While you have taken many standardized tests and know to blacken completely the ovals on the answer sheets and to erase completely any errors, the instructions for the SAT II exam in Biology differs from the directions for other standardized tests you have taken. You need to indicate on the answer key whether you are taking the SAT II Biology with Ecological Emphasis (Biology-E) or Molecular Emphasis (Biology-M).

The instructions on the answer sheet will tell you to fill out the top portion of the answer sheet exactly as shown.

1. Print **BIOLOGY-E** or **BIOLOGY-M** on the line to the right under the words **Subject Test (print)**.

2. In the shaded box labeled **Test Code** fill in four ovals:
   - For **BIOLOGY-E**
     - Fill in oval 1 in the row labeled V.
     - Fill in oval 9 in the row labeled W.
     - Fill in oval 4 in the row labeled X.
     - Fill in oval B in the row labeled Y.
     - Leave the ovals in row Q blank.
   - For **BIOLOGY-M**
     - Fill in oval 1 in the row labeled V.
     - Fill in oval 9 in the row labeled W.
     - Fill in oval 4 in the row labeled X.
     - Fill in oval B in the row labeled Y.
     - Leave the ovals in row Q blank.

3. When everyone has completed filling in this portion of the answer sheet, the supervisor will tell you to turn the page and begin. The answer sheet has 100 numbered ovals on the sheet, but there are only 90 (or 95) multiple-choice questions in the test, so be sure to use only ovals 1 to 90 (or 95) to record your answers.
Directions: Each of the questions or statements below is accompanied by five choices. For each question, select the best of the answer choices given.

Questions 1–3 refer to the following cellular structures:

(A) ribosome
(B) nucleus
(C) chloroplast
(D) mitochondria
(E) endoplasmic reticulum

1. Structure found in plant cells but not animal cells.
2. Structure that functions as the site of protein synthesis in cells.
3. Structure that contains the codes for the specific proteins produced by a cell.

Questions 4–6 refer to the following processes:

(A) protein synthesis
(B) respiration
(C) digestion
(D) photosynthesis
(E) fermentation

4. The process by which both plants and animals obtain energy for cellular function.
5. The process that allows higher plants to be autotrophic (able to manufacture their own food).
6. The process that leads to the production of ethyl alcohol or lactic acid.
7. Which of the groups below represents the correct relationship in order from smallest (or simplest) to largest (or more complex)?
(A) matter — element — compound — electron — atom
(B) electron — element — atom — compound — matter
(C) electron — atom — element — matter — compound
(D) electron — atom — element — compound — matter
(E) atom — electron — element — compound — matter

8. Which of the following pairs does NOT represent a correct relationship?
(A) glucose; polysaccharide
(B) starch; polysaccharide
(C) starch; carbohydrate
(D) glucose; carbohydrate
(E) glucose; monosaccharide

9. Which of the following statements is correct?
(A) The product of transcription is DNA.
(B) The product of transcription is mRNA.
(C) The product of transcription is a protein.
(D) The product of translation is mRNA.
(E) The product of translation is DNA.

10. Which of the following descriptions of a DNA molecule is NOT correct?
(A) Synthesis is semiconservative.
(B) Opposite strands are antiparallel.
(C) It contains the sugar deoxyribose.
(D) The number of adenines present is roughly equal to the number of thymines.
(E) The number of cytosines present is roughly equal to the number of uracils.

11. What defines the Sahara Desert as a desert?
(A) It is characterized by very hot temperatures.
(B) The growing season is very short.
(C) Cacti make up the dominant form of vegetation.
(D) It is very dry.
(E) The average temperature fluctuates very little between winter and summer.
12. Which of the following represents the correct sequence, from simplest to most complex?
   (A) population — organism — community — ecosystem — biosphere
   (B) organism — population — community — ecosystem — biosphere
   (C) organism — population — community — biosphere — ecosystem
   (D) population — organism — community — biosphere — ecosystem
   (E) organism — community — population — ecosystem — biosphere

13. Lichens are composed of both fungal and algal (or cyanobacterial) components. The fungal component absorbs water and nutrients for both organisms, while the algal component manufactures food for both organisms through photosynthesis. This type of symbiotic relationship is referred to as
   (A) parasitism.
   (B) commensalism.
   (C) predation.
   (D) mutualism.
   (E) interspecific competition.

14. In the Eastern United States, many forested areas were cleared for agricultural purposes. If cultivation was abandoned in those areas, they would eventually return to forests. This is an example of
   (A) primary succession.
   (B) secondary succession.
   (C) decomposition.
   (D) interspecific competition.
   (E) eutrophication.

15. What trophic level is represented by the snake?
   (A) producer
   (B) primary consumer
   (C) secondary consumer
   (D) tertiary consumer
   (E) detritivore

16. The hawk could eat either the snake or the mouse and, thus, could represent which two different levels of the food chain?
   (A) producer and primary consumer.
   (B) primary and secondary consumer.
   (C) secondary and tertiary consumer.
   (D) tertiary and quaternary consumer.
   (E) quaternary consumer and detritivore.

17. Which organism in the food chain represents a detritivore?
   (A) earthworm
   (B) hawk
   (C) snake
   (D) mouse
   (E) grasshopper

Questions 15–17 refer to the food chain illustrated below:
rose bush — grasshopper — mouse — snake — hawk — earthworm
18. The amount of nitrogen and phosphorous cycling through an ecosystem is greatly affected by local environmental conditions, such as heavy rainfall or the removal of large numbers of plants. The amount of carbon in an ecosystem is seldom significantly affected by such factors because

(A) plants make their own carbon compounds through photosynthesis.
(B) plants absorb large amounts of carbon from the soil.
(C) bacteria in the soil absorb large amounts of carbon.
(D) the primary source of carbon is the atmosphere, whereas much nitrogen and phosphorous come from the soil.
(E) organisms need only minute levels of carbon.

19. Which of the following represents an example of Mullerian mimicry?

(A) The coloration of the canyon tree frog allows it to blend in with the granite rocks among which it lives.
(B) When disturbed, the larva of the hawkmoth puffs up its head and thorax such that it resembles the head of a small poisonous snake.
(C) In some orchid species, the flowers resemble female moths and attract male moths that attempt to mate with them, contributing to pollination in the process.
(D) The conspicuous coloration of the blue-ring octopus, which inhabits the coastal waters off Australia, serves to warn predators that it is extremely venomous.
(E) Two unrelated poisonous frog species that share the same habitat also resemble each other in coloration.

20. A human cell that contains 22 autosomes and a Y chromosome must be

(A) a zygote.
(B) a somatic cell of a male.
(C) a somatic cell of a female.
(D) a sperm cell.
(E) an egg cell.
21. Which of the following events does NOT lead to genetic variation in a population?
   (A) independent assortment of chromosomes during meiosis
   (B) crossing over between homologous chromosomes during meiosis I
   (C) crossing over between homologous chromosomes during meiosis II
   (D) random union of an egg with a sperm
   (E) random mutation

Questions 22–25 refer to the following breeding experiment, the purpose of which was to develop petunia plants with flowers expressing a new combination of form and shape: double (form) ruffled (shape) flowers.

