Unit 4: Nucleic Acids

Unit Overview:

This unit will focus on understanding of the roles of the nucleic acids in the process of genetic inheritance. Special attention will be given to the processes of replication, transcription and translation. The students will have the opportunity manipulate materials in an effort to understand the form of DNA, the process of protein synthesis, and the process of plasmid transformation.

Unit Objective(s):

Describe components of deoxyribonucleic acid (DNA), and illustrate how information for specifying the traits of an organism is carried in the DNA;

Understand the processes of replication, transcription, and translation.

Identify and illustrate how changes in DNA can cause mutations.

Describe the process of genetic engineering and its application to modern medicine.

Skills attained:

Identify the differences between DNA and RNA.

Discuss the process of DNA replication in relation to the rate of mutation.

Determine a protein from its DNA code by following the steps of protein synthesis.

Correctly discuss the steps of the process of bacterial transformation using a plasmid.

Unit Topics*:*

Nucleic Acids

DNA and RNA

Unit 4: Nucleic Acids– Daily Lesson Plans

Protein Synthesis

DNA Technology

Unit Vocabulary: (DNA, RNA, nucleotides, replication, translation, transcription, codon, restriction enzyme, plasmid, transduction, mutation, adenine, guanine, cytosine, thymine, uracil, m-RNA, t- RNA, and ribosome)

Procedure:

1. Have the students complete the worksheet on DNA and RNA.
2. Have students complete the lab 10: DNA Modeling. The students need color the material before they are allowed to cut them out. It is very important that they align the parts very carefully. If they are off the molecule will not set up correctly. Look at the answer page to get an idea as to how it will look upon completion. Make a dry run through to gage the time it will take to complete it. Try not to allow them to take it home to finish since they may lose a piece or two.
3. Have students carry out the Lab 11: Protein Synthesis. Have the students cut out the labels. Make sure they understand that the DNA is the code. The m-RNA and t-RNA molecules depend on the DNA. They cannot just cut and paste these labels at random. Check the answer sheet for the correct alignment.
4. Students will complete lab 12: DNA Technology. This lab can become very confusing. First have the students read over the directions with you. Make sure they understand that the DNA must be aligned in the order specified. Glue segment 2 to the bottom of segment 1 and segment 3 to the bottom of two, etc. The plasmid is randomly glued. The reason is that there are different bacteria with different plasmids. This is also done to keep the exercise legitimate. It will cut down on copying and will allow the students to work alone. The plasmid contains several marked areas ranging in size. The largest one is the origin of replication, while the others are antibiotic resistant genes. When the students are ready to splice the DNA and the plasmid make sure that the students understand that the origin of replication and at least one antibiotic resistant gene is in the final product. This makes it extra difficult.

Materials list: *scissors, glue sticks, colors, and cardboard*

Content Background:

Nucleic Acids contain DNA and RNA as their examples. DNA is responsible for the code of every protein in an organism's body. The monomers of DNA are called nucleotides. Each of these nucleotides contains a sugar, one of 5 different bases and a phosphate. This is an example of a simple nucleotide.

S - B
|
P

There are 2 types of sugars (S): Deoxyribose and Ribose. There are 5 types of bases (B): DNA contains: **A**denine, **G**uanine, **C**ytosine, and **T**hymine. While RNA contains: **A**denine, **G**uanine, **C**ytosine, and **U**racil.

The nucleotides can only combine in the following order: **A - T** and **C - G**. The bases never touch the **P**. This DNA will twist several times forming the unique corkscrew shape called the double helix.
RNA is a bit different in structure, since it has the base Uracil replacing Thymine. The sugar is different since Ribose replaces the Deoxyribose in the nucleotide. Most of RNA has a linear structure and not that of a ladder. RNA's functions vary from taking the code for a protein to the ribosome (m-RNA) to bringing in the correct amino acids to produce the protein (t-RNA).

