Knowledge

For each question, select the best answer from the four alternatives.

1. What is AUG? (7.1) K/U
   (a) a codon that specifies methionine
   (b) the first coding triplet in eukaryotic mRNA
   (c) the first coding triplet in prokaryotic mRNA
   (d) all of the above
2. Which DNA sequences do the tRNA anticodon sequences CUA, UGU, and AAA correspond to? (7.1) K/U
   (a) CTA, TGT, and AAA
   (b) CUA, UGU, and AAA
   (c) GAT, ACA, and TTT
   (d) GAU, ACA, and UUU
3. Which of the following describes how mRNA is formed? (7.1) K/U
   (a) 3′ to 5′ direction and antiparallel to the DNA
   (b) 3′ to 5′ direction and complementary to the DNA
   (c) 5′ to 3′ direction and antiparallel to the DNA
   (d) 5′ to 3′ direction and complementary to the DNA
4. How is the central dogma best described? (7.1) K/U
   (a) an explanation of how genetic information flows
   (b) an explanation of how proteins are regulated by DNA
   (c) an explanation of the evolution of proteins
   (d) an attempt to explain how genes function
5. mRNA differs from pre-mRNA because of
   (a) the addition of a poly(A) tail
   (b) the addition of a 3′ cap
   (c) the removal of introns
   (d) all the above (7.2) K/U
6. Which is the correct sequence of transcription? (7.2) K/U
   (a) initiation → termination → modification
   (b) initiation → elongation → termination
   (c) promotion → elongation → termination
   (d) promotion → elongation → modification
7. In eukaryotic cells, where is the DNA transcribed into mRNA? (7.2) K/U
   (a) nucleus (c) ribosome
   (b) cytosol (d) mitochondrion
8. Which amino acid is carried by a tRNA molecule with the anticodon 3′-CUA-5′? (7.3) K/U
   (a) histidine (c) aspartic acid
   (b) leucine (d) glutamic acid
9. When does a polysome occur? (7.3) K/U
   (a) when an enzyme digests the poly(A) tail
   (b) when more than one ribosome translates an mRNA molecule
   (c) when more than one ribosome transcribes an mRNA molecule
   (d) when more than one mRNA is read by a ribosome at one time
10. What is one similarity between prokaryotes and eukaryotes in translation? (7.3) K/U
    (a) Elongation occurs at a rate of 15 to 20 elongation cycles per second.
    (b) During termination, the stop codon appears and a release factor binds so that the polypeptide is released.
    (c) mRNA is translated by ribosomes in the cytosol as it is being transcribed from DNA.
    (d) Some translation occurs in mitochondria and chloroplasts.
11. The addition of an acetyl group (CH_3COO^-) to the histones
    (a) loosens a histone complex, making the promoter accessible
    (b) results in the histones attaching themselves to the promoter to increase the rate of transcription
    (c) results in the upstream regulation of the protein being transcribed
    (d) provides a substrate that the RNA polymerase can bind to initiate transcription (7.4) K/U
12. What does upstream regulation mean? (7.4) K/U
    (a) RNA polymerase must read the operator prior to the promoter region.
    (b) RNA polymerase must read the promoter prior to the operator.
    (c) RNA polymerase must read the operator prior to the coding region.
    (d) RNA polymerase must read the coding region prior to the operator.
13. What causes the decrease in protein length that occurs in β-thalassemia? (7.5) K/U
    (a) frameshift mutation (c) nonsense mutation
    (b) missense mutation (d) silent mutation
14. Transposable elements provide proof that genetic information
    (a) can move between individuals
    (b) can move between species
    (c) can move within a genome
    (d) cannot move without causing mutations (7.5) K/U

15. What is studied in comparative genomics? (7.6) K/U
    (a) how to insert DNA into humans
    (b) how to turn on genes in humans
    (c) how genes differ between species
    (d) how humans can live longer using foreign DNA
16. Which feature of viruses makes them useful in medicine? (7.6) K/U
    (a) their simple genetic complement
    (b) their ability to enter another cell and use its machinery
    (c) their ability to be stored for a long period of time
    (d) their high mutation rate

Indicate whether each statement is true or false. If you think the statement is false, rewrite it to make it true.

