

DNA Replication, Transcription, Translation: What is the Difference?

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Overview

The curriculum for science in seventh grade covers cells, their basic structure and function, as well as heredity. Beginning with the cell, I cover the stages of mitosis. Within these stages is the process of DNA replication. Students demonstrated their understanding of replication but when I began the process of transcription, I found that students began to become confused as to how the two processes are different and the purpose of each process is different. It was very difficult to clarify their ideas and I feel that they still are carrying some misconceptions and confusion concerning replication and transcription.

The purpose of this unit is to help students develop a clear understanding of the process of DNA replication, transcription and translation as it relates to the purpose of each process in the development of the body.

Rationale

Cells reproduce from cells and how they are able to accomplish this is through the process of cell division. Cell division plays a key role in the passing of the genetic information (genome) from the parent cell to the genetically identical two daughter cells. This division of cells occurs for several reasons. One is that of replacing cells that have died or the body may have a need for more cells in a particular area especially if is a growing body. Before cell division is able to take place the DNA in each cell needs to be replicated, hence the name DNA replication (Krogh,2005). The structure of the DNA is a double strand helix (Watson and Crick), which lies in the nucleus of the cell. DNA looks like a twisted ladder. This twisted ladder is made up of two strands of nucleotides. Nucleotides are molecules, which are the building blocks for DNA. Nucleotides are made up of a sugar, a phosphate group and one nitrogenous base. The sugar and phosphate group make up the sides of the ladder. Sugar of one nucleotide bonds with the phosphate of the next nucleotide which bonds with the sugar of the next nucleotide. The

nitrogenous bases are adenine, thymine, cytosine and guanine. The two strands of DNA are connected through the weak hydrogen bonding of the nitrogenous bases. The base pairing rules are that adenine always pairs with thymine while cytosine always pairs with guanine (Campbell and Reece, 2005). These base pairs make up the rungs of the ladder. This base pairing is the key to DNA replication.

The first step in cell division is the replication of the DNA in preparation for two daughter cells. Replication begins with the unwinding of the DNA helix. The second step is the separation of the base pairs to serve as the template for the third step, which is the complementary pairing of the template to the free nucleotides. This results in two helices each having a parent strand and a complementary strand (Campbell and Reece, 2005). The cell then continues the process of cell division with the end result being two daughter cells containing the same genetic information as the parent.

Base pairing is also important in the process of protein synthesis (Campbell and Reece, 2005). Protein synthesis is the building of needed proteins for various biological functions. The first step in the process of protein synthesis is transcription. Transcription begins with an enzyme unwinding a part of the DNA molecule to allow this enzyme to make an mRNA copy of a gene, which is a portion of the DNA that codes for one or more proteins. The mRNA copies only the gene within one strand of the DNA in order to provide the information to make a protein. mRNA substitutes uracil for thymine. Now that the gene in the DNA strand has been copied, transcription is complete.

Once the mRNA leaves the nucleus, the process of translation begins. The mRNA enters a ribosome located in the cytoplasm. While in the cytoplasm, tRNA brings the amino acid for the mRNA being read. As the mRNA is read, the amino acids are strung together into a chain, which when finished is folded and forms a protein (Krogh, 2005). The chain of mRNA is read by its codons. Codons are sets of three nucleotides on the strand that are in sequential order. So for every three nucleotides in sequential order, that is a codon which specifies a single amino acid to be inserted in the protein. There are sufficient numbers of codons on the strand to specify all the amino acids form a protein. When the mRNA is attached to the large and small subunits of the ribosome, each codon in the mRNA will pair with a complementary set of nucleotides in the anticodon of a tRNA. tRNA has two main functions. First, the one end of the tRNA picks up an amino acid in the cytoplasm, which it will carry to the ribosome. Secondly, the other end of the tRNA carries the anticodon, which will bond with the codons of the mRNA (Campbell and Reece, 2005). This allows the tRNA to translate from the codon encoding the mRNA to the necessary amino acid by base pair matching the the anticodon to the codon on the mRNA. The complementary anticodon on the one end of the tRNA is able to bond with the codon on the mRNA thereby adding the appropriate amino acid to the polypeptide chain. Once the pairing of the codons to the anticodons is complete, then the string of amino acids, known as a polypeptide chain is released and folded up to form a protein.

From reading all of this information, it is important to note that base pairing is the key in DNA replication, transcription and translation. The process used in each is different and

different types of molecules are produced (DNA, mRNA and proteins) but all three processes depend on base pairing

Objectives

Students will identify the parts of a nucleotide as the building block for DNA

Students will be able to identify complementary base pairs

Students will explain the importance of base pairing in the process of DNA replication

Students will demonstrate how base pairing takes place during DNA replication

Students will be able to explain the two-step process of protein synthesis (transcription and translation)

Students will explain the role of base pairing in translation.

