1. Here is a sketch of a molecule of the sex hormone, testosterone, that is derived from cholesterol.

![Testosterone molecule]

Which of the following statements best describes the action of this hormone on cells of the human gonads?

(A) The hormone acts as the first messenger when it binds to and activates the G protein-coupled receptor on the surface of cells in the testes. This activates the mobile G protein located inside the cell.

(B) The hormone enters cells in the testes by first binding with a membrane receptor, which causes a channel to open in the membrane, allowing the testosterone to flood into the cell.

(C) The hormone readily passes through the cell membrane and binds to a receptor in the cytoplasm. The hormone and receptor then enter the nucleus and act as a transcription factor that turns on one or more genes.

(D) The hormone binds with cAMP on the surface of the cell. Once attached to cAMP, the hormone enters the cell and initiates a signal transduction pathway.
2. Mice are mammals. As such, they are endotherms. They maintain internal heat metabolically. A lizard is an ectotherm and gains its body heat from the environment. Which of the following graphs most accurately depicts this situation?

(A)  
(B)  
(C)  
(D)  

3. Which of the following is a direct result of depolarizing the presynaptic membrane of an axon?

   (A) The postsynaptic cell produces an action potential.
   (B) Synaptic vesicles fuse with the presynaptic membrane.
   (C) Voltage-gated calcium channels in the membrane open.
   (D) Neurotransmitter is released into the synapse.
4. There are two types of enzyme inhibition: competitive and noncompetitive. Competitive inhibitors compete with the substrate for one active site, while noncompetitive inhibitors bind to another part of the enzyme and alter its shape. Malonate is an inhibitor of the respiratory enzyme succinate dehydrogenase in the following reaction.

\[
\text{Succinate dehydrogenase} \\
\text{(enzyme)} \\
\text{Succinate} \rightarrow \text{Malonate} \rightarrow \text{Fumarate} \\
\text{(inhibitor)}
\]

Which of the following choices best describes the best way to determine whether malonate is a competitive or a noncompetitive inhibitor of succinate dehydrogenase?

(A) In the presence of malonate, increase the concentration of succinate, the substrate. If the rate of reaction increases, then malonate is a competitive inhibitor.

(B) In the presence of malonate, increase the concentration of succinate, the substrate. If the rate of reaction increases, then malonate is a noncompetitive inhibitor.

(C) Malonate can alternate between a competitive and noncompetitive inhibitor depending on what is required.

(D) A coenzyme must be affecting the rate of the reaction.

5. Water climate diagrams summarize the climate for a region. Average temperature is shown on the left axis, precipitation on the right axis, and months of the year on the x-axis. Assuming that a major limiting factor for plant growth is availability of water, choose the graph below that depicts the region with the best conditions for plant growth.
6. Here is a graph showing the rate of photosynthesis of a green plant plotted against light intensity.

![Graph showing photosynthesis rate vs. light intensity](image)

Which of the following statements accurately accounts for the shape of the graph?

(A) The rate of photosynthesis stops increasing because chlorophyll molecules begin to decompose due to increased heat, not increased light.
(B) The rate of photosynthesis slows as chlorophyll molecules, which are proteins, denature.
(C) Photosynthesis ceases when protons are no longer released by the photolysis of water.
(D) The rate of photosynthesis increases until the light-harvesting apparatus in the thylakoid membranes become saturated and cannot make use of additional light.

7. The lac operon is found only in prokaryotes and consists of structural genes and a promoter and operator. Which of the following statements explains why we study the lac operon?

(A) It represents a principal means by which gene transcription can be regulated.
(B) It explains how baby mammals utilize lactose from their mothers as they nurse.
(C) It illustrates how RNA is processed after it is transcribed.
(D) It illustrates possible control of the cell cycle and may lead to an understanding of cancer.

8. Here is the simplified equation for photosynthesis:

$$6CO_2 + 12 H_2O \rightarrow C_{6}H_{12}O_{6} + 6H_2O + 6O_2$$

Which of the following choices correctly traces the atom identified with an arrow?

(A) 

$$6CO_2 + 12 H_2O \rightarrow C_{6}H_{12}O_{6} + 6H_2O + 6O_2$$

(B) 

$$6CO_2 + 12 H_2O \rightarrow C_{6}H_{12}O_{6} + 6H_2O + 6O_2$$

(C) 

$$6CO_2 + 12 H_2O \rightarrow C_{6}H_{12}O_{6} + 6H_2O + 6O_2$$

(D) 

$$6CO_2 + 12 H_2O \rightarrow C_{6}H_{12}O_{6} + 6H_2O + 6O_2$$
9. The plasma membrane is selectively permeable and regulates what enters and leaves a cell. It consists of a phospholipid bilayer embedded with proteins. Which of the following statements about the membrane is correct?

(A) Carbon dioxide is a polar molecule and readily diffuses through the hydrophilic layers of the membrane.
(B) Starch readily diffuses across the membrane into the liver, where it is stored as glycogen.
(C) Aquaporins are special water channels in the plasma membrane that facilitate the uptake of large amounts of water without the expenditure of energy.
(D) Oxygen passes through the cristae of mitochondria mainly through ATP synthase channels.

