Protein Synthesis

Contents

Objectives

- To understand the process of protein synthesis.
- To be able to predict the amino acid sequence from a given segment of DNA or RNA.

Introduction

Having information is only worthwhile if that information can be used. If the cell were unable to utilize the information locked within the DNA molecule the cell would quickly die. Cells utilize DNA's information in the process of protein synthesis, sometimes known as the central dogma of molecular biology.

In this process, information held within the DNA molecule is first transcribed into an intermediate molecule called messenger RNA (mRNA). The production of mRNA within the nucleus allows the DNA molecule to stay within the relatively protected confines of the nucleus. Once the mRNA molecule is produced it exits the nucleus through a nuclear pore and enters the cytoplasm. In the cytoplasm the information held within the mRNA molecule is used to construct the primary structure (the amino acid sequence) of a protein. This step is known as translation.

Initially it was thought that this flow of information was one way, from DNA to mRNA to protein. We now know that some information may also be transferred from mRNA to DNA, a process called reverse transcription. This is the process used by retroviruses to insert their genetic information into the cells of their host. Examples of retroviruses are HIV and the viruses which produce leukemia.

Start the Protein Synthesis simulation in the Genetics and Evolution section of the BiologyOne DVD. This simulation contains two exercises. The first part of this simulation provides an overview of the process of protein synthesis. This is followed by two exercises simulating transcription and translation.

Activity 12.1
Overview of Process

The first section of the Protein Synthesis simulation is an overview of the process of converting the information held in DNA into functional protein molecules. Review the information here to be sure you are familiar with the events of protein synthesis.tion to occur,

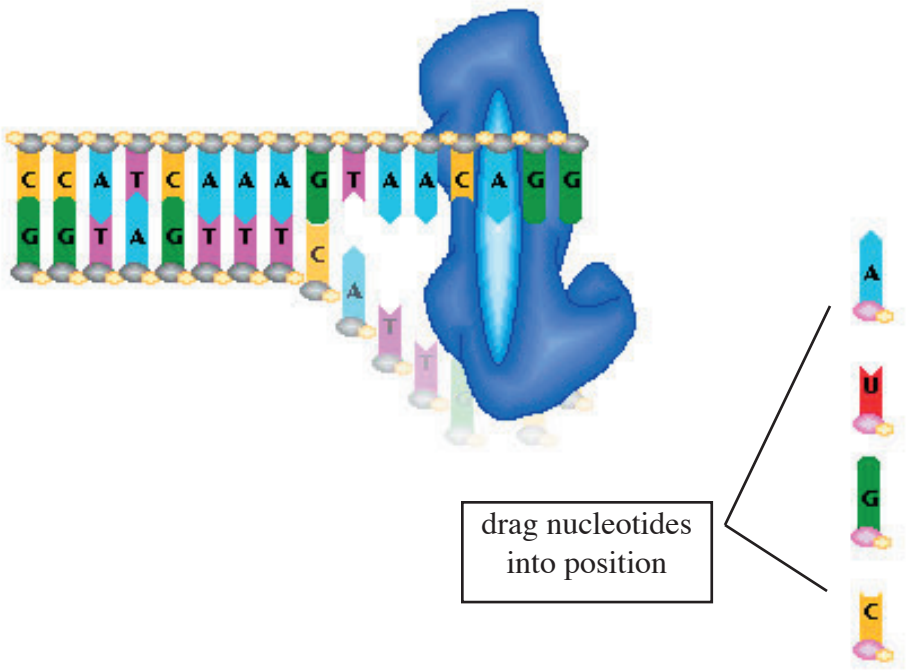
Activity 12.2
Transcription

Following the overview, when you enter the exercise you will see an illustration representing the RNA polymerase molecule moving into position along a segment of DNA. As the RNA polymerase moves onto the DNA it will open the DNA strands to reveal a binding site for RNA nucleotides. Before you begin, record the sequence of nucleotides along the upper strand of DNA in the Results section. Be sure to indicate which is the 3' end of the strand and which is the 5' end of the strand.

To start the process of transcription, determine which nucleotide is complimentary to the DNA nucleotide resting in the RNA polymerase binding site. Click on that complimentary nucleotide from the four RNA nucleotides shown on the right side of the screen and, while holding the mouse button down, drag that nucleotide to the binding site. If you've selected the correct nucleotide it will lock into position and the RNA polymerase will move to the next DNA nucleotide.

Repeat this process until the RNA polymerase has moved to the end of the segment to be transcribed. At this point the RNA polymerase will be released from the DNA. Record the sequence of nucleotides in the RNA you have produced in the Results Section. If you would like to repeat this exercise, click on the "New Transcription" button.

