. There are two phenotypes for wing color: green and beige. The largest predator of moths are birds and bats that prey upon the moths as they rest upon blades of grass. Green moths fare better in wet conditions when the grass takes on a lush green color and beige moths fare better in dry conditions when the grass turns a dry brown color.



- (a) **Identify** which color moth was the most plentiful between 1969 and 1995?
- (b) **Explain** why the lines of the graph never exceed 100?
- (c) **Predict** during which years there was a drought?
- (d) **Explain** how natural selection led to the rise of the beige moth in the late 1970s?

**STOP**

**END OF EXAM**

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