10. Active transport involves the movement of a substance across a membrane against its concentration or electrochemical gradient. Active transport is mediated by specific transport proteins and requires the expenditure of energy. Which of the following statements describes an example of active transport?

(A) Glucose is transported across some membranes by carrier proteins down a concentration gradient.
(B) Freshwater protists such as amoeba and paramecia have contractile vacuoles that pump out excess water.
(C) Countercurrent exchange in the capillaries of fish gills enables fish to absorb large amounts of oxygen from the surrounding water where oxygen levels are low.
(D) A red blood cell will lyse (burst) if placed into a hypotonic solution because large amounts of water flood into the cell.

11. Here is a sketch of an animal cell.

Which of the following statements is correct?

(A) Structure A detoxifies poisons in the cell.
(B) Structure B packages proteins for export.
(C) Structure C synthesizes RNA.
(D) Structure D consists of cytoskeleton.
12. Chronically high levels of glucocorticoids can result in obesity, muscle weakness, and depression. This looks like several diseases but actually is only one, Cushing syndrome. Excessive activity of either the pituitary or the adrenal gland can cause the disease. To determine which gland has abnormal activity in a particular patient, doctors use the drug dexamethasone, a synthetic glucocorticoid that blocks ACTH (adrenocorticotropic hormone) release.

![Bar graph showing cortisol levels in blood for normal patient and patient with Cushing's Syndrome, with dexamethasone treatment highlighted.]

Based on the graph, which gland is affected in the patient with Cushing syndrome and what is the reasoning behind your answer?

(A) The pituitary, because although ACTH is blocked, the pituitary is still sending a signal to the adrenal glands.
(B) The pituitary, because blocking ACTH has no effect on cortisol levels.
(C) The adrenal gland, because the pituitary is prevented from stimulating the adrenal glands, and yet cortisol levels are still high.
(D) The adrenal gland, because the pituitary is sending a signal to the adrenal gland and the adrenal glands have stopped producing cortisol.

13. Here is the final reaction in the citric acid cycle. It shows the regeneration of oxaloacetate.

![Reaction diagram showing the conversion of malate to oxaloacetate with the involvement of malate dehydrogenase and NAD+ and NADH.]

After studying the reaction, determine which of the following statements is correct.

(A) The enzyme malate dehydrogenase is allosteric.
(B) The reaction is exergonic; the released energy is absorbed by NAD⁺.
(C) The reaction is a reduction reaction.
(D) NAD⁺ is oxidized into NADH.
14. Which of the following statements about the DNA in one of your liver cells is correct?

(A) Your liver cells contain the same DNA as your white blood cells.
(B) Most of the DNA in your liver cells will be transcribed but not translated.
(C) Most of the DNA in your liver cells will be transcribed in the nucleus and translated in the cytoplasm.
(D) DNA in your liver cells contains genes unique to storing glycogen, while other cells do not contain those genes.

15. Two genes (B and E) determine coat color in Labrador retrievers. Alleles B and b code for how much melanin is present. The dominant allele B codes for black fur, the recessive allele b codes for brown hair. A second gene consisting of two alleles, E and e, codes for the deposition of pigment in the hair. In this case, the alleles for pigment deposition (E or e) are said to be epistatic to the gene that codes for black or brown pigment. If the dominant allele (B) is not present, regardless of the genotype at the black/brown locus, the animal’s fur will be yellow.

Which of the following statements is correct about the genetics of coat color in Labradors?

(A) BBee will be brown.
(B) BbEe will be brown.
(C) Bbee will be brown.
(D) BBee will be yellow.

16. Within a cell, the amount of protein synthesized using a given mRNA molecule depends in part on which of the following?

(A) DNA methylation suppresses the expression of genes.
(B) Transcription factors mediate the binding of RNA polymerase and the initiation of transcription, which will determine how much protein is manufactured.
(C) The speed with which mRNA is degraded will determine how much protein is synthesized.
(D) The location and number of ribosomes in a cell will solely determine how much protein is synthesized.
17. Oxygen is carried in the blood by the respiratory pigment hemoglobin, which can combine loosely with four oxygen molecules, forming the molecule oxyhemoglobin. To function properly, hemoglobin must bind to oxygen in the lungs and drop it off at body cells. The more easily the hemoglobin binds to oxygen in the lungs, the more difficult the oxygen is to unload at the body cells. Here is a graph showing two different saturation-dissociation curves for one type of hemoglobin at two different pH levels.

Based on your knowledge of biology and the information in this graph, which statement about the hemoglobin curves is correct?

(A) Hemoglobin B has a greater affinity for oxygen and therefore binds more easily to oxygen in the lungs.

(B) Hemoglobin A is characteristic of a mammal that evolved at sea level where oxygen levels are high.

(C) In an acidic environment, hemoglobin drops off oxygen more easily at body cells.