Simulation Screen for Transcription



Activity 12.3
Translation

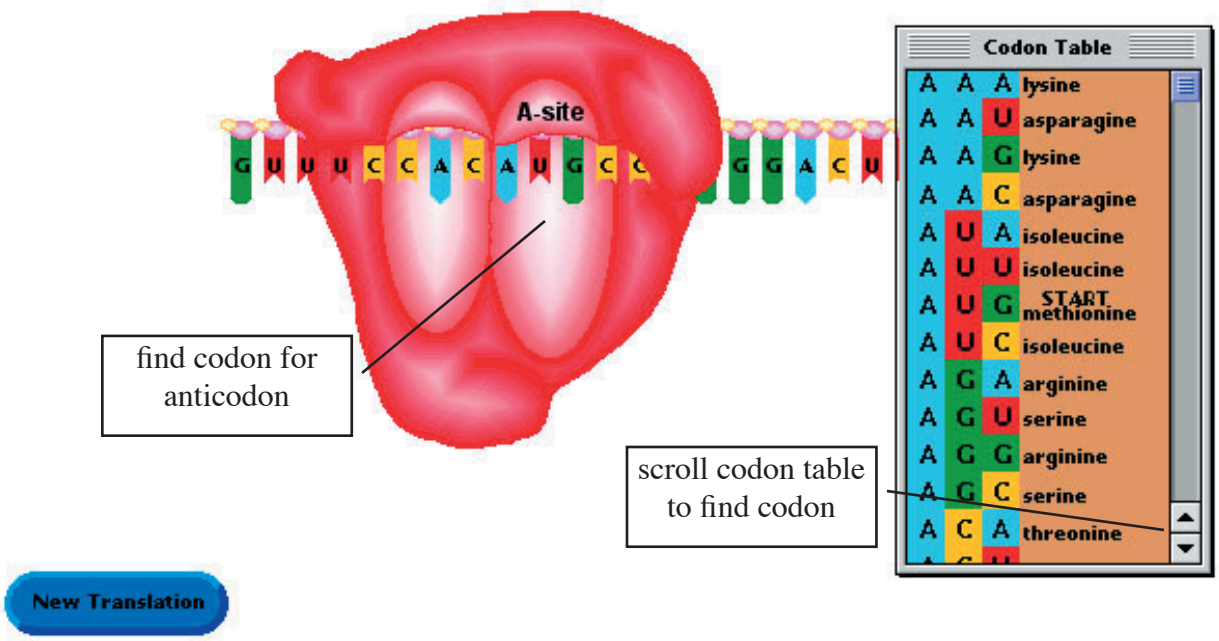
Starting the second exercise of this simulation you will see the two components of a ribosome move into position on a strand of mRNA (the mRNA strand is not the same one you generated in exercise one) and move along the strand until it reaches the start codon. At this point, the start codon will be exposed in the A site (the right binding site in this illustration). Find the start codon in the codon table and click on it. A tRNA with the appropriate amino acid will appear in the lower right. Click and while holding the mouse down, drag the tRNA to the A binding site. If you've selected the correct tRNA/amino acid it will snap into position and the mRNA strand will move along the ribosome placing the first codon in the P site and exposing the next codon in the A site. Before you continue, record the codon and amino acid you have inserted in the Results Section.

Find the codon in the codon table which matches the sequence exposed in the A binding site of the ribosome. Click on that codon and move the tRNA/ amino acid that appears into position. If correct, the tRNA will snap into position, a condensation reactions will bind the two amino acids together, and the mRNA will move down the ribosome exposing a new codon at the A site. Record the second codon and amino acid in the Results Section.

Continue this process until you reach the stop codon. At this point, clicking on the stop codon in the codon table will cause the release of the ribosome from the mRNA strand as well as the release of the amino acid sequence you have generated. If you would like to work with a new mRNA strand, click on the "New Translation" button.

Complete the problems in the Results Section.

Simulation Screen for Translation



Lab Exercise 12 Name _____

Results Section

Activity 12.2 Transcription

Parent DNA strand:

___ __ __ __ __ __ __ __ __ __ __ __ __ __ __ ___ __

(3' or 5') (3' or 5')

mRNA strand:

___ __ __ __ __ __ __ __ __ __ __ __ __ __ __ ___ __

(3' or 5') (3' or 5')

Activity 12.3 Translation

Codons:

___ __ __ __ __ __ __ __ __ __ __ __ __ __ __ ___ __ __

(you mignt not need all the spaces)

Amino Acids:

_____ _____ _____ _____ _____ _____

(you mignt not need all the spaces)

mRNA strand:

5' - G G A C A A C U G C G A A C A A C A A G G
G C A C A U C C U G A U G U G U U G C A A
A A C G G C G A C U C A C G **A** A U A U U C
C U C G A G C U U G U U U G G G U G C A G
U A A A G C A C* G G A U G U U C A C C G U
U G U C A C C C A G G A A A A U A C G A C
A U A C U A G A A A U U C C G U G C C C G
C U U G U U A -3'

Use a codon translation table to determine the amino acid sequence coded for in the above mRNA strand. Circle the start and stop codons. You will not use all of the blanks in the amino acid sequence below.(hint: look for the start codon for the point to start translation)

Amino Acid sequence: ____ ____ ____ ____ ____ ____ ____ ____

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

If the Cytosine (C) marked with an * above is substituted by Adenine (A), what difference will this have on the amino acid sequence?

If the Adenine (A) in bold face and underlined above is substituted by Uracil (U), what affect will this have on the amino acid sequence? (This type of mutation is responsible for sickle-cell anemia).

If your were not told that this sequence was RNA, could you still identify it as RNA? How?