<table>
<thead>
<tr>
<th></th>
<th>plants with single ruffled flowers</th>
<th>plants with double plain flowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>( F_1 )</td>
<td>all offspring have single plain flowers</td>
<td>( F_2 ) 290 plants have single plain flowers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>99 plants have single ruffled flowers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>101 plants have double plain flowers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32 plants have double ruffled flowers</td>
</tr>
</tbody>
</table>

22. The results of the cross indicate which of the following for the original parents (P-generation)?
   (A) Both were heterozygous for flower form and flower shape.
   (B) One was homozygous dominant for flower form and flower shape, whereas the other was homozygous recessive for both traits.
   (C) One was homozygous dominant for flower form and homozygous recessive for flower shape, whereas the other was homozygous recessive for both traits.
   (D) One was homozygous dominant for both traits, whereas the other was heterozygous for both traits.
   (E) One was homozygous recessive for both traits, whereas the other was heterozygous for both traits.

23. Based on the results, how many genes control the four traits observed among the plants (single, double, plain, and ruffled)?
   (A) one
   (B) two
   (C) four
   (D) eight
   (E) sixteen

24. How many different genotypes are represented by the four phenotypic classes observed among the \( F_2 \) progeny?
   (A) four
   (B) eight
   (C) nine
   (D) thirty-two
   (E) sixty-four
25. The results suggest that the inheritance of flower form and flower shape are controlled by
(A) different alleles of the same gene.
(B) two different genes on the same chromosome.
(C) four different genes on the same chromosome.
(D) two different genes on different chromosomes.
(E) four different genes on different chromosomes.

26. There are three alleles of the gene that controls the inheritance of the ABO blood groups; the A and B alleles are co-dominant, and O is recessive to both the A and B alleles. A man with type B blood and a woman with type A blood could have children showing which of the following phenotype(s)?
(A) A only
(B) B only
(C) AB only
(D) A, B, or AB
(E) A, B, AB, or O

27. Most recessive sex-linked traits, such as colorblindness, show up more frequently in males than females because
(A) males have no corresponding allele on their X chromosome to mask the allele carried on their Y chromosome.
(B) males have no corresponding allele on their Y chromosome to mask the allele carried on their X chromosome.
(C) males carry all sex-linked traits on their Y chromosome.
(D) females always carry at least one dominant allele for sex-linked traits because they have two X chromosomes.
(E) females compensate by “turning” off the recessive allele through dosage compensation.

Questions 28–32 relate to various tissue types found in the human body. For each question, choose the term that corresponds to the definition given and fill in the corresponding oval on your answer sheet.

28. A special form of loose connective tissue that pads and insulates the body and stores fuel reserves is known as
(A) epithelial tissue.
(B) adipose tissue.
(C) fibrous connective tissue.
(D) nervous tissue.
(E) muscle tissue.
29. The tissue that consists of long contractile cells (fibers) that are packed with microfilaments of actin and myosin is known as
   (A) epithelial tissue.
   (B) adipose tissue.
   (C) fibrous connective tissue.
   (D) nervous tissue.
   (E) muscle tissue.

30. Tissue that lines the outer and inner surfaces of the body in protective sheets of tightly packed cells is known as
   (A) epithelial tissue.
   (B) adipose tissue.
   (C) fibrous connective tissue.
   (D) nervous tissue.
   (E) muscle tissue.

31. The tissue that senses stimuli and transmits electrical signals to the brain and other parts of the body is known as
   (A) epithelial tissue.
   (B) adipose tissue.
   (C) fibrous connective tissue.
   (D) nervous tissue.
   (E) muscle tissue.

32. Tissue consisting of a dense arrangement of parallel collagenous fibers found in tendons and ligaments is known as
   (A) epithelial tissue.
   (B) adipose tissue.
   (C) fibrous connective tissue.
   (D) nervous tissue.
   (E) muscle tissue.

33. Which of the following correctly describes the relationship, from simplest to most complex, among the terms listed?
   (A) cell — tissue — organ — organism
   (B) organism — organ — tissue — cell
   (C) cell — tissue — organism — organ
   (D) tissue — cell — organ — organism
   (E) tissue — organ — organism — cell

Questions 34–38 relate to various organ systems found in animals. For each question, choose the term that corresponds to the definition given and fill in the corresponding oval on your answer sheet.

34. The organ system that transports materials, such as nutrients, oxygen, and hormones, to body cells and transports carbon dioxide and various waste products away from cells is known as the
   (A) digestive system.
   (B) respiratory system.
   (C) circulatory system.
   (D) endocrine system.
   (E) nervous system.

35. The organ system that forms a communication and coordination network throughout all parts of an animal’s body is known as the
   (A) digestive system.
   (B) respiratory system.
   (C) circulatory system.
   (D) skeletal system.
   (E) nervous system.
36. The organ system that functions in exchanging gases with the environment is known as the
   (A) digestive system.
   (B) respiratory system.
   (C) circulatory system.
   (D) endocrine system.
   (E) nervous system.

37. The organ system that takes in food, breaks it down into smaller chemical units, and absorbs the nutrient molecules is known as the
   (A) digestive system.
   (B) respiratory system.
   (C) circulatory system.
   (D) endocrine system.
   (E) nervous system.

38. The organ system that consists of ductless glands that secrete hormones and the molecular receptors on target cells that respond to the hormones is known as the
   (A) digestive system.
   (B) respiratory system.
   (C) circulatory system.
   (D) endocrine system.
   (E) nervous system.

39. Which of the following best describes how a salmon is able to regulate its internal water and salt concentrations when it is swimming in the ocean and when it migrates into fresh water to spawn?
   (A) In salt water, the salmon loses water by osmosis; it drinks salt water and disposes of excess salt through its gills. In fresh water, the salmon gains water by osmosis; its kidneys excrete large quantities of urine along with some salts, and it replenishes the lost salts through uptake by its gills and digestive system.
   (B) In salt water, the salmon gains water by osmosis; it drinks salt water and disposes of excess salt through its gills. In fresh water, the salmon loses water by osmosis; its kidneys excrete large quantities of urine along with some salts, and it replenishes the lost salts through uptake by its gills and digestive system.
   (C) In salt water, the salmon loses water by osmosis; it drinks salt water and stores excess salt in its body cavity. In fresh water, the salmon gains water by osmosis; its kidneys excrete large quantities of urine and salts.
   (D) In salt water, the salmon gains water by osmosis; it drinks salt water and stores excess salt in its body cavity. In fresh water, the salmon loses water by osmosis; its kidneys excrete large quantities of urine and salt.
   (E) In salt water, the salmon gains water by osmosis and loses salt by diffusion. In fresh water, the salmon loses water by osmosis and gains salt through diffusion.
Questions 40–45 refer to the following pairs of organisms:

(A) cyanobacteria and algae
(B) algae and fungi
(C) mosses and ferns
(D) ferns and gymnosperms
(E) gymnosperms and angiosperms

40. One produces seeds, whereas the other does not.

41. One produces fruits, whereas the other does not.

42. One has vascular tissue, whereas the other does not.

43. One is a prokaryote, whereas the other is a eukaryote.

44. One photosynthesizes, whereas the other does not.

45. One produces naked seeds, whereas the other produces seeds enclosed in maternally derived tissue.

Questions 46–48 refer to the following terms:

(A) xylem
(B) phloem
(C) vascular cambium
(D) mesophyll
(E) pith

46. Responsible for secondary growth in woody plants.

47. Responsible for conducting water and dissolved minerals throughout the plant body.

48. Responsible for transporting food (mainly sugars) made during photosynthesis throughout the plant body.
49. Which of the following statements most accurately describes the process of double fertilization in angiosperms?