(D) Hemoglobin A is found in mammals with a higher metabolism.

18. Banana plants, which are triploid, are seedless and therefore sterile. Which is the most likely explanation for this phenomenon?

(A) Because they are triploid, bananas cannot generate gametes because homologous pairs cannot line up during meiosis.

(B) Because they are triploid, there are no male or female banana plants.

(C) Because they are triploid, bananas cannot generate homologous pairs during mitosis.

(D) Because they are triploid, bananas cannot carry out crossing-over.
19. Animals maintain a minimum metabolic rate for basic functions such as breathing, heart rate, and maintaining body temperature. The minimum metabolic rate for an animal at rest is the basal metabolic rate (BMR). The BMR is affected by many factors, including whether an animal is an ectotherm or endotherm; its age and sex; and size and body mass. Here is a graph that shows the relationship of BMR per kilogram of body mass to body size for a group of mammals.

Which statement correctly describes the relationship between BMR and body mass?

(A) The relationship between BMR and body mass is a direct one. The larger the body mass, the higher the BMR is and the greater the breathing rate is.
(B) The relationship between BMR and body mass is a direct one. The larger the body mass, the higher the BMR is and the lower the breathing rate is.
(C) The relationship between BMR and body mass is inversely proportional. The larger the body mass, the lower the BMR is and the lower the breathing rate is.
(D) The larger the animal, the faster the heart rate and breathing rate both are.
20. Here is a graph that depicts a first exposure to antigen \( A \) on Day 1 with a subsequent, primary immune response. A second exposure to antigen \( A \) on Day 30 results in a secondary immune response due to the presence of circulating memory cells that release antibodies against antigen \( A \). There is also a first exposure to antigen \( B \) on Day 30.
Which of the following graphs accurately depicts the immune response to antigen B and the reason for it?

(A) Graph A. The primary response to antigen B is almost as fast and large as the secondary immune response to antigen A because the entire immune system was activated by the first exposure to antigen A.

(B) Graph B. Immune responses are specific. The fact that there was an earlier exposure to antigen A has no bearing on the response to antigen B on Day 30.

(C) The response to antigen B on Day 30 is larger than the secondary immune response to antigen A because the immune system has already been activated and all new responses are heightened.

(D) There is almost no immune response to antigen B because the immune system is fully engaged in a secondary response to antigen A.
21. Incomplete dominance and epistasis are two terms that define genetic relationships. Which of the following statements best describes the differences or similarities between the two terms?

(A) Both terms describe inheritance controlled by the interaction of multiple alleles at different loci.
(B) Both terms describe inheritance controlled by the interaction of multiple genes at different loci.
(C) Incomplete dominance describes the interaction of two genes at different loci; epistasis describes the interaction of two alleles.
(D) Incomplete dominance describes the interaction of two alleles on one gene; epistasis describes the interaction of two genes and their respective alleles.

22. Before the human genome was sequenced by the Human Genome Project, scientists expected that they would find about 100,000 genes. In fact, they discovered that humans have only about 24,000 genes. How can we exhibit so many different traits from so few genes?

(A) Modification of histone proteins usually increases the function of genes.
(B) Epigenetics enables one gene to produce many different traits.
(C) This is proof that pseudogenes and introns are expressed.
(D) A single gene can produce more than one trait because of alternative splicing.

23. Which of the following statements about the light-dependent reactions of photosynthesis is correct?

(A) They provide the carbon that becomes incorporated into sugar.
(B) They produce PGA, which is converted to glucose by carbon fixation in the light-independent reactions.
(C) Water is split apart, providing hydrogen ions and electrons to NADP for temporary storage.
(D) They occur in the stroma of chloroplasts.

24. The acrosome and cortical reactions that occur immediately after fertilization ensure which of the following?

(A) The sperm will fertilize the ovum.
(B) The zygote will begin to divide normally.
(C) One and only one sperm will fertilize the egg.
(D) The zygote will not divide into two embryos, producing twins.

25. Which aspects of cell structure best reveals the unity of all life?

(A) All cells are surrounded by a plasma membrane.
(B) All cells have at least one nucleus.
(C) All cells carry out cellular respiration in mitochondria.
(D) The surface-to-volume ratio of all cells is the same.
26. Refer to the codon table for the following question.

Here is a small stretch of mRNA that would be translated at the ribosome:

...AUG CUG UAA UCA GGG...

Suppose a spontaneous mutation altered the boldface A and changed it to a U. What effect, if any, would this have on the protein formed?

(A) Because of redundancy in the code, there would be no change in the protein formed.
(B) The amino acid sequence formed from this stretch of DNA would be Met-Leu-Lys-Ser-Gly.
(C) The polypeptide would not form because translation would stop at UAA.
(D) Translation would continue and a polypeptide would form because AUG codes for start as well as for methionine.

27. Stretching out from the equator is a wide belt of tropical rain forests that are being cut down to provide exotic woods for export to the U.S. and to make land available to graze beef cattle. Which of the following statements is a negative consequence of clear-cutting the tropical rain forests?

