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Chapter 2: Protein Synthesis

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. What is the relationship among genes, DNA, and proteins?
A. DNA is composed of a series of amino acids that provide the directions for synthesizing proteins.
B. Protein is composed of DNA that is organized into specific gene sequences called amino acids.
C. A gene is a section of DNA that provides the directions for synthesizing a specific protein.
D. Proteins are the nitrogenous bases that form double strands of DNA in its helical shape.

____ 2. What is the best meaning for the term *gene expression*?
A. The location of a specific gene allele on a specific autosomal chromosome
B. The specific trait or protein coded for by a single gene is actually present
C. The ability of a single gene to code for more than one trait or characteristic
D. The loss of a trait or characteristic from one family generation to the next generation

____ 3. What is the difference between DNA transcription for DNA synthesis and DNA transcription for protein synthesis?
A. Transcription for DNA synthesis is rapidly followed by the process of translation.
B. Transcription for protein synthesis has "greater fidelity" than does transcription for DNA synthesis.
C. Transcription for protein synthesis occurs only in cells undergoing mitosis, and transcription for DNA synthesis occurs in both dividing and nondividing cells.
D. Transcription for DNA synthesis occurs with both the "sense" and the "antisense" strands, while transcription for protein synthesis occurs with only the "antisense" strand.

____ 4. Which mature messenger RNA strand correctly reflects the accurate transcription of the following segment of DNA, in which large letters represent introns and small letters represent exons?
tTGCGaAccaGaCTtaaAAtTAAA
A. AUGGUUAUUA
B. ACGCTCGATTATTT
C. CGCUCGAUUAUUU
D. AACGCUUGGUCUGAAUUUUAAUUU

____ 5. What is the function of ribosomes (also known as ribosomal RNA) in protein synthesis?
A. Allow interpretation of the two strands of DNA to determine which is the "sense" strand and which is the "antisense" strand
B. Serve as the coordinator mechanism to allow proper reading of the mRNA and placement of the correct amino acid in the sequence by the tRNAs
C. Allow further processing of synthesized proteins (posttranslational modification)

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in order to ensure that the final product is physiologically active
D. Serve as transport molecules able to move a specific amino acid to the site of protein synthesis (peptide chain elongation) in the correct sequence

____ 6. A strand of recently transcribed mRNA contains the following components: intron (1), intron (2), exon (3), intron (4), exon (5), exon (6), exon (7), intron (8). Which sequence is expected to appear in the mature mRNA?
A. 1, 2, 3, 4, 5, 6, 7, 8
B. 2, 3, 4, 5, 6, 7
C. 1, 2, 4, 8
D. 3, 5, 6, 7

____ 7. Which process occurs outside of the nucleus?
A. DNA transcription
B. RNA transcription
C. Splicing out of introns
D. Translation of mRNA

____ 8. What would be the consequence for protein synthesis if only limited amounts of adenine were available in a cell?
A. Increased rate of mRNA degradation
B. Increased formation of mutation “hot spots”
C. Decreased production of cellular proteins
D. Decreased amounts of uracil in the cytoplasm

____ 9. Which process would be directly inhibited by a lack of conversion of thymine to uracil?
A. Translation
B. Transcription
C. MicroRNA silencing
D. Posttranscriptional modification

____ 10. What would be the sequence of RNA complementary to single-stranded DNA with the base sequence of ACCTGAACGTCGCTA?
A. TGGACTTGCAGCGAT
B. ACCTGAACGTCGCTA
C. UGGACUUGCAGCGAU
D. ACCUGAACGUCGCUA

____ 11. Which events, structures, or processes are likely to trigger transcription of the beta-globin gene?
A. Anemia and TATA boxes upstream from the beta-globin gene
B. Anemia and polyadenylation downstream from the beta-globin gene
C. Polycythemia and TATA boxes upstream from the beta-globin gene
D. Polycythemia and polyadenylation downstream from the beta-globin gene

____ 12. After a protein is synthesized during translation, what further process or processes is/are needed for it to be fully functional?
A. No further processing beyond the linear arrangement of amino acids is required.
B. Although minimal function can occur in the linear form, the protein is more active when it undergoes mitosis.

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C. The protein first twists into a secondary structure and then "folds" into a specific tertiary structure for activation and function.
D. The initial protein produced is a "preprotein" that requires a series of depolarizations by electrical impulses for conversion to an active protein.