17. Garrod concluded that alkaptonuria was an "inborn error of metabolism." (7.1) K/U
18. During the formation of a polypeptide, tRNA is transcribed from the DNA, exits the nucleus, and is translated on a ribosome to mRNA molecules, which carry the amino acids to form the polypeptide. (7.1) K/U
19. RNA polymerase requires a primer when making a complementary strand. (7.1) K/U
20. tRNA binds with proteins to form ribosomes. (7.1) K/U
21. Prokaryotes use spliceosomes to remove exons during post-transcriptional modification. (7.2) K/U
22. The process of alternative splicing results in different combinations of exons being removed to synthesize multiple proteins from the one gene. (7.2) K/U
23. Protein synthesis occurs faster in prokaryotes because transcription and translation both occur in the cytosol. (7.3) K/U
24. DNA is transcribed to a complementary 3′→5′ mRNA, and the mRNA is complementary to 5′→3′ anticodons on tRNA. (7.3) K/U
25. The formation of proteins is faster in eukaryotes than in prokaryotes because polysomes can form in the nucleus, coupling transcription and translation. (7.3) K/U
26. Post-transcriptional control of genes can be accomplished using proteins that mask mRNA. (7.3) K/U
27. The *trp* repressor is inhibited by high concentrations of tryptophan. (7.4) K/U
28. When lactose is absent, the *lac* repressor is inactive and binds to the promoter. (7.4) K/U
29. Ionizing radiation is considered a mutagen because it has the ability to break bonds within the DNA molecule, causing the rearrangement or deletion of large portions of chromosomes. (7.5) K/U
30. Silent mutations insert, delete, or change base(s) in a gene and thereby usually alter the protein. (7.5) K/U
31. Transposons are mutated vestigial genes that have lost their evolutionary adaptive value. (7.6) K/U
32. In transduction, viral vectors are used to insert transgenic material into cells. (7.7) K/U

Match each term on the left with the most appropriate description on the right.

33.

(a) mRNA	(i) transfer of information from DNA to mRNA
(b) RNA polymerase	(ii) structural component of a ribosome
(c) transcription	(iii) reads the DNA template strand and synthesizes precursor mRNA
(d) tRNA	(iv) intermediary between DNA and ribosomes
(e) translation	(v) transfer of information from mRNA into a polypeptide
(f) rRNA	(vi) short single-stranded sequence of 70 to 90 ribonucleotides, which loops back on itself (7.1, 7.2, 7.3) K/U

34.

(a) LINEs	(i) a non-coding sequence of DNA or RNA
(b) transposon	(ii) a sequence of DNA that is similar to an existing gene but does not code for proteins
(c) SINEs	(iii) repetitive DNA sequences, approximately 6500 bp in length on average
(d) pseudogene	(iv) a small sequence of DNA that can move about the genome
(e) intron	(v) a sequence of DNA or RNA that codes for part of a gene
(f) exon	(vi) repetitive DNA sequences, approximately 500 bp in length on average (7.2, 7.6) K/U

Write a short answer to each question.

35. Write the amino acid sequence that corresponds to the DNA template strand 5′-GTTGATTTTCGC-3′. (7.1) K/U
36. Identify at least three different DNA sequences that correspond to the polypeptide sequence Gly-His-Ile. (7.1) K/U
37. Describe the process of alternative splicing. (7.2) K/U
38. Outline the importance of snRNPs in RNA splicing. (7.2) K/U
39. What is the purpose of the aminoacylation of tRNA? (7.3) K/U
40. List the advantages that prokaryotes have over eukaryotes in protein synthesis. (7.3) K/U
41. What are the effects of the poly(A) tail during translation in eukaryotes? (7.4) K/U
42. Why is it important that cells regulate genes? (7.4) K/U
43. Explain the role of the following three mRNA codons: UAA, UGA, and UAG. (7.5) K/U
44. List the different types of mutagens, and give an example of each. (7.5) K/U
45. How do scientists think the human genome benefits from transposons, LINEs, and SINEs? (7.6) K/U
46. List the genomic structures that are found in viruses. (7.7) K/U

Understanding

47. Suppose that you are given the following data from a sample of a nucleic acid. What can you conclude from the data? Why? (7.1) K/U T/I