(A) Two pollen grains land on each stigma; thus, two ovules are fertilized.
(B) Two sperm cells produced by a single pollen grain fertilize two separate ovules, resulting in the formation of two seeds.
(C) One sperm cell from a single pollen grain fertilizes an egg cell to form a diploid zygote, while a second sperm cell from the same pollen grain combines with two fused nuclei in the embryo sac, resulting in the formation of a triploid endosperm nucleus.
(D) One sperm cell from a single pollen grain fertilizes an egg cell to form a haploid zygote, while a second sperm cell from the same pollen grain combines with a single nucleus in the embryo sac, resulting in the formation of a diploid endosperm nucleus.
(E) Two sperm cells from a single pollen grain fertilize the same egg cell to double the chance that fertilization will be successful.

50. Which of the above structures develops into the seed once fertilization has occurred?

51. Which of the above structures develops into the fruit once fertilization has occurred?

Questions 52–55 refer to the following terms:

(A) integument
(B) cotyledon
(C) ovule
(D) ovary
(E) endosperm

52. Evidence validating the theory of evolution based on the study of similarities and differences in body structure among various species is known as ____________.

53. Evidence validating the theory of evolution based on the study of local, regional, and global distributions of species is known as ____________.

54. Evidence validating the theory of evolution based on the study of structures that appear during the development of different organisms is known as ____________.

55. Evidence validating the theory of evolution based on the study of the genetic makeup of species at the DNA level is known as ____________.
56. Which of the following statements is NOT part of Darwin’s theory of natural selection?

(A) Genetic variation exists among individuals in a population.

(B) The size of most populations remains relatively constant, despite the fact that more offspring are produced than are needed to maintain it.

(C) Early settlers saved seed only from the most productive crop plants to plant the following year.

(D) Disease, competition, and other environmental forces tend to eliminate the individuals in a population that are less adapted to their environment.

(E) Individuals that are best adapted to their environment tend to pass on heritable advantageous characteristics to their offspring.

Questions 58–59 refer to the Hardy–Weinberg equation used to reflect genotypic frequencies in a population, as given below.

\[ p^2 + 2pq + q^2 = 1 \]

58. Which of the following is reflected by the value of \( p^2 \)?

(A) the frequency of individuals in the population with the dominant phenotype

(B) the frequency of individuals in the population with the homozygous dominant genotype

(C) the frequency of the dominant allele in the population

(D) the frequency of individuals in the population with the homozygous recessive genotype

(E) the frequency of individuals in the population that are heterozygous

59. The term \( 2pq \) indicates that

(A) there are two alleles for that gene in the population.

(B) there are two genes in the population.

(C) there are twice as many dominant alleles as recessive alleles in the population.

(D) there are twice as many heterozygotes as homozygotes in the population.

(E) there are two separate reproductive combinations that can result in the formation of a heterozygous individual.
60. A tetraploid individual would have

(A) one copy of each chromosome.
(B) two copies of each chromosome.
(C) four copies of each chromosome.
(D) two copies of a single chromosome.
(E) four copies of a single chromosome.

STOP

IF YOU ARE TAKING THE BIOLOGY-M TEST, GO TO QUESTION 81 NOW.
61. Which of the following best describes the relationship between a population and a species?
   (A) A species is one type of population.
   (B) A species is a local subset of a population.
   (C) A population is a group of organisms occupying a specific area.
   (D) A population encompasses many different species.
   (E) The terms population and species are interchangeable.

62. The number of individuals in a population that the environment can just maintain with no net increase or decrease from generation to generation is known as
   (A) the logistic growth curve.
   (B) the carrying capacity.
   (C) the dispersion pattern.
   (D) the habitat cap.
   (E) the exponential growth curve.

63. Which of the following pairs of figures would you need to know to determine the population density of elk living in Rocky Mountain National Park?
   (A) the birth rate of the elk population and whether population growth is logistic or exponential
   (B) the birth rate of the elk population and the area of land encompassed by the park
   (C) the number of elk living in the park and the dispersion pattern of the elk population
   (D) the number of elk living in the park and the area of land encompassed by the park
   (E) the number of elk living in the park and the birth rate of the elk population

64. A small isolated population found on a remote island is more likely to undergo speciation than a large widespread population because a small isolated population
   (A) is more susceptible to genetic drift.
   (B) inherently contains much greater genetic diversity.
   (C) is more readily adaptable to extreme environmental changes.
   (D) is more likely to migrate to other islands or the nearest mainland.
   (E) has a greater likelihood of containing sterile hybrid individuals.
65. Which of the following represents the correct order of eras, from most ancient to most recent, along the geological time scale?

(A) paleozoic — precambrian — mesozoic — cenozoic
(B) precambrian — cenozoic — paleozoic — mesozoic
(C) precambrian — mesozoic — paleozoic — cenozoic
(D) precambrian — paleozoic — mesozoic — cenozoic
(E) cenozoic — mesozoic — paleozoic — precambrian

66. Two snails in the same class must also be in the same

(A) order.
(B) species.
(C) genus.
(D) family.
(E) phylum.

67. As development continues to encroach on natural areas, individuals in local hawk populations must increasingly compete for a limited number of nesting sites. This type of behavior is likely to result in

(A) a convergent dispersion pattern within the population.
(B) a uniform dispersion pattern within the population.
(C) a random dispersion pattern within the population.
(D) a clumped dispersion pattern within the population.
(E) multiple individuals simultaneously occupying the same nest.

68. Interactions among species in an ecosystem defined as +/- would be characteristic of

(A) predation only.
(B) parasitism only.
(C) mutualism only.
(D) both predation and mutualism.
(E) both predation and parasitism.

69. Which of the following organisms would NOT be considered a primary producer?

(A) phytoplankton
(B) algae
(C) moss
(D) fungi
(E) cyanobacteria
Questions 70–71 refer to the following population in Hardy-Weinberg equilibrium:

Within the squirrel population at City Park, 16% show the recessive phenotype of a curled tail (tt).

70. What is the frequency of the dominant allele (T) in the population?
   (A) 0.40
   (B) 0.16
   (C) 0.26
   (D) 0.60
   (E) 0.32

71. What is the frequency of heterozygotes in the population?
   (A) 0.08
   (B) 0.24
   (C) 0.36
   (D) 0.48
   (E) 0.64

72. Which of the following is NOT a requirement for a population to be maintained in Hardy-Weinberg equilibrium through several generations of intermating?
   (A) nonrandom mating among individuals
   (B) no net mutations
   (C) large population size
   (D) isolation from other populations (no migration into or out of the population)
   (E) no natural selection occurring

73. Kingdom Monera in the traditional five-kingdom classification system has been divided into two separate kingdoms in the alternative eight-kingdom system of classification, the
   (A) Bacteria and Archaea.
   (B) Bacteria and Protista.
   (C) Archaea and Protista.
   (D) Archaea and Euarchaea.
   (E) Euarchaea and Protista.
Questions 74–77 refer to the diagram below that shows a hypothetical pyramid of net productivity that depicts the multiplicative loss of energy in a food chain. Each trophic level in the food chain is represented by a block in the pyramid, with primary producers forming the foundation of the pyramid. The size of each block is proportional to the productivity at each trophic level per unit of time.