(A) Indigenous populations will have access to modern conveniences.
(B) There will be less precipitation in those clear-cut areas.
(C) U.S. markets will have access to less expensive beef.
(D) Deforestation will allow more sunlight to penetrate areas that were kept dark by dense vegetation.
28. Mosquitoes resistant to the pesticide DDT first appeared in India in 1959 within 15 years of widespread spraying of the insecticide. Which of the following statement best explains how the resistant mosquitoes arose?

(A) Some mosquitoes experienced a mutation after being exposed to DDT that made them resistant to the insecticide. Then their population expanded because these mosquitoes had no competition.

(B) Some mosquitoes were already resistant to DDT when DDT was first sprayed. Then their population expanded because all the susceptible mosquitoes had been exterminated.

(C) DDT is generally a very effective insecticide. One can only conclude that it was manufactured improperly.

(D) Although DDT is effective against a wide range of insects, it is not effective against mosquitoes.

29. DNA sequences in many human genes are very similar to the corresponding sequences in chimpanzees. Which statement gives the most likely explanation of this fact?

(A) Humans evolved from chimpanzees millions of years ago.

(B) Chimpanzees evolved from humans millions of years ago.

(C) Humans and chimpanzees evolved from a recent common ancestor—about 6 million years ago.

(D) Humans and chimpanzees evolved from a distant common ancestor about 4 billion years ago.

Questions 30 and 31

Two ecologists, Peter and Rosemary Grant, spent thirty years observing, tagging, and measuring finches (a type of bird) in the Galápagos Islands. They made their observations on Daphne Major—one of the most desolate of the Galápagos Islands. It is an uninhabited volcanic cone where only low to the ground cacti and shrubs grow. During 1977, there was a severe drought and seeds of all kinds became scarce. The small, soft seeds were quickly eaten by the birds, leaving mainly large, tough seeds that the finches normally ignore. The year after the drought, the Grants discovered that the average width of the finches' beak had increased.
30. Which of the following statements best explains the increase in beak size?

(A) Finches with bigger and stronger beaks were able to attack and kill the finches with smaller beaks.
(B) Finches with bigger beaks were larger animals with stronger wings that could fly to other islands and gather a wide variety of seeds.
(C) During the drought, the finches’ beaks grew larger to accommodate the need to eat tougher seeds.
(D) Finches with larger beaks were able to eat the tougher seeds and were healthier and reproduced more offspring that inherited the trait for wider beaks.

31. Which of the following statements best explains the mechanism behind the change in beak size?

(A) A new allele appeared in the finch population as a result of a mutation.
(B) A change in the frequency of a gene was due to selective pressure from the environment.
(C) A new trait appeared in the population because of recombination of alleles.
(D) A new trait appeared in the population because of genetic drift.

Questions 32 and 33

Answer the following two questions based on this pedigree for the biochemical disorder known as alkaptonuria. Affected individuals are unable to break down a substance called alkapton, which colors the urine black and stains body tissues. Otherwise, the condition is of no consequence. Males are shown as squares, females as circles. Afflicted individuals are shown in black. If there is a carrier condition, it is not displayed.

![Pedigree Diagram]

32. Which of the following best states the pattern of inheritance shown in the pedigree?

(A) The trait is sex-linked dominant.
(B) The trait is sex-linked recessive.
(C) The trait is autosomal dominant.
(D) The trait is autosomal recessive.
33. Which of the following statements is supported by the information given in the pedigree?

(A) The P generation mother is X-X.
(B) The P generation father is X-Y.
(C) If parents 1 and 2 in row II have another child, the chance that the child would be afflicted with alkaptonuria is 25%.
(D) The genotype of woman 1 is X-X.

34. Sea otters in the North Pacific are a keystone species. That means they are not abundant in a community. However, they do exert major control over other species in the community. Here is a food chain in which the sea otter is a keystone species.

Kelp → Sea urchin → Sea otter → Orca

Here are two graphs showing the populations of sea otters and sea urchins from 1970 to 2000.

In the late 1990s, orcas, which are active hunters of sea otter, moved into the area. Which of the following graphs correctly shows the kelp population from 1970 to 2000?
Questions 35–36

Four vials were set up to investigate bacterial transformation. Vials 1 and 2 each contained *E. coli* bacteria that had been made competent and had then been mixed with a plasmid containing the gene for ampicillin (pAMP) resistance. Vials 3 and 4 both contained *E. coli* that had also been made competent but had not been mixed with a plasmid. Each vial of bacteria was poured onto a nutrient agar plate. Vials 1 and 3 were poured onto plates that contained the antibiotic ampicillin. Vials 2 and 4 were poured onto plates that did not contain ampicillin.

This figure shows what the nutrient agar plates looked like. The shaded plates represent extensive growth, and the dots represent individual bacterial colonies.