    adenine: 25 %

    uracil: 30 %

    guanine: 40 %

    cytosine: 5 %
48. Explain how Garrod's work with alkaptonuria helped him understand the nature of a gene. (7.1) K/U
49. Use a Venn diagram to compare and contrast the codons and anticodons found in RNA. (7.1) K/U T/I C
50. Explain mathematically why the amino acid sequence Arg-Leu-Ser is a good example of the wobble hypothesis. (7.1) K/U T/I
51. Use a labelled diagram to illustrate the formation of mRNA from a double-stranded section of DNA. (7.2) K/U C
52. You are asked to research a gene that appears in both prokaryotes and eukaryotes. One of the genes is 70 kbp in length and the other is only 20 kbp. Which belongs to which group? Explain. (7.2) K/U T/I
53. Cryptography is the study of codes. What properties of RNA and transcription could you use to manufacture a genetically based secret code? (7.2) K/U T/I
54. Explain the significance of alternative splicing. (7.2) K/U T/I
55. Explain the differences between the A, E, and P sites of the ribosome. (7.3) K/U T/I
56. The antibiotic erythromycin works by blocking ribosomal movement (translocation) along an mRNA strand in some prokaryotes. Predict the effect on protein synthesis. (7.3) K/U T/I
57. Copy **Table 1** into your notebook. Use your knowledge of the genetic code, mRNA, tRNA, and amino acids to complete the table. Assume that the table is read from left to right. (7.1, 7.2, 7.3) T/I

    Table 1

DNA template strand		G							
DNA other strand						A			
mRNA			U	U					
tRNA	C				U				
amino acids							Trp		

58. Draw the feedback mechanism that is involved in regulating the *lac* enzymes. (7.4) K/U T/I C
59. Explain the importance of ubiquitin in post-translational modification. (7.4) K/U T/I
60. Defend the statement: Not all mutations are harmful. (7.5) K/U T/I
61. Non-coding sequences used to be referred to as "junk" DNA. How has our understanding of non-coding sequences caused the name change? (7.5) K/U T/I
62. Use a graphic organizer to compare and contrast the *lac* and *trp* repressors. (7.6) K/U T/I C
63. Use a flow chart to summarize how a retrovirus enters a cell and hijacks the cell's replication machinery. (7.7) K/U T/I C

Analysis and Application

64. Suppose that you are investigating an organism that has attached itself to the outside of the International Space Station. (7.1) T/I
    (a) You discover that this organism uses six different nucleotides to code for 180 amino acids. Suggest the minimum number of nucleotides that might make up a single codon.
    (b) How would your answer to (a) change if you discovered that this organism actually uses six nucleotides to code for 356 amino acids? Provide a mathematical solution.

65. Compare and contrast DNA replication and mRNA transcription. (7.2) T/I

66. Eukaryotes can vary the number of proteins that are synthesized by an individual gene based on the number of introns in a sequence. Copy **Table 2** into your notebook and complete it to compare the effect of introns on the number of proteins using a sequence consisting of 5 exons. Assume that any combination can occur, but regions cannot be repeated. (7.2) K/U T/I

Table 2

Number of exons	Number of introns	Number of possible genes
5	1	5
5	2	
5	3	
5	4	

67. During an investigation of the promoter region of a gene, you apply heat to two sections of DNA that you believe could be promoter regions. One region unwinds at 80 °C and the other unwinds around 60 °C. Which of the two strands contains the promoter? Explain (7.2) K/U T/I

68. You are growing cells in culture and you briefly introduce fluorescently labelled uracil into the cell culture (treatment A). Then you wash out the fluorescently labelled uracil and reintroduce unlabelled uracil (treatment B). Where would you expect to find the fluorescence during treatments A and B? (7.2) K/U T/I

69. Tetracycline, a common medication that is used to treat bacterial infections, prevents the aminoacyl–tRNA from binding to the ribosomal subunit. Describe the effect on the cell. (7.3) T/I

70. The wobble hypothesis predicts that fewer than 61 tRNA molecules are required to read the 61 sense codons. State the minimum number required. Explain. (7.3) K/U T/I

71. The final steps in deciphering the genetic code involved using synthetic mRNA, with known mRNA sequences, as well as a complete set of tRNA. One by one, all but three of the tRNA sequences were matched to specific amino acids. (7.3) K/U T/I A
    (a) Which three tRNA sequences did not attract an amino acid?
    (b) What experiment could you perform to determine the function of these three codons?

72. Defend the following statement: The mechanisms of gene regulation in prokaryotes are profoundly different from those in eukaryotes. (7.4) K/U T/I

73. Examine the following sequences of DNA before and after treatment with a mutagen. Identify the type of mutation and describe the effect, if any, on the amino acid sequence.