74. In the above example, approximately how much energy available in each trophic level is converted into new biomass in the trophic level above it?
   (A) 1%
   (B) 5%
   (C) 10%
   (D) 50%
   (E) 100%

75. The percentage of energy transferred from one trophic level to the next (the ratio of net productivity at one trophic level to net productivity at the level below) is known as
   (A) ecological efficiency.
   (B) biomass.
   (C) gross productivity.
   (D) turnover.
   (E) transformation.

76. In terms of the decline in productivity with energy transfer from one trophic level to the next higher trophic level, which of the following would be the most efficient means of trapping the energy produced in photosynthesis?
   (A) a human eating beef that was raised on meat by-products
   (B) a human eating beef that was raised on a combination of grain and meat by-products
   (C) a human eating grain-fed beef
   (D) a human eating grain along with grain-fed beef
   (E) a human eating grain along with soybeans
77. Which of the following would likely remove the most energy from the food chain (so that it cannot be passed on to the next trophic level through the biomass of the organism) at the primary consumer level?

(A) photosynthesis
(B) excretion
(C) metabolism
(D) growth
(E) respiration

78. Which of the following statements is NOT one of the principle observations upon which Darwin based his theory of natural selection?

(A) The population size of a species would increase exponentially if all individuals that were born reproduced successfully.

(B) Populations tend to remain stable in size, aside from seasonal fluctuations.

(C) Environmental resources are limited.

(D) Individuals in a population vary extensively in their characteristics.

(E) Most of the variation observed among individuals in a population is due to environmental causes; thus, very little variation is heritable (passed on from parent to offspring).
Questions 79–80 refer to the series of graphs below.

79. Which of the above graphs best illustrates the concept of stabilizing selection (selection that favors intermediate variants by acting against individuals with extreme phenotypes)?
   (A) Graph I only
   (B) Graph II only
   (C) both Graph I and Graph II
   (D) Graph III only
   (E) both Graph II and Graph III

80. Which of the above graphs best illustrates the concept of diversifying selection (selection that favors extreme phenotypes over intermediate phenotypes)?
   (A) Graph I only
   (B) Graph II only
   (C) both Graph I and Graph II
   (D) Graph III only
   (E) both Graph II and Graph III

STOP
If you answered the first 80 questions STOP HERE.
If you are taking the Biology-M test CONTINUE HERE.
81. In human DNA, adenine (A) makes up approximately 30.9% of the bases, and guanine (G) makes up approximately 19.9% of the bases; therefore the percentage thymine (T) and cytosine (C) are
(A) 19.8% T and 19.8% C.
(B) 19.8% T and 29.4% C.
(C) 29.4% T and 19.8% C.
(D) 29.8% T and 29.8% C.
(E) 19.9% T and 30.9% C.

82. If the chromosomes of a eukaryotic cell were lacking telomerase, the cell would
(A) have a greater potential to become cancerous than one with telomerase.
(B) would be able to repair mismatched base pairs during replication.
(C) not produce okazaki fragments.
(D) become increasingly shorter with each cycle of replication.
(E) be unable to take up extraneous DNA from the surrounding solution.

83. Which of the following statements concerning transcription and translation in eukaryotic cells is NOT correct?
(A) Transcription results in the production of mRNA, whereas translation results in the production of polypeptides.
(B) Transcription results in the production of polypeptides, whereas translation results in the production of mRNA.
(C) Transcription occurs in the nucleus, whereas translation occurs in the cytoplasm.
(D) Transcription uses a nucleotide “language,” whereas translation uses an amino acid “language.”
(E) Transcription uses DNA as a template, whereas translation uses mRNA as a template.

84. The open, less compacted form of DNA that is available for transcription is known as the
(A) promoter.
(B) enhancer.
(C) operator.
(D) euchromatin.
(E) heterochromatin.
85. A sequence on a DNA molecule that recognizes specific transcription factors that can stimulate transcription of nearby genes is known as the
   (A) promoter.
   (B) enhancer.
   (C) operator.
   (D) euchromatin.
   (E) heterochromatin.

86. The tightly coiled, condensed form of DNA that is not transcribed is known as the
   (A) promoter.
   (B) enhancer.
   (C) operator.
   (D) euchromatin.
   (E) heterochromatin.

Questions 87–90 refer to the following steps involved in cloning a eukaryotic gene in a bacterial plasmid vector.

I. Introduction of cloning vector into cells.
II. Insertion of eukaryotic DNA into the vector.
III. Identification of cell clones that carry the inserted eukaryotic gene.
IV. Isolation of the vector and the eukaryotic gene-source DNA.
V. Cloning of cells (and foreign DNA).

87. Which of the following depicts the correct sequence of the steps (from first to last) involved in cloning a eukaryotic gene in a bacterial plasmid described above?
   (A) I — II — III — IV — V
   (B) V — IV — III — II — I
   (C) III — V — II — IV — I
   (D) IV — II — I — V — III
   (E) II — IV — I — III — V

88. During the stage in which insertion of eukaryotic DNA into the plasmid vector occurs, the sticky ends formed by digestion of both DNA types with the same restriction enzyme may join in a recombinant molecule because
   (A) the eukaryotic DNA and plasmid DNA will have the same sequence.
   (B) the eukaryotic DNA and plasmid DNA will have complementary sequences.
   (C) the eukaryotic DNA can join with any plasmid DNA, regardless of sequence.
   (D) the plasmid DNA can join with any eukaryotic DNA, regardless of sequence.
   (E) the plasmid DNA and the eukaryotic DNA cannot join together due to differences in the structure of their DNA molecules.
89. Which of the following statements is NOT true of restriction enzymes?

(A) Each restriction enzyme recognizes a specific sequence of bases on the DNA molecule.

(B) Each restriction enzyme cuts at random locations along the DNA molecule.

(C) Most restriction enzymes are named after the bacterial organism from which they were first isolated.

(D) Restriction enzymes protect their bacterial host against intruding foreign DNA from viruses or other bacterial cells.

(E) When a particular sequence of DNA is digested with a specific restriction enzyme, the resulting set of restriction fragments will usually be the same.

90. The uptake of naked DNA from solution by bacterial cells is known as

(A) transpiration.

(B) electroporation.

(C) translation.

(D) transduction.

(E) transformation.

91. The classification of organisms into kingdoms has come under debate in recent years, with most of the debate focused on the

(A) algae and fungi.

(B) algae and plants.

(C) fungi and plants

(D) fungi and animals.

(E) prokaryotes and simple eukaryotes.

92. In the steps leading up to the origin of life on earth, early protobionts could not have evolved into living cells without both

(A) a semipermeable membrane and a nucleus.

(B) competition for resources and the development of hereditary mechanisms.

(C) a semipermeable membrane and the ability to catalyze chemical reactions.

(D) a nucleus and the ability to catalyze chemical reactions.