Transcription: DNA is too large to leave the nucleus so an intermediate must be produced. This intermediate is called m-RNA. m-RNA is formed in the following way, RNA polymerase binds to, a region of the DNA called, the promoter. Here is found the start codon TAC that codes for the amino acid methionine. Once this has been established the m-RNA sequence will grow. This occurs at the rate of 60 nucleotides / sec. The terminator sequence will keep the process from going on indefinitely. The eukaryotic m-RNA must be modified before going to the ribosome, while the prokaryotic does not.
Translation: t-RNA: a specialized form of RNA used to carry a specific amino acid to the ribosome and place it in the proper position. t-RNA contains 80 nucleotides in the form of a clover leaf. The t-RNA must attach the correct amino acid to itself.
Ribosomes: Before translation ribosomes consist of 2 separate sub-units. As translation proceeds the ribosome parts come together to allow protein synthesis to begin.
There are 3 steps to protein synthesis:
1. m-RNA binds to the small subunit of the ribosome. The t-RNA begins by carrying the amino acid AUG (start codon). It is in place in the appropriate place and it delivers the amino acid Methionine. The large sub unit then joins and creates a functional ribosome.
2. The chain grows as it moves from the 5' - 3' direction.
3. The termination codons: UAA, UAG, and UGA stop the process by adding water to the end of the chain instead of an amino acid. In order for the protein to become functional, it must be folded into its appropriate shape, and/ or have some amino acids removed, and/or have some of the polypeptides modified by adding sugars or phosphate groups to them.

DNA Engineering

The science of DNA technology includes the use of special enzymes called restriction enzymes, DNA vectors, and the host organisms.

Restriction Enzymes:
These special enzymes were discovered in the late 1960's as naturally occurring agents in bacteria. They protect the bacterium against foreign DNA from other organisms. Invading DNA is cut into pieces and made inoperable. This process is called restriction. As with any enzyme, these are specific in the job they do. Many of them only recognize short, specific nucleotide sequences (recognition sequences) and cut at specific points within those sequences. Recognition Sequences: are symmetric in that the same sequence of 4 to 8 nucleotides is found on both strands, but run in opposite directions. The restriction enzymes usually cut the bonds of both strands in a staggered manner. The result being both ends have a single stranded area called the sticky ends. It is within this space that the new piece of DNA is added, attaching to the sticky ends.

Vectors: are used as carriers for moving DNA from test tubes into cells. Bacterial plasmids and viruses are the most widely used vectors in DNA transfer. Bacterial cells can pick up the DNA through the process of transformation.
Host Organisms: Bacteria are usually used as hosts in genetic engineering. Yeast cells and some plant and animal cells can be a host for foreign DNA, but it is often difficult to get such cells to take up engineered DNA.

Steps for using Bacteria and Plasmids to Clone Genes:
a. Isolation of two kinds of DNA.
b. Treatment of plasmid and foreign DNA with the same restriction enzyme.
c. Mixture of foreign DNA with clipped plasmids.
d. Addition of DNA ligase.
e. Introduction of recombinant plasmid into bacterial cells.
f. Production of multiple gene copies by gene cloning and selection process for transformed cells.
g. Final screening for transformed cells.

Lecture Support:
1. Present the lesson on Nucleic Acids. Read the above notes on nucleic acids and preview the lesson's notes. It would be a great idea to hand out a picture of DNA to each student. They can write on it while following the section on each of its parts.
2. Present the lesson on Protein Synthesis. This is a difficult concept to grasp. It is very important that you go over the notes as many times as necessary until you are sure most of the students have grasped the concept. Read over the worksheet and familiarize yourself with the answers. You may use some of these questions in your lecture. Also read the chapter in your assigned textbook for further examples and ideas.
3. Present the lesson on DNA Technology. The main objective here is to make sure your students understand why this technology is important. They also need to understand that the process would not be possible if the restriction enzymes were not discovered. Examine the notes above and read the section in the textbook. This will give you an idea of how deep you need to go into the subject.

Assessment: *(Unit 4 Test, All worksheets and Labs may be used as an assessment)*

Homework: You may assign questions at the end of the chapter, vocabulary word definitions, or selected readings from the text book as appropriate homework assignments.