    Before: 5′-CAC TCT TGC CDC-3′

    After: 5′-CAC TCT TGT CDC-3′ (7.5) K/U T/I

74. Use the DNA sequence 5′-ACA GGC TAA TGG-3′ to demonstrate an inversion mutation. How could this mutation change the polypeptide? (7.5) K/U T/I

75. Currently, Canada has no clear legislation on genetic rights. Take the role of a citizen, doctor, lawyer, geneticist, genetic counsellor, or drug manufacturer. Write a set of guidelines that you think the Government of Canada should adopt. (7.6) K/U C A

Evaluation

76. Consider the following statement: The genetic code is degenerate. (7.1) K/U T/I A
    (a) What does this statement mean?
    (b) Determine the ratio of sense codons that have synonyms to sense codons that do not.
    (c) Hypothesize how degeneracy could protect a cell from mutations.
    (d) Develop a testable question that would use degenerate DNA to examine your hypothesis in (c).

77. You have been investigating the production of a novel protein in a human cell. However, you cannot determine where the protein is being produced. You administer a drug called cyclohexamide, which is a eukaryotic protein transcription inhibitor. The protein is still produced. Where do you think it is being produced? Explain your answer. (7.2, 7.3) K/U T/I

78. As a grad student, you have been working on the gene to produce human insulin. During a set of routine tests on a gene that has been working to produce insulin, you attempt to use *E. coli* as a method of producing human insulin. However, despite your best attempts, the *E. coli* will not produce the protein. (7.3) K/U T/I A
    (a) Explain why the insulin is not being synthesised.
    (b) What would you have to do to get the process to work?

79. All the cells in an organism contain the same DNA. However, every cell does not transcribe or translate the same information, or even the same information in the same way. In a paragraph, explain how this illustrates the idea that you are the product of your environment. (7.4) K/U T/I

80. Copy **Figure 1** into your notebook. Indicate the position of the promoter region by drawing a rectangle and the position of the terminator region by drawing a square. Explain your choice of locations. (7.4) K/U T/I C

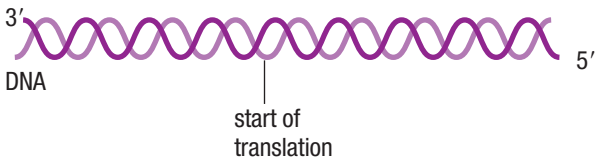

Figure 1

81. You have been asked by Health Canada to verify the claim that the drug Actinomycin D blocks transcription in bacteria. You decide to use a culture of *E. coli*. How would you determine if this claim is correct? (7.4) K/U T/I

82. Use the following sequences to answer the questions below. (7.3, 7.4) K/U T/I

Sequence A: 5′-GCAGGCCATATAAAATAGCGCCA TACTAGATACGGGCCATATTATTGCATATCCGC CGATTACAGGATTTAATTTGGGAATTCCCCGAT TAACGCGATCGATCGGGCCATATCGATATGCAT CGTAATCCGGTAGATTCACAGGTAG-3′

Sequence B: 5′-GCATACCCAAATTAATAACGGCG GTAGGCGACTCATTCTGATATACGCATCGGCAT TTACCTACGGCCGGCCGGCCGGCCGGCCTAGA TTTACCGCATTTACCGGCCGCATCGGATCGGG ATTAGCATAATTAAAATGCATCGGCGTAGTAGG CAATCGGCGCAGCCGAGCCACCTCCCGGAGAA TCATCATCATCATCATCATCATCATCATCATCAT CATCATACGGATAGATCCATTACCATGCGATTT AAAGGCCATTCATGGGCCCCCGATTTATCCAT TTAGGCCGGATTCCATGGATTCATTTCCATTTT TCGGCATCATCATCATCATCATCATCATCATCA TCATCATCATCATCATCAT-3′

(a) If these sequences code for the same protein, which gene is from a eukaryote? Why?

(b) How many promoter regions does each genome have? How can you identify them?

(c) How many copies of the gene are in each genome?

83. While investigating a strand of DNA, you identify three individuals who have a small change in one particular area. Using the following sequences, identify the types of mutations in the individuals. reference DNA: 5′-TCTATAGGA-3′ (7.5) K/U T/I

(a) individual A: 5′-TCTAAGGA-3′

(b) individual B: 5′-TCTATGGGA-3′

(c) individual C: 5′-TCTGGAGCTA-3′

84. Many products that we interact with and ingest have mutagenic effects. Two in particular—cigarettes and alcohol—have well-established links to cancer. Why are both of these products still sold, while other products are removed with less data to support their removal? Construct a one-page argument to either support or refute the continued sale of cigarettes and alcohol in Ontario. (7.5) T/I C A

Reflect on Your Learning

85. Suppose that you are watching the news and you hear the following statement: Genes code for enzymes. How would you react to hearing this statement? Explain your answer. K/U T/I