____ 13. How does an "anticodon" participate in protein synthesis?
A. Splicing out the introns to form a functional and mature messenger RNA
B. Identifying which DNA strand is the "sense" strand to transcribe into RNA
C. Ensuring the appropriate tRNA places the correct amino acid into the protein
D. Interpreting the correct "stop" triplet or codon that signals for translation termination

____ 14. The protein glucagon contains 29 amino acids in its active linear form. What is the minimum number of bases present in the mature messenger RNA for this protein?
A. 29
B. 58
C. 87
D. 116

____ 15. Which feature or characteristic is most critical for protein function or activity?
A. The number of amino acids
B. The sequence of amino acids
C. Deletion of all active exons
D. Transcription occurring after translation

____ 16. How does a "codon" participate in protein synthesis?
A. Carrying amino acid for peptide bond attachment
B. Ensuring that ribosomal RNA is securely wrapped around the mature mRNA
C. Preventing microRNA from binding to mRNA and prematurely degrading it
D. Indicating which amino acid is to be placed within the growing protein chain

____ 17. How does replacement of thymine with uracil in messenger RNA help in the process of protein synthesis?
A. Allowing messenger RNA to leave the nucleus
B. Ensuring only the "antisense" strand of DNA is transcribed
C. Determining the placement of the "start" signal for translation
D. Promoting posttranslational modification for conversion to an active protein

____ 18. How does the process of *polyadenylation* affect protein synthesis?
A. Binding to the antisense DNA strand to prevent inappropriate transcription
B. Promoting attachment of ribosomes to the correct end of messenger RNA
C. Linking the exons into the mature messenger RNA
D. Signaling the termination of mRNA translation

____ 19. Why are ribonucleases that digest mature messenger RNA a necessary part of protein synthesis?
A. These enzymes prevent overexpression of critical proteins.
B. Without ribonucleases, messenger RNA could leave one cell type and lead to excessive protein synthesis in a different cell type.
C. When ribonucleases degrade RNA, the degradation products are recycled, making

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protein synthesis more energy efficient.
D. The activity of these enzymes promotes increased translation of individual messenger RNAs so that fewer RNA molecules are needed for protein production.

____ 20. Which statement about the introns within one gene is correct?
A. These small pieces of DNA form microRNAs that regulate gene expression.
B. They are part of the desert DNA composing the noncoding regions.
C. When expressed, they induce posttranslational modifications.
D. The introns of one gene may be the exons of another gene.

____ 21. Which DNA segment deletion would cause a frameshift mutation?
A. TCT
B. GAGTC
C. TACTAC
D. GCATGACCC

____ 22. A person who is worried that he may have inherited the gene mutation for Huntington disease is told that he has the "wild-type" form of this gene. What is the best interpretation of this finding?
A. His gene for Huntington disease (HD) has more "hot spots" for mutations than the general population.
B. His Huntington disease has unusual mutations of unknown significance.
C. His Huntington disease gene is considered normal.
D. He has no Huntington disease gene.

____ 23. What is the expected result of a "nonsense" point mutation?
A. Total disruption of the gene reading frame, no production of protein
B. Replacement of one amino acid with another in the final gene product
C. Replacing an amino acid codon with a "stop" codon, resulting in a truncated protein product
D. No change in amino acid sequence and no change in the composition of the protein product

____ 24. What makes a frameshift mutational event more serious than a point mutational event?
A. Frameshift mutations occur primarily in germline cells, and point mutations occur only in somatic cells.
B. Frameshift mutations result in the deletion or addition of whole chromosomes (aneuploidy), and point mutations are undetectable at the chromosome level.
C. The rate of frameshift mutations increases with aging because DNA repair mechanisms decline, whereas the rate of point mutations is unchanged with age.
D. When the mutations occur in expressed genes, frameshift mutations always result in disruption of the gene function, whereas a point mutation can be silent.

____ 25. What is the expected outcome when a person (twin A) experiences a large deletion of DNA in one of his noncoding regions and his monozygotic twin (twin B) does not?
A. DNA identification of each twin will be more specific.
B. Only their somatic cells will remain identical at all loci.
C. Only their germline cells will remain identical at all loci.
D. They will now be dizygotic twins instead of monozygotic twins.

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____ 26. Which statement about single-nucleotide polymorphisms (SNPs) is true?
A. SNPs can change an exon sequence into an intron sequence.
B. SNPs can change an intron sequence into an exon sequence.
C. SNPs are generally responsible for frameshift mutations.
D. SNPs are generally responsible for point mutations.