35. Plates that have only ampicillin-resistant bacteria growing on them include which of the following?
   (A) Plate 1 only
   (B) Plate 2 only
   (C) Plate 3 only
   (D) Plates 1 and 3 only

36. Which of the following statements explains why there was no growth on Plate 3?
   (A) The heat shock technique to make the *E. coli* competent killed the bacteria.
   (B) Those particular *E. coli* bacteria were inhibited from growing by the nutrient in the agar.
   (C) Those bacteria were not transformed.
   (D) The bacteria culture died because they have a short life span.

37. Which of the following statements best explains why there were fewer colonies on Plate 1 than on Plate 2?
   (A) The bacteria on Plate 2 did not transform.
   (B) There was no antibiotic in the agar in Plate 2 that would have restricted growth of bacteria.
   (C) The transformation of bacteria on Plate 2 was more successful.
   (D) The bacteria on Plates 1 and 2 were not taken from the same culture.
38. In a variant of this experiment, the plasmid contained GFP (green fluorescent protein) in addition to ampicillin resistance. Which of the following plates would have the highest percentage of bacteria that would fluoresce?

(A) Plate 1 only
(B) Plate 2 only
(C) Plate 3 only
(D) Plate 4 only

39. Here is a sketch of a neuromuscular junction in a patient with an autoimmune disease. Acetylcholine (ACh) is the stimulatory neurotransmitter.

Which of the following predicts what will happen in the continued presence of the antibodies?

(A) Ca²⁺ ions will flood into the motor neuron ending, increasing the release of more ACh.
(B) The amount of neurotransmitter being released will decrease.
(C) The number of action potentials in the motor neuron will decrease.
(D) Antibodies will destroy the postsynaptic receptors, and the muscle response will diminish.
40. Which cell type is most likely involved in storage?

(A)  

(B)  

(C)  

(D)  

41. In 1953, Stanley Miller, while working under the guidance of Harold Urey at the University of Chicago, carried out a series of experiments with substances that mimicked those of early Earth. His experimental setup yielded a variety of amino acids that are found in organisms alive on Earth today. The purpose of these experiments best supports which of the following hypotheses?

(A) The basic building blocks of life originated in outer space and came to Earth carried by comets or meteorites.
(B) The molecules necessary for life to develop were located in deep-sea vents.
(C) The molecules necessary for life to develop could have formed under the conditions of the early Earth.
(D) The molecules necessary for life on Earth were self-replicating proteins, just like the ones produced in Miller’s experiments.
42. The graph on the left (A) shows an absorption spectrum for chlorophyll a extracted from a plant. The graph on the right (B) shows an action spectrum from a living plant, with wave lengths of light plotted against the rate of photosynthesis as measured by release of oxygen.

Which statement best explains the difference between the two spectra?

(A) Graph A plots the absorption spectrum of a red plant; graph B plots an absorption spectrum for a green plant.

(B) The chlorophyll from Graph A cannot carry out the light-dependent reactions; but the chlorophyll in graph B can.

(C) The data from Graph A characterize several photosynthetic pigments that reflect almost no light; the data from Graph B characterize chlorophyll a, which reflects only green light.

(D) Graph A shows an absorption spectrum for an unusual type of chlorophyll a.
Cystic fibrosis is the most common inherited disease in the U.S. Among people of European descent, 4% are carriers of the recessive cystic fibrosis allele. The most common mutation in individuals with cystic fibrosis is a mutation in the CFTR protein that functions in the transport of chloride ions between certain cells and extracellular fluid. These chloride transport channels are defective or absent in the plasma membranes of people with the disorder. The result is abnormally high concentration of extracellular chloride that causes the mucus that coats certain cells to become thicker and stickier than normal. Mucus builds up in the pancreas, lungs, digestive tract, and other organs. This leads to multiple effects, including poor absorption of nutrients from the intestines, chronic bronchitis, and recurrent bacterial infections.

43. Scientific work has been carried out to measure where the relative amounts of CFTR protein are localized in the affected cells.

![Bar graph showing CFTR protein amounts in normal and CF cells]

After studying the graph, which of the following statements about CFTR protein is correct?

(A) Transcription is not occurring.
(B) Translation is not occurring.
(C) CFTR protein does not fold properly after it is synthesized.
(D) CFTR protein is not being packaged in the cytoplasm.

44. From the description of cystic fibrosis above, which of the following statements is correct?

(A) The disease is similar to cancer in that it has both an environmental and a genetic cause.
(B) Cystic fibrosis is an example of a genetic disease caused by polygenic inheritance because several genes must be mutated in order for the disease to occur.
(C) Cystic fibrosis is an example of pleiotropy because one mutated gene causes multiple effects.
(D) A person who has one cystic fibrosis allele will have the disease.
45. Referring to the simplified reaction of cellular respiration shown here, which of the following statements is correct?

\[ C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy} \]

(A) \( C_6H_{12}O_6 \) is reduced.
(B) \( O_2 \) is reduced.
(C) \( CO_2 \) is reduced.
(D) \( H_2O \) is reduced.