86. Garrod worked on heredity without knowing about DNA. Beedle and Tatum knew that DNA existed, but they did not know its structure or function. Does this information change your opinion about the need for an answer in all scientific experiments? Explain your reasoning. T/I A

87. What concept was the easiest for you to understand in this chapter? Why was it the easiest to understand? What did you do to understand it? How could you use your new knowledge to change your study habits? T/I C

88. Design a concept map to summarize your learning from this chapter. Use DNA as your starting point. K/U C

89. Has your impression of viruses changed after this chapter? Explain why or why not. K/U A

Research

WEB LINK

90. The "RNA world" hypothesis suggests that life existed with RNA before DNA evolved. Conduct research using the Internet and other sources to answer the following questions. T/I A

(a) What evidence supports this hypothesis?

(b) What properties of RNA would enable it to be the foundation of life?

(c) How could this hypothesis change our understanding of the origin of life on Earth?

91. Prokaryotes and eukaryotes have many similarities, including the use of ribosomes to synthesize proteins. However, there are subtle differences in the structure of their ribosomes. Research the structure of ribosomes and answer the following questions. T/I

(a) Use a method of your choice to summarize these differences.

(b) Erythromycin is often prescribed to treat bacterial infections. How does erythromycin disrupt bacterial ribosomes?

92. People often take antibiotics to treat viral infections. Research the effectiveness of antibiotics on bacterial and viral infections. Prepare a public service announcement or poster to advise people about this issue. T/I C

93. Vaccines have played an important role in the evolution of modern health care. In many cases, scientist have been able to develop vaccines to prevent the infection of a virus. However, the development of a vaccine for HIV has long eluded scientists. **Figure 2** shows the drugs that many HIV patients take daily to control the spread of the virus. Using the Internet, prepare a short summary of the quest to develop a vaccine for HIV. T/I C A

Figure 2

94. Some farmers are using a species of bacteria called *Pseudomonas syringae* to help them combat ice formation on their crops. *P. syringae* encourages the formation of ice crystals and rain. Farmers spray their crops with a genetically modified version of the bacteria to reduce the risk of frost damage. Research this topic by interviewing farmers on the issue (if possible) and using the Internet. Answer the following questions. T/I A

(a) What ethical issues are associated with this practice?

(b) How would you feel about consuming food that has been treated with *P. syringae*? Explain your thinking.

(c) In your opinion, what actions or legislations should be in place for consumers?

95. The human epigenome project has a mandate to identify and determine the patterns of DNA methylation in the human population. Use the Internet to research the following questions. T/I C A

(a) What is the epigenome?

(b) What is a methylation variable position (MVP)?

(c) Why do scientists want to focus their research on methylation?

(d) Suppose that you have been put in charge of fundraising for the human epigenome project. Design a pamphlet that could be used to seek support from the general public for this project.

96. Skin cancer is the result of exposure of skin to ultraviolet light (**Figure 3**). There has been a recent push to ban teenagers from tanning salons in Ontario. This is backed by the World Health Organization's International Agency for Research on Cancer, which has labelled tanning beds as carcinogenic. Many schools have even pledged a tan-free prom since many teenagers believe that tanning salons are less of a risk than exposure to the Sun. Develop an informational poster, pamphlet, or infomercial for teenagers to educate them on the dangers of exposure to UV rays. Make sure to include the following:

- how UV causes melanoma
- why tanning beds and exposure to the Sun are the same
- why humans darken when they tan T/I C A

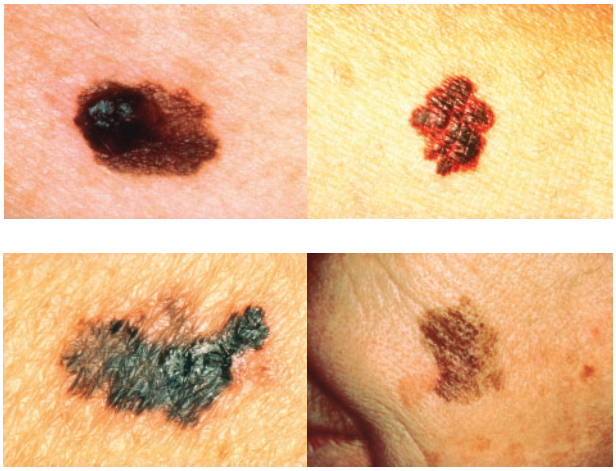

Figure 3 Signs of skin cancer