____ 27. Why are people who have poor DNA repair mechanisms at greater risk for cancer development?
A. Their cancers are usually resistant to chemotherapy.
B. Their somatic mutations are more likely to be permanent.
C. They have greater exposure to environmental carcinogens.
D. They have sustained a mutational event in all cells and tissues.

____ 28. How does an acquired mutation in a somatic cell gene leading to cancer development affect a person's ability to pass on a predisposition for that cancer type to his or her children?
A. The predisposition can only be passed on if the person with the somatic cell mutation is female.
B. There is no risk of passing on a cancer predisposition to one's children from a somatic cell mutation.
C. The risk for predisposition is dependent on which tissue type experienced the somatic mutation.
D. Multiple somatic mutations are required for passing on a predisposition to cancer development.

____ 29. Which factor has the greatest influence on protein tertiary structure?
A. The presence of a poly-A tail
B. The specific amino acids that are in close proximity to each other
C. Bond formation between amino acids that are distant from each other
D. The number and position of additional proteins needed to form the complex structure

____ 30. Jack and Jill go up a hill that has high levels of gamma radiation emission. Jack suffers 10 point mutational events in a noncoding region, and Jill suffers only one frameshift mutation in the insulin gene–coding region of all her pancreatic beta cells. What are the possible and probable outcomes of these events for both people?
A. Jack will have major deficiencies in the production of 10 proteins; Jill will have reduced insulin activity.
B. Jack will have less functional proteins and an increased risk for cancer; Jill will have type 2 diabetes mellitus.
C. Jack will have few, if any, effects on protein synthesis but will have more personal DNA markers; Jill will not produce any functional insulin and will have type 1 diabetes mellitus.
D. Jack will not have any change in protein synthesis or function; Jill will have an increased risk for developing type 1 diabetes mellitus and can pass this risk on to her children.

____ 31. A new experimental drug has been developed that reduces the activity of microRNA in the beta cells of the pancreas of people with type 2 diabetes mellitus. If this drug was specific only for pancreatic beta cells, what would be its effect?

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A. Increased production of insulin
B. Decreased production of insulin
C. Increased degradation of insulin
D. Decreased degradation of insulin

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Chapter 2: Protein Synthesis
Answer Section

MULTIPLE CHOICE

1. ANS: C
   The correct sequence and relationships are listed in option C. A gene is a section of a specific DNA sequence that encodes the instructions for the amino acid sequence of a specific protein. The DNA is "read" and transcribed into messenger RNA, which is translated as a series of amino acids. When these amino acids are joined together in the correct sequence encoded by the DNA, it is a protein.

   PTS: 1
2. ANS: B
   Genes are always present within a cell's nucleus. However, they only produce the proper protein when they are activated, read, and transcribed.

   PTS: 1
3. ANS: D
   Transcription is the process of making a strand of RNA that is complementary to the DNA sequence that contains the gene for the protein needed. During DNA replication, both of the double strands of DNA within one cell are entirely copied, resulting in the total synthesis of two new complete strands. During protein synthesis, only the segment of DNA that contains the antisense strand that is complementary for the actual gene is involved in the process, not the entire genome. This means that only a segment of *one* DNA strand is read and transcribed into RNA.

   PTS: 1
4. ANS: A
   The introns are not part of the gene and must be spliced out to form the mature messenger RNA that contains only the information encoded in the exons (expressed regions of a gene). In RNA, which is complementary to the DNA of the "sense strand," thymine is replaced with uracil. Therefore, response *B* is incorrect because it contains thymine. Response *C* is incorrect because it shows the segments corresponding to the introns and not the exons. Response *D* is incorrect because it shows retention of both the exons and the introns.

   PTS: 1
5. ANS: B
   A ribosome is a cytoplasmic adapter molecule containing a complex of proteins and some RNA that essentially decodes the mRNA and places the proper individual amino acid into the growing peptide chain during protein synthesis. It does not have anything to do with double-stranded DNA, nor does it perform any posttranslational modification. The transport molecules are the transfer RNAs (tRNAs), not the ribosomes.

   PTS: 1
6. ANS: D

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Converting the early transcript of mRNA into mature mRNA requires splicing out the introns, which are the intervening sequences that are not part of the gene encoding for a specific protein. Only the exons (expressed regions) of the initial transcript should remain in the mature messenger RNA ready for translation.

PTS: 1

7. ANS: D
DNA transcription, RNA transcription, and splicing out of introns occur in the nucleus to develop mature mRNA, which then moves into the cytoplasm for translation.

PTS: 1

8. ANS: C
Protein synthesis requires adequate amounts of all four bases (as nucleotides). If there are inadequate amounts of any one, all protein synthesis will be decreased or halted in that cell.