46. Based on the cladogram, which of the following is NOT true?

(A) Only some tetrapods have amnions.
(B) Mammals and amphibians are more closely related than mammals and birds.
(C) Ancestor 2 lived before ancestor 3; but we do not know when that was.
(D) Lungfishes and amphibians share a common ancestor.

47. On Andros Islands in the Bahamas, populations of mosquito fish, *Gambusia hubbii*, colonized a series of ponds. These ponds are no longer connected. However, the environments are very similar except that some ponds contain predatory fish, while others do not. In high predation ponds, selection has favored the evolution of a body shape that enables rapid bursts of speed. In low predation ponds, another body type is favored—one that is well-suited to swim for long periods of time.

When scientists brought together sample mosquito fish from the two types of ponds, they found that the females mated only with males that had the same body type as their own. Which of the following statements best describes what happened to the mosquito fish as evidenced by the mating choice in the female fish?

(A) Reproductive isolation caused geographic isolation.
(B) Reproductive isolation was not complete.
(C) Allopatric isolation brought about reproductive isolation.
(D) Sympatric isolation brought about reproductive isolation.
48. From 1972 to 2004, researchers studying the greater prairie chicken observed that a population collapse mirrored a reduction in fertility as measured by the hatching rate of eggs. Comparison of DNA samples from the Jasper County, Illinois, population with DNA from feathers in a museum collection showed that genetic variation had declined in the studied population. The researchers translocated prairie chickens from Minnesota, Kansas, and Nebraska into the Illinois prairie chicken population in 1992 and found that the hatching rate in Illinois prairie chickens changed. Here is a graph of the data.

![Graph showing hatching rate (%) over time, with a peak labeled Translocation.]

Which of the following statements most accurately explains what happened to the studied population of prairie chickens after translocation and why?

(A) The hatching rate increased because genetic variation declined.
(B) The hatching rate increased because genetic variation increased.
(C) The hatching rate decreased because genetic variation decreased.
(D) The hatching rate decreased because the translocated animals were invasive and grew to dominate the population.

49. Which of the following statements about the immune system is NOT correct?

(A) A lymphocyte has receptors for many different antigens.
(B) An antigen can have different epitopes.
(C) Dendritic cells are antigen-presenting cells.
(D) T cells attack infected body cells.
50. In a study of dusty salamanders, *Desmognathus ochrophaeus*, scientists brought individuals from different populations into the laboratory and tested their ability to mate and produce viable, fertile offspring. Here is the graph of the data.

The degree of reproductive isolation is represented by an index ranging from 0 (no isolation) to 2 (complete isolation).

Which of the following statements best describes the evolutionary history of dusty salamanders?

(A) Mutation alone caused the two populations to diverge.
(B) Both mutation and genetic drift cause the two populations to diverge.
(C) Both mutation and genetic drift caused the two populations to become separate species after they were separated by great distance.
(D) Reproductive isolation between the two populations increases as the distance between them increases.

51. Which of the following statements best describes what a Barr body is and its significance?

(A) It is an inactivated Y chromosome and results in a man being sterile.
(B) It is an inactivated Y chromosome, and the person who has it appears female.
(C) It is an inactivated X chromosome and results in females with half their cells having one X inactivated and the other half of their cells having the other X inactivated.
(D) It is an inactivated X chromosome and results in females who are sterile.
52. Scientists carried out a series of experiments to study innate immunity in fruit flies. They began with a mutant fly strain in which a pathogen is recognized but the signaling that would normally trigger an innate response is blocked. As a result, the flies did not make any antimicrobial peptides (AMP). The researchers then genetically engineered some of the mutant flies to express significant amounts of a single AMP, either defensin or drosomycin. They then infected the flies with a fungus, Neurospora crassa, by shaking anesthetized flies for 30 seconds in a Petri dish containing a sporulating fungal culture. The 6-day survival rate was monitored and recorded.

Here is a graph displaying some data from the experiment.

KEY:
A Wild type
B Mutant + drosomycin
C Mutant + defensin
D Mutant

Which of the following statements is supported by the data?

(A) Each AMP provided minimal immunity against fungal infection.
(B) Both AMPs provided better immunity than did either one alone.
(C) Drosomycin provided immunity against the fungal infection.
(D) There was no control in this experiment.
Questions 53–54

An experiment was carried out with guppies, which are brightly colored, popular, aquarium fish. Three hundred guppies were added to 12 large pools. Cichlids, a voracious predator, were added to 4 of the pools. Killifish that rarely eat guppies were added to 4 other pools. No other fish were added to the last 4 pools. After 16 months, a time period that represents 10 generations for guppies, all the guppies were analyzed for size and coloration. Here are the data.

![Graph showing guppy coloration over time with options: Guppies with killifish, Guppies alone, Guppies with cichlids]

53. Which of the following statements is supported by the data?

(A) Cichlids were an agent of selection, eating the more visible, brightly colored guppies.

(B) Killifish were an agent of selection, eating the more visible, brightly colored guppies.

(C) Guppies, as a group, experienced change in coloration, from brightly colored to dull in order to survive.

