Molecular Genetics

RNA, Transcription, & Protein Synthesis
Section 1

RNA AND TRANSCRIPTION
Objectives

• Describe the primary functions of RNA
• Identify how RNA differs from DNA
• Describe the structure and function of each type of RNA
• Describe the basic process of transcription
Remember…

- DNA is coded instructions on how to make specific proteins
- In eukaryotes, the genes that code for production are located in the nucleus, while the enzymes and amino acids needed for protein production are located in the cytosol
RNA Function

- RNA is responsible for the movement of genetic information from the DNA in the nucleus to the site of protein production in the cytosol.
- RNA is also involved in the production of proteins (protein synthesis).
RNA Structure

- RNA is made of a chain of nucleotides, like DNA
- However, the sugar in RNA is **ribose**
- Instead of thymine (T), RNA has the N-base called **Uracil (U)**
  - Uracil is a pyrimidine and pairs with adenine
- RNA is made of a **single strand** of nucleotides
Types of RNA

• There are 3 types of RNA:
  – Messenger RNA (mRNA)
  – Ribosomal RNA (rRNA)
  – Transfer RNA (tRNA)

• All 3 types of are involved in protein synthesis

• All 3 types of RNA are made from DNA in the nucleus
Messenger RNA (mRNA)

- mRNA forms a single, uncoiled chain of nucleotides
- mRNA carries genetic information from the DNA in the nucleus to the cytosol
- In this sense, they are “messengers” from the DNA to the rest of the cell
Transfer RNA (tRNA)

- tRNA consists of a single chain of about 80 nucleotides folded up into a hairpin shape
- tRNA binds to a specific amino acid
Ribosomal RNA (rRNA)

- rRNA is the most abundant form of RNA
- rRNA consists of RNA nucleotides in a globular form
- rRNA joins with proteins to make ribosomes
Transcription

- RNA carries genetic information from the DNA in the nucleus to the cytosol
- The process by which genetic information is copied from DNA to RNA is called transcription
Transcription

• **RNA polymerase** is the primary enzyme that synthesizes RNA copies of specific sequences of DNA

• RNA polymerase binds to DNA **promoters** and separates the two strands of DNA
  – **Promoters** are regions of DNA that are specific base sequences that mark the beginning of a single gene

• RNA polymerase moves along the DNA strand and adds complimentary RNA nucleotides to the forming RNA molecule

• It moves until it reaches the **termination signal**
  – A **termination signal** is a specific sequence of nucleotides that marks the end of a gene
Review

• What is the function of RNA?
  – RNA carries genetic information from DNA in the nucleus to the cytosol to be used in protein synthesis.

• What is the structure of RNA?
  – RNA is a single strand of nucleotides made up of a sugar (ribose), a phosphate group, and nitrogen base pairs (A,U,G,C).
Review

• Describe the structure and function of the 3 types of RNA.
  – Messenger RNA (mRNA) is a single, uncoiled strand of nucleotides that carries genetic information from the DNA in the nucleus to the cytosol.
  – Transfer RNA (tRNA) is a single coil of RNA in a hairpin shape that binds to a certain amino acid.
  – Ribosomal RNA (rRNA) is made of RNA nucleotides in a globular form and joins with proteins to form ribosomes.

• Describe transcription.
  – RNA polymerase binds to DNA promoters and separates the two strands of DNA. RNA polymerase then moves along the DNA strand and adds complimentary RNA nucleotides to form an RNA molecule. It stops at the terminal signal.
Section 2

PROTEIN SYNTHESIS
Objectives

- Describe the genetic code
- Distinguish between a codon and an anticodon
- Summarize the process of translation
Introduction

- The amount and kind of proteins that are produced in a cell determine the structure and function of the cell.
- In this way, proteins carry out the genetic instructions encoded in an organism’s DNA.
Protein Structure

- Proteins, DNA, and RNA are polymers.
- Proteins are made up of one or more polypeptides, each of which consists of a specific sequence of amino acids linked together by peptide bonds.
- Polypeptides can have 100’s or 1000’s of the 20 different amino acids.
Protein Structure

• The sequence of amino acids determines how the polypeptides twist and fold
• The function of a protein depends on its ability to bind with another molecule, which is determined by its three-dimensional shape
The Genetic Code

- During protein synthesis, the sequence of nucleotides in mRNA is translated into a sequence of amino acids.
- Organisms use the genetic code to translate the mRNA transcript into amino acids.
  - The genetic code consists of 4 letters:
    - A, U, G, C
The Genetic Code

- The genetic code is read three letters at a time
- Each three-letter group is called a **codon**
- Each codon codes for a specific amino acid
- Since there are four bases, there are 64 possible three-base codons (4x4x4=64) that code for 20 different amino acids
- Some amino acids can be coded by more than one codon
- Codons often differ from each other by the codon in the third position
- Some codons do not code for amino acids at all
The Genetic Code

- "AUG" can code for the amino acid methionine or serve as a "start" codon
  - A start codon codes for a ribosome to start translating mRNA
- UAA, UAG, and UGA are "stop" codons
  - Stop codons cause a ribosome to stop translating mRNA
The Genetic Code

- RNA Sequence – UCGCACGGU
- Codons: UCG-CAC-GGU
- Code for the amino acids: Serine-Histidine-Glycine
The process of assembling polypeptides (proteins) from the code in mRNA is called **translation**.

Translation takes place on **ribosomes**.

All 3 types of RNA are used in translation.
Translation

• Translation begins when mRNA leaves the nucleus through the pores in the nuclear membrane
• mRNA then migrates to a ribosome in the cytosol
• tRNA transports free floating amino acids to the ribosomes based on the codons in mRNA
  – One side of tRNA attaches to an amino acid
  – On the loop opposite of the amino acid attachment site is a sequence of 3 nucleotides called **anticodons**
  – Anticodons are complimentary to and pair with the corresponding codon in mRNA
Translation

- In the ribosome, each amino acid is added to a growing chain of polypeptides.
- The polypeptide chain continues to grow until the ribosome reaches the stop codon on mRNA.
Protein Assembly

- The assembly of proteins begins when a ribosome attaches to the start codon (AUG) on an mRNA transcript.
- The start codon pairs with the anticodon UAC on a tRNA.
  - Because tRNA carries the anticodon UAC, it also carries the amino acid methionine.
  - Therefore, the first amino acid of every polypeptide is initially methionine, but it may be removed later so that every polypeptide does not start with methionine.
Protein Assembly

- The ribosome moves along mRNA, pairing each codon with its tRNA anticodon
- Each pairing of codon and anticodon adds an amino acid to the polypeptide chain
- When the ribosome reaches the mRNA stop codon, translation ends and the mRNA is released
- As the polypeptide folds and associates with other polypeptides that make up the protein, it assumes the functional structure of the completed protein
Review

- Describe the genetic code
  - Genetic code is used to translate mRNA transcripts into proteins.
  - The genetic information is encoded in groups of three mRNA nucleotides called codons.

- Distinguish between a codon and an anticodon
  - Codons are series of three mRNA nucleotides that code for a specific amino acid
  - Anticodons are carried by tRNA and are complementary to and pair with its corresponding mRNA codon
Review

- Summarize the process of translation
  - Translation is the process of decoding mRNA into proteins
  - Translation begins when mRNA leaves the nucleus
    - mRNA then goes to the Ribosomes in the cytosol for protein synthesis
    - The start codon pairs with the anticodon UAC on tRNA
    - Each pairing of anticodon and codon adds an amino acid to the growing polypeptide chain
    - When the ribosome reaches a stop codon, translation ends and the mRNA is released