(E) a mechanism for growth and a mechanism for asexual reproduction.
93. One goal of phylogenetic systematics is to make classification of organisms more objective and consistent with evolutionary history. Which of the following statements regarding this important area of study is NOT correct?

(A) The two main analytical approaches to the study of phylogenetic systematics are phenetics and cladistics.

(B) Phenetic analysis compares as many characters as possible without distinguishing between homologous and analogous characters.

(C) Cladistic analysis classifies organisms according to the order in time that branches arose along a dichotomous phylogenetic tree.

(D) Cladistic analysis relies on analogous characters among organisms while ignoring novel homologies unique to the various organisms on a branch.

(E) The most accurate phylogenetic trees are those in which molecular data agree with other forms of evidence for phylogenetic relationships (such as morphology, fossil records, and biochemical analysis).

Questions 94–95 refer to the genetic codon table below:

94. Which of the following partial polypeptides is coded for by the series of codons below?
- UUC — CCA — CAG — GGU — ACA —

(A) Start — Thr — Phe — Ala — Stop

(B) Met — Thr — Phe — Ala — Stop

(C) Leu — Lys — Ser — Arg — Val

(D) Phe — Pro — Gln — Gly — Thr

(E) Phe — Ser — Pro — Trp — Stop
95. Which of the following base substitution mutations in the mRNA above would have the least effect on the resulting polypeptide?

(A) substitution of UCC for UUC in Phe
(B) substitution of CAA for CCA in Pro
(C) substitution of CAC for CAG in Gln
(D) substitution of GGA for GGU in Gly
(E) substitution of CCA for ACA in Thr

96. The pattern of DNA fragments resulting from restriction enzyme digestion of genomic DNA from two species of skunk with EcoRI show extensive similarities. This suggests that

(A) the two skunks must be the same species, not different species.
(B) most of the restriction sites recognized by EcoRI are found at approximately the same distances apart in the DNA from both skunk species.
(C) restriction enzyme digestion with EcoRI produces the same pattern of DNA fragments in all organisms.
(D) restriction enzyme digestion with EcoRI produces the same pattern of DNA fragments in all species of skunks.
(E) the genetic makeup of the two skunk species is identical.

Questions 97–98 refer to the hypothetical phylogenetic tree below:

97. Which organism depicted on the phylogenetic tree above represents the outgroup?

(A) Z
(B) A
(C) B
(D) C
(E) D

98. Which pair of organisms on the phylogenetic tree depicted above represents the most closely related taxa?

(A) Z and A
(B) A and B
(C) B and C
(D) C and D
(E) Z and D
99. Restriction enzyme digestion with HindIII of genomic DNA from three toad species (A, B, and C) revealed that species A and B each produced unique fragment patterns, whereas species C shared fragments with both species A and species B. These results suggest that

(A) species C served as an outgroup for the study.
(B) restriction enzyme analysis should not be used in the comparison of more than two species simultaneously.
(C) species C is the most recent living ancestor of both species A and species B.
(D) the DNA sample from species C must have been contaminated.
(E) species C is a hybrid between species A and species B.

100. One of the earliest theories pertaining to the origin of life on earth suggested that life began in shallow pools. Recent studies have led to extensive debate regarding the origin of life, with some researchers suggesting that life may have originated

(A) near deep sea vents.
(B) as viral particles.
(C) in mudflats.
(D) from debris left behind when meteorites crashed to earth.
(E) from naked strands of RNA.

STOP

If you finish before the hour is up, you may review your work on this test only. You may not turn to any other test in this book.
1. The correct answer is (C). Chloroplasts are the site of photosynthesis, a process that occurs in plants but not in animals.

2. The correct answer is (A). Ribosomes function as the sites for protein synthesis.

3. The correct answer is (B). The nucleus contains DNA, which is packaged into chromosomes. The base sequence on the DNA molecule provides the code for the specific proteins to be manufactured by the cell.

4. The correct answer is (B). Respiration utilizes oxygen in the breakdown of organic compounds (such as glucose) to produce energy (in the form of ATP) for the function of cellular processes.

5. The correct answer is (D). Photosynthesis utilizes carbon dioxide and water from the atmosphere and light energy produced by the sun in the formation of chemical energy that is stored as glucose, starch, or other organic compounds in plant cells.

6. The correct answer is (E). Fermentation (sometimes referred to as anaerobic respiration) allows for the production of ATP in the absence of oxygen. Certain fungi and bacteria (for example, brewer’s yeast) produce alcohol as a result of fermentation, while human muscle cells produce lactic acid.

7. The correct answer is (D). An electron is a subatomic particle with a negative charge; an atom (composed of electrons, protons, and neutrons) is the smallest part of an element that retains the properties of that element; a compound is a substance.
composed of two or more elements in a fixed ratio; matter is anything that takes up space and has mass.

8. **The correct answer is (A).** Glucose is a monosaccharide—a simple, single-unit sugar molecule. Starch is a polysaccharide composed of numerous glucose molecules. Both starch and glucose are classified as carbohydrates.

9. **The correct answer is (B).** Transcription involves the synthesis of mRNA from a DNA template. Translation involves the synthesis of proteins encoded on mRNA molecules.

10. **The correct answer is (E).** The number of cytosines is equal to the number of guanines. Uracil is found in RNA, not DNA.

11. **The correct answer is (D).** Desert regions are defined by their dryness, usually the result of a minimal amount of rainfall combined with rapid evaporation.

12. **The correct answer is (B).** The biosphere consists of the global ecosystem—all life on earth and where it lives. An ecosystem consists of all the organisms in a given area along with all nonliving (abiotic) factors with which they may interact. A community is an assemblage of populations of different species living close enough together for potential interaction among them. A population is a group of individuals of a single species that live in a particular area. An organism is an individual living entity.

13. **The correct answer is (D).** Mutualism involves a symbiotic relationship in which both organisms benefit from their association. In commensalism, one organism benefits while the other is not significantly affected by the relationship. Neither parasitism nor predation are symbiotic relationships; in both cases, the association is detrimental to one of the organisms involved.

14. **The correct answer is (B).** The example illustrates secondary succession, in which a disturbance (clearing the forest for agriculture) destroys the existing community (forest) but leaves the soil intact. Primary succession takes place when a community arises in a virtually lifeless area with little or no soil, such as the colonization of newly formed volcanic islands.

15. **The correct answer is (D).**

16. **The correct answer is (D).**

17. **The correct answer is (A).** This set of questions involves the trophic structure (a pattern of feeding relationships with multiple levels) of a terrestrial ecosystem. The base of most food chains consists of autotrophic organisms referred to as producers (the rose bush). Primary consumers are herbivores that feed directly on the producers (the grasshopper). Secondary consumers are
carnivores that feed on organisms in the trophic level below (the mouse). Tertiary consumers (the snake) typically feed on secondary consumers, and quaternary consumers (the hawk) feed on tertiary consumers. An organism can occupy more than one trophic level in an ecosystem. In the above example, if the hawk consumed the mouse, it would be considered a tertiary consumer rather than a quaternary consumer. Detritivores derive their energy from detritus, the dead material left behind by the other trophic levels. The earthworm might feed on decaying matter from the hawk when it dies or from any of the other organisms in the food chain.