(D) Individual guppies experienced a mutation that caused a change in coloration and enabled them to avoid being eaten.

54. Which of the following statements best expresses the point of this experiment?

(A) Mutations can be brought about by the environment.

(B) Mutations occur randomly.

(C) Agents of selection are not always readily apparent.

(D) Evolution does not always require millions of years.

55. In the Tularosa Basin of New Mexico are black lava formations surrounded by light-colored sandy desert. Pocket mice inhabit both areas. Dark-colored ones inhabit the lava formations, while light-colored mice inhabit the desert. Which of the following statements is correct about this scenario?

(A) The two varieties of mice descended from a recent common ancestor.

(B) The mouse population was originally one population that diverged into two species because of mutations.

(C) Selection favors some phenotypes over others.

(D) Originally the mice were all dark colored. As the lava decomposed into sand, the color of some mice changed because that color was favored in that environment.
56. What is the best explanation for the fact that tuna, sharks, and dolphins all have a similar streamlined appearance?
   (A) They all share a recent common ancestor.
   (B) They all sustained the same set of mutations.
   (C) They acquire a streamlined body type to survive in their particular environment.
   (D) The streamlined body has a selective advantage in that environment.

57. Which of the following statements is NOT correct about lipids?
   (A) Lipids consist of fatty acids and glycerol.
   (B) Steroids are examples of lipids.
   (C) The molecules of a saturated fatty acid are packed so close together that they form a solid at room temperature.
   (D) The head of a phospholipid is hydrophobic, and the tails are hydrophilic.

Questions 58–59

Here is a sketch of prokaryotic DNA undergoing replication and transcription simultaneously.

58. If 1 is thymine, what is α?
   (A) Adenine
   (B) Thymine
   (C) Cytosine
   (D) Uracil

59. If 4 is adenine, what is D?
   (A) Adenine
   (B) Thymine
   (C) Cytosine
   (D) Uracil
60. Yeast cells carry out both aerobic and anaerobic respiration. A yeast cell that is fed on glucose is moved from an aerobic to an anaerobic environment. Which of the following statements is correct and gives the correct reason for it?

(A) The cell dies because it cannot make ATP.
(B) The cell would need to consume glucose at a much greater rate because aerobic respiration is much more efficient as compared with anaerobic respiration.
(C) The cell would need to consume another food source other than glucose because it will not be able to make adequate ATP with only glucose.
(D) The cell will begin to divide rapidly because larger cells require more oxygen and glucose than smaller ones.

Questions 61–62

Intact chloroplasts are isolated from dark-green leaves by low-speed centrifugation and are placed into six tubes containing cold buffer. A blue dye, DPIP, which turns clear when reduced, is also added to all the tubes. Then each tube is exposed to different wavelengths of light. A measurement of the amount of decolorization is made, and the data are plotted on a graph. Although the wavelengths of light vary, the light intensity is the same.

![Graph showing the measurement of color change with different wavelengths of light.]

61. Which statement below best describes the results of the experiment?

(A) The lower the wavelength of light, the greater the rate of photosynthesis.
(B) The highest wavelengths of light provide the fastest rate of photosynthesis.
(C) The highest rate of photosynthesis results from exposure to two different wavelengths of light.
(D) The greatest reduction in DPIP occurs at 550 nm light intensity.
62. What is the best explanation for the results in Question 61?

(A) 650 nm and 700 nm of light have the greatest penetrating power.
(B) The photosynthetic pigments in the experiment do not absorb light in the 650 nm and 700 nm range.
(C) Only wavelengths of 650 nm and 700 nm are reflected by the chlorophyll.
(D) The chloroplasts have two photosystems that absorb light in different wavelengths.

63. A group of scientists wished to learn about the energy efficiency of different modes of locomotion. They studied the literature that was based on accurate measurements and produced this graph based on the data they analyzed.

![Graph showing energy cost vs. body mass for different modes of locomotion: Flying, Running, and Swimming.]

Which of the following statement accurately describes what the scientists discovered?

(A) An animal with a large body mass expends more energy per kilogram of body mass than a small animal, regardless of the type of locomotion.
(B) Swimming has to overcome drag as well as gravity.
(C) Running is the least energy-efficient means of locomotion.
(D) The best parameter to measure in this type of experiment is CO₂ consumption.
1. A female fruit fly hybrid for both gray body (Gg) and normal wings (Nn) is crossed with a male with black body (gg) and vestigial wings (nn): GgNn × ggnn

The F1 results of the cross are shown in the chart below.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gray normal</td>
<td>Black vestigial</td>
<td>Gray vestigial</td>
<td>Black normal</td>
</tr>
<tr>
<td>969</td>
<td>941</td>
<td>190</td>
<td>184</td>
<td></td>
</tr>
</tbody>
</table>

Given the data above, calculate the rate of cross-over that produced the gray vestigial and black normal offspring. Give your answer to the nearest tenth.