PTS: 1

9. ANS: A
Translation of mRNA into protein occurs in the cytoplasm, whereas transcription occurs in the nucleus. Transcription as a process would be unaffected by the lack of uracil; however, the transcript would have only thymine, not uracil. The methyl group of thymine would prevent the transcript from leaving the nucleus and entering the cytoplasm where translation and protein finishing can occur. Thus, translation would be directly disrupted, and posttranslational modification would be indirectly disrupted. MicroRNA silencing is not part of this process.

PTS: 1

10. ANS: C
RNA is complementary to the antisense (template) strand of DNA. It also does not contain thymine (T). Instead, wherever an adenine (A) is present in the DNA, uracil (U) is placed in RNA.

PTS: 1

11. ANS: A
A “TATA” box is a transcription start signal located upstream (5' to 3') of a specific gene. Anemia is a physiologic trigger that more beta globin should be synthesized. Polycythemia indicates an excess of red blood cells and no need for beta-globin production. Polyadenylation only finishes the transcription and does not signal the need to start it.

PTS: 1

12. ANS: C
Proteins are not in their final forms for active function when they are first synthesized and require posttranslational modification, the further processing of the newly translated primary protein structure into at least its secondary and tertiary structures to make it fully functional. Secondary protein structure is a twisting of the primary structure as a result of the interaction of amino acids located near each other. Tertiary structure is the folding of the linear structure and occurs as a result of remote amino acids interacting with each other. Folding often creates a “pocket” within the protein that becomes an “active site,” able to interact with other structures or substances.

PTS: 1

13. ANS: C

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The amino acid attachment site is the location that a specific amino acid can attach to and be carried by any one tRNA. Which amino acid attaches depends on the tRNA's anticodon, which is the tRNA complementary code for an amino acid codon. Thus, for every RNA codon, there is a corresponding complementary anticodon on the tRNA that can attach and carry the correct amino acid. (Every single amino acid has its own specific tRNAs.)

PTS: 1

14. ANS: C
Each amino acid is coded for by a triplet of bases in the DNA, which corresponds to the complementary triplet of bases composing the codon in RNA for each amino acid. Because each amino acid codon has three bases, the minimum number of bases needed in the mature messenger RNA for glucagon is 29 multiplied by 3, or 87.

PTS: 1

15. ANS: B
Every active protein has a specific amount of the amino acids and a unique sequence in which they are connected together. The exact sequence is critical for protein function. It is possible for two separate proteins to have the same total number of amino acids and perhaps even the same numbers of individual amino acids (so response *A* is incorrect). However, the sequencing order of the amino acids is what makes one protein different in structure and function from another protein. The exons are the actual directions for the sequence of amino acids. Deleting these would not result in a functional protein. Transcription always occurs *before*, not after, translation in the process of protein synthesis.

PTS: 1

16. ANS: D
Codons are the RNA code for specific amino acids within a protein. When these are read properly, the correct amino acid is placed properly into the growing peptide chain to lead to the formation of a functional protein.

PTS: 1

17. ANS: A
RNA does not contain the pyrimidine base thymine. The base uracil is used in place of thymine because it is a pyrimidine base with a structure that does not contain the methyl group (CH_3) that thymine has. This difference between thymine and uracil is important because molecules in the nucleus that contain a methyl group remain trapped inside the nucleus. Because the remaining phases of protein synthesis occur outside the nucleus, the newly transcribed RNA must be able to exit the nucleus.

PTS: 1

18. ANS: D
The addition of a *poly-A tail* to the newly transcribed RNA, known as *polyadenylation,* results in a segment of RNA that contains mostly adenine and is not translated into part of the protein. Thus, it serves as a signal to stop translation.

PTS: 1

19. ANS: A

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Once in the cytoplasm, mRNA molecules have a very short life span, only seconds, before they are degraded by enzymes known as *ribonucleases* (RNases). This rapid degradation of mRNA is important in preventing an inadvertent overproduction of specific proteins. The idea is to make just enough active protein as is needed at that time and no extra. This makes protein synthesis less wasteful and more efficient. It also prevents too much of a specific protein from being present and exerting effects that are not needed.

PTS: 1

20. ANS: D
Introns are the sectional parts of DNA within a gene-coding region that do not belong to the gene-coding sequence of the protein being synthesized. However, because these introns are in gene-coding regions, they are parts of another gene. In that other gene, they would be considered exons for that gene. Thus, they are not part of the desert DNA and have no role in the synthesis of the gene product for which they are introns.

