Chapter 13 – RNA and Protein Synthesis

Study Guide

Section 1 – RNA

- RNA Structure
  1. What is **RNA**?
     - **Ribonucleic Acid** – single stranded nucleic acid that work together with DNA to make proteins.
  2. What are the monomers of RNA?
     - **Nucleotides** – phosphate, ribose, and nitrogen base
  3. What 5-carbon sugar is found in RNA?
     - The 5-carbon sugar is **ribose**.
  4. What are the nitrogen bases of RNA?
     - Guanine, Cytosine, Adenine, and **Uracil**
  5. What are the 3 types of RNA molecules and their roles?
     - **mRNA** – carries message from DNA, **tRNA** – transfers amino acids to ribosomes, **rRNA** – form ribosomes and assembles polypeptides (chain of amino acids)

- DNA vs. RNA
  1. In what ways are RNA and DNA similar?
     - Both are nucleic acids, made of nucleotides, work together to make proteins, both have sugar-phosphate backbone; both have guanine, cytosine, and adenine
  2. In what ways are they different?
     - | RNA       | DNA          |
        |-----------|--------------|
        | Single strand | Double strand |
        | Uracil     | Thymine      |
        | Ribose     | Deoxyribose  |
  3. How is **ribose** different from deoxyribose?
     - Ribose is found in RNA while deoxyribose is found in DNA.
     - Ribose is C₅H₁₀O₅; deoxyribose is C₅H₁₀O₄
  4. How is the function of RNA different from DNA?
     - The different RNA molecules work to assemble amino acids. DNA provides the instructions for the sequence of amino acids.
  5. How are DNA and RNA involved in protein synthesis?
     - The sequence of DNA provides a template that has a coded message on the order of the amino acids. mRNA delivers the instructions from DNA to the ribosome. tRNA brings amino acids. rRNA forms the ribosomes to assemble the amino acids.

- Transcription
  1. What is a **gene**?
     - A gene is a segment of DNA that has instructions for assembling amino acids (making proteins).
  2. What is **transcription**?
     - Transcription is the process that produces RNA from a sequence of DNA. The sequence of nitrogen bases on DNA is copied to a strand of RNA.
3. What is RNA polymerase?
   RNA polymerase is the enzyme that transcribes RNA from DNA.

4. How does RNA polymerase know when to transcribe?
   There are specific areas on DNA called promoter regions.

5. What are introns and exons?
   During RNA editing, introns are regions of RNA that are cut out and discarded while exons are spliced or put back together.

Section 2 – Ribosomes and Protein Synthesis

- Translation

1. What is the genetic code?
   The relationship between specific sequences of nitrogen bases to amino acids.

2. How is one protein different from another protein?
   Proteins are different by the sequence and type of amino acids that form the polypeptide.

3. What is translation?
   Translation is the process that takes the code from DNA to assemble the amino acids in a specified sequence to make a polypeptide.

4. Where does translation occur?
   Translation occurs in the ribosome.

5. How does translation occur?
   A strand of mRNA goes to the ribosome. The ribosome reads the message on the mRNA codon by codon by matching the anticodons on the tRNA molecules. The ribosome forms bonds between the amino acids.

- Codons and anticodons

1. What are codons?
   Codons are the nitrogen bases on mRNA grouped into clusters of three.

2. How many codons are there?
   With 4 different nitrogen bases grouped into groups of three, there are 64 different combinations; therefore, there are 64 different codons.

3. What is the start codon?
   The start codon is the codon that starts translation. Specifically, it is AUG which codes for the amino acid methionine.

4. What are anticodons?
   Anticodons are three nitrogen bases on tRNA that have complementary matches on the mRNA. The anticodons distinguishes one tRNA from another.

5. What is the relationship between codons, anticodons, and amino acids?
   Codons on the mRNA provides information on the order of amino acids. The anticodons on tRNA with specific amino acids match up to the codons. Bonds are formed between the amino acids to form a polypeptide.

- Sequencing of amino acids

1. What are amino acids?
   Amino acids are the building blocks (monomers) of proteins.

2. How many different amino acids are there?
   There are twenty different amino acids.

3. Why is the sequence of amino acids important?
   The sequence of amino acids determine the type of protein.

4. What determines the sequence of the amino acids?
   The sequence of amino acids is determined by the order of the codons. The codons are from the DNA template from transcription.

5. What type of bond forms between the amino acids?
   Peptide bonds form between amino acids to form polypeptide chains.
Central Dogma of Biology

1. What are the three parts of the central dogma of biology?
   1. DNA is transcribed to RNA.  2. RNA is edited (introns removed, exons spliced).  3. mRNA is translated to form proteins.
2. Where does transcription occur?
   Transcription occurs in the nucleus.
3. Where does translation occur?
   Translation occurs in the ribosomes. Ribosomes are either in the cytoplasm or embedded in the ER (rough ER).
4. What is the relationship between anticodons, tRNA, and amino acids?
   tRNA molecules have different anticodons. The tRNA molecules only transfer specific amino acids according to their anticodons. For example, if a tRNA molecule has UAC as its anticodon, it only transfers the amino acid methionine.
5. What are ribosomes made of?
   Ribosomes are made of ribosomal RNA (rRNA).

Section 3 – Mutations

1. What are mutations?
   Mutations are changes that occur to the sequence of nitrogen bases on DNA that code for protein – changes in a gene.
2. Why do mutations occur?
   Mutations occur because of high energy (radiation) and chemicals. These substances are called mutagens.
3. What are the two types of mutations?
   The two types of mutations are gene mutations and chromosomal mutations.
4. What are the three types of gene mutations?
   The three types of gene mutations are substitution, deletion, and insertion.
5. What is a point mutation? What causes it?
   Point mutation is a form of gene mutation where only a specific amino acid is affected. When nitrogen bases are replaced by a different nitrogen base (substitution), a point mutation occurs.
6. What is a frameshift mutation? What causes it?
   Frameshift mutations are mutations that change the entire sequence of codons when the DNA is transcribed. This changes all of the amino acids from the point of mutation. Deletion and insertion cause frameshift mutations.
7. What are the four types of chromosomal mutations?
   The four types of chromosomal mutations are duplication, deletion, inversion, and translocation.
8. Explain how a mutation can occur without changing the protein.
   Many amino acids are associated to more than one codon. If the mutation of a codon does not change the amino acid, then the sequence of amino acids is not changed. Because the sequence of amino acid isn’t changed, the protein does not change.
9. How can mutations be harmful?
   Most mutations lead to cancer. Other mutations, depending on its severity can cause death or deformities.
10. How can mutations be beneficial?
    Mutations lead to genetic diversity. Genetic diversity provides variations in organisms that could lead to better fitness in an environment.
Chapter 12 – DNA
1. DNA structure and components
2. Discovery of DNA
3. Replication

Chapter 7 – Cellular Transport and Biological Membranes
1. Passive vs. Active Transport
2. Cell membrane – phospholipid bilayer
3. Hypertonic vs. Hypotonic vs. Isotonic

Chapter 8 & 9 – Photosynthesis and Cellular Respiration
1. ATP
2. Photosynthesis
3. Cellular respiration

Chapter 7 – Cell Structure and Function
1. Prokaryotes vs. Eukaryotes
2. Plant cells vs. Animal Cells
3. Organelles and Structures

Chapter 2 – Chemistry of Life
1. Atoms, Ions, and Isotopes
2. Chemistry of Water
3. Enzymes and Chemical Reactions

Chapter 1 – Science of Biology
1. Characteristics of Living Things
2. Scientific Method
3. Metric System