2. A student crossed a purple dahlia with a yellow dahlia and found that all the offspring produced purple-flowers. She then crossed those purple-flowered offspring (F1) and produced 350 plants. Of their offspring (F2), 101 produced yellow flowers and 249 produced purple flowers. Calculate the chi-squared value for the null hypothesis that the purple-flowered F1 plants were all hybrid. Give your answer to the nearest tenth.

3. Here is a graph that shows a growth curve for a population of bacteria.

![Graph showing population growth over time]

Calculate the mean rate of population growth between day 2 and day 4. Give your answer to the nearest whole number.
4. In a certain population of birds, the allele for a crown on the head (C) is dominant to the allele for no crown on the head (c). A particularly cold and long winter favored the birds with no crown. When spring came, researchers determined that the population was currently in Hardy-Weinberg equilibrium and that the occurrence of the birds with no crown was up to 24%. What will the frequency of the no-crown allele be in 10 years? Give your answer to the nearest hundredth.

5. Here is the volume of the world's water supply ($\times 1,000 \text{ km}^3$). Our drinking water comes from the freshwater located in groundwater, lakes, ice sheets, glaciers, and rivers.

<table>
<thead>
<tr>
<th>Source</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceans, seas, and bays</td>
<td>1,338,000</td>
</tr>
<tr>
<td>Ice sheets and glaciers</td>
<td>24,064</td>
</tr>
<tr>
<td>Groundwater</td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td>23,400</td>
</tr>
<tr>
<td>Saline</td>
<td>(10,530.)</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>16.5</td>
</tr>
<tr>
<td>Ground ice and Permafrost</td>
<td>300.</td>
</tr>
<tr>
<td>Lakes</td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td>176.4</td>
</tr>
<tr>
<td>Saline</td>
<td>(91.0)</td>
</tr>
<tr>
<td>Saline</td>
<td>(85.4)</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>12.9</td>
</tr>
<tr>
<td>Swampwater</td>
<td>11.47</td>
</tr>
<tr>
<td>Rivers</td>
<td>2.12</td>
</tr>
<tr>
<td>Biological water</td>
<td>1.12</td>
</tr>
<tr>
<td>Total</td>
<td>1,385,984</td>
</tr>
</tbody>
</table>

What percentage of all the water on Earth is freshwater? Give your answer in percent to the tenths place.
6. Here is a sketch that shows Earth’s water cycle including the oceans and continents. Assuming that total precipitation equals total evaporation, what is the value of evaporation from the land to the atmosphere?

**Earth’s Water Cycle**

- **Continental atmosphere**
  - 45 x 10^15 kg
  - Evaporation: ?
  - Precipitation: 107 x 10^15 kg/yr

- **Air flow**
  - 36 x 10^15 kg/yr

- **Maritime atmosphere**
  - 11 x 10^15 kg
  - Evaporation: 434 x 10^15 kg/yr
  - Precipitation: 396 x 10^15 kg/yr

- **Land**
  - Ice and snow: 43,400
  - Surface water: 360
  - Underground water: 15,300
  - Biota: 2
  - Total: 59,000 x 10^15 kg

- **River runoff**
  - 36 x 10^15 kg/yr

- **Oceans**
  - Mixed layer: 50,000
  - Thermocline: 460,000
  - Abyssal: 890,000
  - Total: 1,400,000 x 10^15 kg

**Key:**
- Reservoirs of water in 10^15 kg = boxes
- Flow of water in 10^15 kg/yr = arrows
SECTION II
8 Free-Response Questions
Time: 90 minutes

8 FREE-RESPONSE QUESTIONS

Directions: The first two questions are long, free-response questions. Spend about 20 minutes answering each. Questions 3 through 8 are short, free response questions. Take about 6 minutes answering each. Write your response on a separate piece of paper and ask your teacher to "grade" it.

1. Cells communicate with each other using a complex process that involves signals, receptors, and pathways. Discuss the different ways in which cells send signals to each other. Include the following:
   (a) Different types of signals based on distance from a signal's origin
   (b) Different types of receptors
   (c) What constitutes a cellular response
   (d) What the signal transduction pathway says about the evolution of cell communication

2. Terrestrial biomes are diverse. They are controlled by the climate.
   (a) Describe the difference between climate and weather.
   (b) Describe one biome. Give its location on Earth and characterize the organisms that live there.
   (c) Describe how a disturbance might affect this biome and how it might reconstitute itself.
   (d) Give an example of how a geographic cline might affect the evolution of an organism.

3. Name two properties of a eutrophic lake.

4. Many organisms live in estuaries and experience both freshwater and saltwater conditions every day as the water rises and falls with the tides. Explain how changing salinity levels challenge the survival of the organisms.

5. It is now known that very little of the human genome actually codes for proteins. Briefly explain how microRNAs, also called miRNA, relate to this.

6. Explain and give one example of stabilizing selection.

7. Give two differences between innate and adaptive immunity.

8. Explain why a poison that inhibits an enzyme in the Calvin cycle would also inhibit the light-dependent reactions.