PTS: 1

21. ANS: B
Because an amino acid is encoded in the DNA by a "triplet" of bases, deletion of any number of bases that is not a multiple of three will alter the reading frame and result in a frameshift mutation. Although deletion of "triplet" bases can result in a change in some areas of the amino acid sequence and have an influence on protein function, the essential reading frame is not disrupted.

PTS: 1

22. ANS: C
The most common form of a normal functional gene is known as the wild type. Thus, a person with the wild-type form of the HD gene has a functional gene with no increased risk for developing the disease.

PTS: 1

23. ANS: C
A nonsense point mutation results in an inappropriate placement of a stop signal, which has a negative effect on protein function. This type of mutation prevents the completion of a protein. The protein may not be synthesized at all if the stop signal is present early in the reading sequence. If it is present later in the sequence, protein synthesis stops prematurely and results in a short or truncated protein that usually has little if any function.

PTS: 1

24. ANS: D
Frameshift mutations are disruptions of the DNA reading frame (not the chromosome) as a result of having a whole base or group of bases added or deleted. They can occur in somatic cells or germline cells. When this type of mutation occurs in gene-coding regions, it always disrupts the reading frame from the start of the mutation to the end of the gene. The result is complete alteration of amino acid position and prevention of synthesis of a functional protein. A normal protein cannot be made from a gene with a frameshift mutation. Although mutations may accumulate over a lifetime, frameshift mutations do not occur more often than point mutations as a person ages.

PTS: 1

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25. ANS: A
Mutations of any type that occur in noncoding regions are responsible for making one person's DNA different from and identifiable from another person's DNA. Even identical twins (monozygotic twins) do not have absolutely identical DNA by the time they are born, although they probably did when the embryo first split into two embryos. By the time identical twins are born, they usually have at least 100 base pairs different from each other in the noncoding regions. As they live their lives, each twin continues to accumulate more and different mutations so that as they age, these identical twins become less identical in their DNA.

PTS: 1
26. ANS: D
Point mutations are substitutions of one base for another and can occur in DNA or RNA. This type of change does not result in an extra base or a lost base, just a substitution. This type of base change is known as a single-nucleotide polymorphism (SNP). Frameshift mutations are deletions or insertions of DNA bases, not one-for-one substitutions. SNPs do not interconvert introns and exons.

PTS: 1
27. ANS: B
Everyone experiences some mutational events as a result of spontaneous DNA replication error or exposure to mutagens or carcinogens in the environment. Many of these mutational events are correctly repaired and have no lasting consequences. However, when they remain unrepaired and occur in a gene-coding region for cell growth regulation, they can have permanent consequences for the individual, including a greater risk for cancer development.

PTS: 1
28. ANS: B
Somatic cell mutations occur only in ordinary body cells, not in germline cells (eggs or sperm). Thus, somatic mutations cannot be passed on to one's children. The presence of somatic mutations is a major cause of sporadic cancer in a person, but this predisposition cannot be inherited by his or her children.

PTS: 1
29. ANS: C
Tertiary structure is the folding of the linear structure and occurs as a result of remote amino acids interacting with each other. These interactions, including bod formation, allow parts of the linear structure to draw closer together in some areas and have greater distances in other areas. These shape-changing factors influence a protein's activity. The poly-A tail only finishes the transcription and is not translated. Additional proteins in specific association are a protein's quaternary structure. The specific amino acids in close proximity to each other in a peptide help for the protein's secondary structure.

PTS: 1
30. ANS: C

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It is most likely that the mutational events in a noncoding region will not interfere with correct reading of any genes. These changes in the noncoding regions can make Jack's DNA more identifiable. With Jill having a frameshift mutation in the gene-coding region, it is likely that she will not be able to produce functional insulin and will have type 1 diabetes mellitus, requiring insulin replacement. Because this large mutational event (all the pancreatic beta cells) is occurring only in somatic cells, Jill cannot pass this problem on to her children.

PTS: 1

31. ANS: A

MicroRNA is a small, noncoding piece of RNA that regulates gene expression at the RNA level by binding to parts of targeted mRNA molecules, making them partially double stranded, which cannot be translated. This action "silences" the translation ability of selected mRNA molecules and increases the rate at which they are degraded. This experimental drug has the potential to increase insulin production by allowing insulin-coding mRNA to be present longer and not have its translation inhibited by being double stranded. MicroRNA has no effect on a protein once it has been produced. Thus, the degradation of formed insulin is not changed.

PTS: 1

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