18. The correct answer is (D). The primary source of carbon in an ecosystem comes from CO\textsubscript{2} in the atmosphere. The return of CO\textsubscript{2} to the atmosphere through respiration is largely balanced by its removal through photosynthesis; thus, carbon is less subject to large fluctuations in quantity as a result of changes in local environmental conditions than other nutrients, such as nitrogen and phosphorous.

19. The correct answer is (E). Mullerian mimicry involves a mutual mimicry between two unpalatable or venomous species. Choice (A) is an example of cryptic coloration; choice (B) is an example of Batesian mimicry; choice (C) is an example of plant-pollinator interaction; and choice (D) is an example of aposematic coloration.

20. The correct answer is (D). The normal chromosomal complement of a human being is 46 chromosomes—22 pairs of autosomes plus a pair of sex chromosomes (either XX or XY). Thus, a cell with 22 autosomes and one sex chromosome must be a gamete. Females can only produce gametes (eggs) containing the ‘X’ sex chromosome, whereas, males can produce gametes (sperm cells) containing either of the sex chromosomes—‘X’ or ‘Y’.

21. The correct answer is (C). Crossing over occurs during meiosis I only; it does not occur during meiosis II. All of the other events contribute to genetic variation in a population.

22. The correct answer is (C). First, you should observe that the only traits occurring in the F\textsubscript{1} generation are single flower form and ruffled flower shape, whereas all four traits show up among the F\textsubscript{2} progeny. This suggests that single flower form and plain flower shape are dominant over double flower form and ruffled flower shape, respectively. The parents must have been homozygous for each trait, as only the dominant traits were present among their offspring. Thus, the parent with single ruffled flowers must have been homozygous dominant for flower form.
and homozygous recessive for flower shape, whereas the other parent with double plain flowers must have been homozygous recessive for flower form and homozygous dominant for flower shape.

23. **The correct answer is (B).** The ratios produced in the F₂ could have occurred only if two different genes control the inheritance of flower form and flower shape; and those genes reside on separate chromosomes (i.e., they are not linked). A simple Punnet square derived from intermating the F₁ generation would reveal the 9 genotypes represented by the four phenotypic classes found among the F₂ progeny.

24. **The correct answer is (C).** See the explanation for question 23.

25. **The correct answer is (D).** See the explanation for question 23.

26. **The correct answer is (E).** If the father with type B blood is heterozygous (BO) and the mother with type A blood is also heterozygous (AO), their children could inherit the B allele from the father and the O allele from the mother, producing type B blood; they could inherit the O allele from the father and the A allele from the mother, producing type A blood; they could inherit the B allele from the father and the A allele from the mother, producing type AB blood; or they could inherit an O allele from each parent, resulting in type O blood.

27. **The correct answer is (B).** Females have two X chromosomes, whereas males have one X and one Y chromosome. The Y chromosome typically lacks alleles for the corresponding genes along the X chromosome. Therefore, when a recessive allele is present on the X chromosome, it will automatically be expressed in males, while females have a high probability of masking a recessive allele on one X chromosome with a dominant allele on the other X chromosome.

28. **The correct answer is (B).**

29. **The correct answer is (E).**

30. **The correct answer is (A).**

31. **The correct answer is (D).**

32. **The correct answer is (C).**

33. **The correct answer is (A).** Tissue are collections of cells with a common structure and function (e.g., muscle tissue is composed of muscle cells), organs are made up of several types of tissue (e.g., the heart contains muscle tissue, nervous tissue, and connective tissue), and organisms have multiple organs (e.g., humans have a heart, liver, and kidneys).

34. **The correct answer is (C).**
35. The correct answer is (E).
36. The correct answer is (B).
37. The correct answer is (A).
38. The correct answer is (D).
39. The correct answer is (A). In salt water, the concentration of water inside the salmon is greater than that of the surrounding water; therefore, it loses water by osmosis (the movement of water from a region of high concentration to a region of low concentration). Because it must drink salt water, it disposes of salt through its gills while the kidneys conserve water and excrete excess salts. In fresh water, the salmon will gain water by osmosis, resulting in an increase in urine production by the kidneys. Salt lost through the urine is replenished by increasing the uptake of salts through both the gills and the digestive system.
40. The correct answer is (D). This question asks you to distinguish between plants that reproduce by spores (ferns) and those that reproduce by seeds (gymnosperms), which are thus more advanced on an evolutionary scale.
41. The correct answer is (E). The distinction is made between plants that produce exposed (“naked”) seeds (gymnosperms) and those that produce seeds enclosed in a protective covering of maternal tissue—the fruit (angiosperms).
42. The correct answer is (C). Question 42 asks you to recognize the difference between plants lacking vascular tissue (xylem and phloem) and which are, thus, quite restricted in size (mosses) and those that contain vascular tissue and can obtain considerable height (ferns).
43. The correct answer is (A). This question asks you to make the distinction between prokaryotic photosynthetic organisms lacking a distinct nucleus (cyanobacteria—kingdom Monera) and eukaryotic photosynthetic organisms having a distinct nucleus and other cellular organelles (algae—kingdom Protista).
44. The correct answer is (B). Question 44 asks you to recognize the difference between two organisms that were once thought to be members of the plant kingdom but that are now classified separately. The algae (in kingdom Protista) contain chlorophyll and various accessory pigments and are able to carry out photosynthesis. Fungi are currently classified in their own kingdom (kingdom Fungi). These organisms lack photosynthetic pigments and are typically saprobic (absorbing nutrients from nonliving material) or parasitic (absorbing nutrients from a living host organism).
45. The correct answer is (E). The distinction is made between plants that produce exposed ("naked") seeds (gymnosperms) and those that produce seeds enclosed in a protective covering of maternal tissue—the fruit (angiosperms).

46. The correct answer is (C). The vascular cambium consists of meristematic tissue that divides laterally to increase growth in width of woody plants (secondary growth).

47. The correct answer is (A). Xylem tissue consists of several cell types, most of which are nonliving at maturity, and is responsible for conducting water and dissolved minerals upward from the roots where they are absorbed.

48. The correct answer is (B). Phloem tissue consists of several types of food-conducting cells and is responsible for transporting sugars made in the leaves during photosynthesis, along with those stored in other parts of the plant body, to regions of the plant that require energy.

49. The correct answer is (C). When a pollen grain lands on the stigma of a compatible flower, it germinates to form a pollen tube that grows down through the style until it reaches the ovary. Two (haploid) sperm cells travel down the pollen tube and enter the ovule through an opening called the micropyle. One sperm cell fuses with the (haploid) egg cell to form a diploid zygote that divides mitotically and grows into the embryo. The other sperm cell fuses with the central cell of the embryo sac. The central cell is formed by the fusion of two haploid nuclei and is, therefore, diploid. Fusion of a sperm cell with the central cell results in the formation of a triploid cell, referred to as the endosperm nucleus, that divides mitotically to form triploid endosperm tissue, which serves as a nutritive source for the developing embryo.

50. The correct answer is (C). Following double fertilization, the ovule containing the fertilized egg cell (now a zygote) and the fertilized central cell (now the endosperm nucleus) divide mitotically to form the embryo and endosperm, respectively. The tissue surrounding the ovule hardens to form a seed coat.

51. The correct answer is (D). Once fertilization has taken place and the seed begins developing, the tissues of the ovary swell and develop into a fruit. Some fruits are fleshy upon maturity (e.g., a tomato) while others are dry at maturity (e.g., a peanut). In some fruits (e.g., apples), other tissues in addition to the ovary tissue develop into part of the fruit; these are often referred to as accessory fruits.

52. The correct answer is (C).
53. The correct answer is (A).
54. The correct answer is (D).
55. The correct answer is (E).

56. The correct answer is (C). This would be an example of artificial selection, not natural selection. Selecting only the most productive plants leads to the favoring of characteristics desired by those individuals making the selection, but these characteristics may not be the most beneficial to the species as a whole in its natural environment. Choosing only those plants that are most productive often leads to loss of other favorable characteristics, such as disease resistance and drought tolerance.

57. The correct answer is (A). The biological species concept requires that individuals can mate with others of the same species (reproduce sexually) and produce fertile offspring. For species that reproduce only by asexual means, it cannot be determined whether reproductive isolation would occur upon mating with other individuals, and reproductive isolation is a key component of the biological species concept. If an organism is extinct, existing only in the fossil record, its reproductive potential upon intermating cannot be determined. Species living on separate continents also cannot intermate in nature unless one or both are artificially moved, such that they share a common habitat.

58. The correct answer is (B). By definition, \( p \) is used to reflect the frequency of the dominant allele for a given gene in a population, whereas \( q \) is used to reflect the frequency of the corresponding recessive allele. Thus, \( p^2 \) reflects the union of two gametes, each carrying the dominant allele and, thus, reflects the frequency of the homozygous dominant genotype in the population. If the trait in question is governed by codominance or incomplete dominance, such that heterozygotes can be distinguished phenotypically from homozygous dominant individuals, then, by default, \( p^2 \) may also reflect the frequency of individuals in the population with the dominant phenotype; however, that is not always the case.

59. The correct answer is (E). A heterozygous individual may result from the union of a dominant allele from the maternal parent and a recessive allele from the paternal parent, or it may result from the union of a recessive allele from the maternal parent and a dominant allele from the paternal parent. Both possibilities must be considered when determining the frequency with which a heterozygous individual could be produced in a given population.
60. The correct answer is (C). An individual with multiple copies of its entire set of chromosomes is referred to as polyploid: three sets = triploid; four sets = tetraploid; 5 sets = pentaploid, etc. An individual with extra copies of a single chromosome is referred to as aneuploid.

**BIOLOGY-E TEST**

61. The correct answer is (C). A population refers to an interacting group of individuals of the same species occupying the same habitat and, therefore, could be thought of as a local subset of a species with a much wider distribution.

62. The correct answer is (B).

63. The correct answer is (D). Population density refers to the number of individuals of a species per unit area or volume.

64. The correct answer is (A). Genetic drift refers to a change in the gene pool of a population by chance. The smaller the population, the more likely it will lose alleles simply by random chance.

65. The correct answer is (D). Precambrian is the division of geologic time from the formation of the earth 4,600 million years ago (mya) to approximately 570 mya. Paleozoic (ancient animal) is the era from approximately 570 mya to 245 mya. Mesozoic (middle animal) is the era from approximately 245 mya to 65 mya. Cenozoic (recent animal) is the era beginning approximately 65 mya and continuing to modern times.

66. The correct answer is (E). The correct hierarchical classification of organisms is: kingdom — phylum — class — order — family — genus — species

67. The correct answer is (B). A uniform, evenly spaced pattern of dispersion is characteristic of direct competition among individuals within a population for a limited supply of one or more resources.

68. The correct answer is (E). A +/- interaction indicates that one organism benefits from the interaction while the relationship is detrimental to the other organism. Predation is where one organism, the predator, seeks out and usually destroys another organism, the prey. Parasitism is where one organism, the parasite, lives on or in another organism, the host, from which it obtains its nutrients, usually with some degree of damage to the host. Both are examples of +/- relationships.

69. The correct answer is (D). Fungi are detritivores, feeding on decaying matter. All of the other organisms listed are photosyn-
thetic autotrophs and, therefore, make up the base of the food chain—the producers.

70. The correct answer is (D). If 16 percent (0.16) of the population shows the recessive phenotype \(q^2\), then the square root of 0.16 (0.40) would equal the frequency of the recessive allele, \(q\). Because \(p + q = 1\), then \(p = 1 - q = 0.60\).

71. The correct answer is (D). The frequency of heterozygotes in the population is equal to two times the product of the frequencies of the recessive (\(q\)) and dominant (\(p\)) alleles. Thus, the frequency of heterozygotes is \(2pq = 2(0.6)(0.4) = 0.48\).

72. The correct answer is (A). For a population to remain in Hardy-Weinberg equilibrium, the individuals must be randomly mating; nonrandom mating (e.g., positive or negative assortative mating) leads to changes in allelic and genotypic frequencies within the population. All of the other conditions listed above must be met for Hardy-Weinberg equilibrium to be maintained in a population. Failure to meet any of the conditions leads to microevolution and changes in allelic and genotypic frequencies in the population.

73. The correct answer is (A). Also in the eight-kingdom system, the kingdom Protista, of the traditional five-kingdom system, has been divided into three separate kingdoms (Archaezoa, Protista, Chromista); the remaining kingdoms (Plantae, Fungi, Animalia) are the same in both the five- and eight-kingdom systems. Another system of classification, the three-domain system, uses a “domain” as a superkingdom taxa to emphasize the significance to the evolutionary split between the Bacteria and Archaea. In this system, the Bacteria and Archaea are each assigned a domain, with the third domain (Eukarya) encompassing all eukaryotic organisms. Also, the three-domain system further subdivides the kingdom Protista into five separate groups (Archaeazoa, Euglenozoa, Alveolata, Stramenopila, and Rhodophyta).

74. The correct answer is (C). In this example, 10 percent of the energy is transferred from each trophic level to the next higher level. In actual ecosystems, the decline in productivity with the transfer of energy between trophic levels varies according to the species present, usually ranging from approximately 5 to 20 percent.

75. The correct answer is (A).

76. The correct answer is (E). The consumption of primary producers is the most energy-efficient form of consumption. The higher up on the food chain consumption takes place, the less energy-efficient it becomes.
77. **The correct answer is (E).** Primary consumers do not photosynthesize (only producers carry out photosynthesis). Excretion provides some metabolic waste materials that can be utilized by detritivores and, thus, are not lost from the ecosystem. Energy that goes into the metabolism and growth of an organism contributes to the biomass of the organism and is subsequently passed on to the next higher trophic level. The energy used in respiration results in the production of inorganic molecules and heat; it is largely lost from the flow of energy in the ecosystem.

78. **The correct answer is (E).** The heritability of variation is a key component to the theory of natural selection and is necessary for evolution to occur. Those individuals that are most adapted to their environment are most likely to survive and successfully reproduce, passing on favorable genes to their offspring. As long as the selection forces remain in place, the number of individuals in the population with favorable genes will continue to increase, possibly leading to the development of a new species after many generations.

79. **The correct answer is (A).**

80. **The correct answer is (D).**

**BIOLOGY-M TEST**

81. **The correct answer is (C).** In the DNA molecule, base pairing occurs between adenine and thymine, which are held together by two hydrogen bonds, and base pairing occurs between guanine and cytosine, which are held together by three hydrogen bonds.

82. **The correct answer is (D).** Under normal conditions of DNA replication, telomeres that are present on the end of each chromosome in eukaryotic cells become shorter and shorter with each cycle of replication. The length of the telomeres typically predetermines the life span of the cell by controlling the number of possible cycles of DNA replication. Telomerase, an enzyme that catalyzes the lengthening of telomeres, is not present in the cells of most multicellular organisms other than those giving rise to gametes. Telomerase has been found to occur in cells that become cancerous, suggesting a possible link between “uncontrolled” cell division and the cancerous nature of the cell.

83. **The correct answer is (B).** The process of transcription takes place in the nucleus of eukaryotic cells. The nucleotide sequence on the DNA molecule is transcribed into an RNA replica (messenger RNA, or mRNA). The mRNA transcript moves out of the nucleus through pores in the nuclear envelope and attaches to a ribosome.
complex. The mRNA is then translated into a polypeptide chain consisting of amino acids in the sequence that is coded for by the sequence of base triplets on the mRNA molecule.

84. The correct answer is (D).
85. The correct answer is (B).
86. The correct answer is (E).
87. The correct answer is (D). First, one must isolate the bacterial plasmid that is to be the cloning vector from its bacterial host and isolate the region of DNA that contains the gene of interest to be cloned from eukaryotic tissue cells. Next, both the plasmid and the eukaryotic DNA are digested with the same restriction enzyme, creating sticky ends. When the two cell types are mixed together in the presence of DNA ligase, the plasmid DNA and eukaryotic DNA may bind together (also, the eukaryotic DNA may reassociate and the plasmid DNA may reassociate; thus, the mixture will contain both recombinant molecules and molecules like the originals). Bacteria that are bathed in a solution of the naked DNA mixture will take up the plasmid vector by transfection. As the bacterial cells replicate, so, too, will any plasmids that they contain. If the plasmid(s) are recombinant, the eukaryotic gene of interest also will be replicated many times. Finally, the eukaryotic gene insert can be detected using either nucleic acid hybridization or a similar method.

88. The correct answer is (B). The union of the sticky ends of eukaryotic DNA and plasmid DNA is similar to the formation of the DNA double helix, relying on pairing between complementary bases (A with T; G with C).

89. The correct answer is (B). Each restriction enzyme recognizes a specific sequence of bases (usually four to six nucleotides in length), known as the restriction site (or target site), on a DNA molecule; it does not cleave DNA at random sites.

90. The correct answer is (E). Transpiration, choice (A), is the loss of water vapor by plants to the atmosphere. Electroporation, choice (B), is the application of electrical impulses to animal cells or plant protoplasts. This increases the permeability of their membranes that aid the uptake of foreign DNA by transformation, choice (E), the uptake by cells of soluble fragments of foreign DNA in solution. Translation, choice (C), is the process by which the genetic information in living cells encoded in the form of base triplets in mRNA is converted to a sequence of amino acids in a polypeptide chain. Transduction, choice (D), is the transfer of genetic material from one bacterial cell to another using a phage as a vector.
91. **The correct answer is (E).** Evidence from molecular genetic studies suggests earlier evolutionary splits among prokaryotic organisms and relatively simple eukaryotic organisms (primarily those organisms classified as Protists in the five-kingdom system) than was previously thought. Such evidence has led many researchers to further subdivide these groups of organisms into separate kingdoms, based on their ancient evolutionary lineages.

92. **The correct answer is (B).** Competition for a limited supply of resources and a mechanism for passing on traits that confer an advantage for adaptation to environmental conditions from parents to offspring are necessary for evolution to occur at any level. Protobionts (aggregates of abiotic molecules that maintain an internal environment that is different from their surroundings) could not have evolved into early living cells (with semipermeable membranes, the ability to reproduce, the ability to catalyze chemical reactions, or any other characteristics typically associated with living cells) without competition among individuals for limited resources and the ability to pass favorable traits on to offspring.

93. **The correct answer is (D).** Cladistic analysis relies on homology (similarity of characteristics among species due to a shared ancestry) in the construction of phylogenetic trees while avoiding analogous characters (similarity of characteristics among species that are not closely related; these characteristics are usually attributed to convergent evolution).

94. **The correct answer is (D).** Each triplet of bases on the mRNA molecule (codon) codes for a specific amino acid. The code has been deciphered and is represented in the table of genetic codons, with the first base along the left side, the second base across the top, and the third base along the right side of the table. More than one codon may code for the same amino acid. The codon AUG may code for methionine or it may code for a start site, signaling ribosomes to begin translating the mRNA at that site. Three “stop” codons (UAA, UAG, UGA), when present within a genetic message, signal the end of the message and termination of translation in that region.

95. **The correct answer is (D).** The substitution of an “A” for a “U” in the third base position of the codon for Gly results in a codon that also codes for Gly; thus, the resulting polypeptide should function normally. All of the other substitutions described above result in the replacement of the ‘correct’ amino acid with an ‘incorrect’ amino acid in the polypeptide chain produced in translation. The relative effects of such substitutions on an individual depend on the degree to which the incorrect amino acid changes the function of the polypeptide. For example, a single base substitution (U for A)
results in the incorporation of Val in place of Glu in the sixth position of the polypeptide coding for the primary structure of hemoglobin, resulting in the abnormally shaped cells that are characteristic of sickle cell anemia.

96. The correct answer is (B). Restriction enzymes recognize specific base sequences along the DNA molecule (usually 4 to 6 bases long) and cleave the molecule at each of these sites. When the fragments of DNA that are produced are separated electrophoretically, a characteristic pattern is produced. If two species share a similar pattern, they must share a similar number of restriction sites at equivalent distances along the DNA molecule. This suggests that the genomes of the two species are similar and that they most likely diverged in relatively recent history.

97. The correct answer is (A). In the figure, taxon Z represents the outgroup—a species or group of species that is closely related to the other taxa being studied, but not as closely related as each of the study taxa are to each other. The position of taxon Z on the phylogenetic tree suggests that it possesses the primitive condition shared by all of the taxa depicted and from which the other taxa have diverged.

98. The correct answer is (D). The change from a primitive to a derived state of character I separates taxon Z (the outgroup) from the remaining species. Taxa B, C, and D share two derived characters and, thus, are more closely related to each other than each is to taxon A. Following this reasoning, taxa C and D appear to be the most closely related pair of taxa depicted. These two taxa share three derived characters (I, II, and III), suggesting that they are more closely related to each other than either is to taxon B.

99. The correct answer is (E). The results suggest that species C shares genetic information with species A as well as with species B, whereas species A and B are genetically distinct from one another. The most likely explanation is that species C inherited genetic material from both species A and B, suggesting that it is a hybrid between the two.

100. The correct answer is (A). Some scientists suggest that the earth’s surface was inhospitable during the period in which life began. Recent molecular studies suggest that the ancestors of modern-day prokaryotes thrived in very hot conditions and possibly utilized inorganic sulfur compounds. These conditions are common in deep sea vent environments, and the location also would have reduced exposure of early life forms to the inhospitable conditions that were present on the earth’s surface.