Strategies

Think-Pair-Share

This strategy allows time for each student to reflect on a given question, idea, or concept, before pairing with someone else to share. I have found it to be effective especially for students who are shy about answering in class or for students who are afraid of being wrong in front of others. This strategy offers some anonymity while allowing for the ideas and thoughts of the students to be shared and heard. It also helps me in discovering any misconceptions students may hold regarding a specific concept.

Models

One of the most important aspects of teaching concepts that are on a microscopic level is the use of models. During this unit, it will be impossible for the students to view first hand the processes of DNA replication, transcription, and translation without the use of some type of visual aid. I would like to have two models available for the students use. The first model is the actual DNA double helix model with which they can view and learn the structure of the DNA molecule. They will be able to see how the nucleotide is the building block for the structure as well as identify the parts of that nucleotide. Students will observe the base pairings of the nucleotides, which form the rungs of the helix. The second model is one that I am creating and will involve the use of colored coded magnets and popsicle sticks. These pieces will replicate base pairing during the processes of DNA replication, transcription, and translation.

Inquiry based learning

Guided inquiry is another strategy that I have successfully employed in my classroom. I present students with the overarching question for the unit. It is really the big idea turned into a question. From the big idea question, I develop several smaller sets of essential questions. It could also be interpreted as chunking. I then set up the necessary activities and labs that would lead the students to answer the questions. Based on my experience in the classroom, this

technique models science process skills and demonstrates the iterative process of science.

Technology learning

The computer will be of valuable use for this unit since it will allow the students to perform simulations, webquests, and get a genuine look inside the world of the cells basic functions. There are many great websites that will be incorporated into the lessons I will teach. On the flip side, students will also be able to use technology to complete presentations on what they have learned through experimentation or research. I recommend PowerPoints, Google Docs, and especially Prezis, which are similar to PowerPoints but allow students to incorporate any software, pictures, links, and texts they would need to complete their project.

Cooperative learning

This strategy is one of my favorites and most effective. I usually do not have any more than four students in a group. For me, the optimal number is three. Each member in the group must take a role assignment and follow through on that assignment. The roles vary depending upon the activity, but generally they are leader, material collector, recorder, researcher, presenter, and checker. Each task has a specific set of guidelines for the student to follow in order for the group to be successful.

Socratic Method

Socratic Method goes hand in hand with inquiry-based learning. This method is used to lead students into the direction of learning that needs to take place within a given content area. Questions asked are to be thought provoking, intellectual and spark discussion on any number of topics.

Classroom Activities

Day One

Objective:

Students will identify the parts of a nucleotide, the building blocks for the DNA molecule.

Students will identify the 4 bases in a nucleotide, in addition to identifying the complementary pairs when nucleotides are joined on the DNA helix

Essential Question: What makes up the DNA molecule and how is it structured?

Guiding Question: How are base pairs formed?

Materials: See Appendix A for details

Magnets color-coded for each of the four bases

Styrofoam balls color-coded for sugar and phosphate backbone

Computer

White board

Begin the class with a discussion to the question posed to them. Gather their ideas, and elicit prior knowledge and possible misconceptions a student may hold. Record their responses on chart paper to be referred to at the close of the lesson. Explain to the students that they will view a video with James Watson concerning how he and Crick discovered the structure of the DNA molecule.

Students will review the rule of base pairing that is adenine-thymine and cytosine-guanine as well as the sugar phosphate backbone of the helix. Students will be shown a model of the double helix structure of the DNA molecule as a result of the work of Crick and Watson. Students will then be given materials to reconstruct the double helix through the use of color-coded magnets and Styrofoam balls (Appendix). The goal of this model is to use magnets that represent the 4 bases. By using the magnetic attraction created between two magnets of opposite poles, will allow for the students to visualize how complementary base pairs are formed. I want the students to understand how cytosine pairs with guanine while adenine pairs with thymine.

Allow students to work in pairs to manipulate the nucleotides into their complementary base pairs. Allow them time to experiment with the number of different sequences they can come up with in their model.

Video to view: <http://www.dnalc.org/view/15492-Discovering-the-double-helix-structure-of%20DNA-James%20Watson-video-with-3D-animation-and-%20narration.html>

Assessment:

Have students answer the essential question introduced at the beginning of the lesson.

Day Two

Objectives:

Students will explain the importance of base pairing in the process of DNA replication.

Essential Questions:

How is base pairing important in the process of DNA replication?

How is the process of base pairing completed during replication?

Begin the lesson with a quick review of the previous day's lesson concerning nucleotides and the structure of the DNA molecule. Have students build a DNA molecule using the models built yesterday. Ask students to use their models to simulate how replication might occur within the complementary base pairs.

Invite students to look at a video of DNA replication:

<http://www.dnatube.com/video/365/DNA-Replication>

Students can then practice with a DNA replication simulation by clicking on this link:

<http://learn.genetics.utah.edu/content/begin/dna/builddna/>

After students have practiced the DNA replication simulation, have them begin the next activity, which focuses on the importance of the base pairing during replication. This activity requires the students to look at base pairing and its importance in the replication of the gene for Human Growth Hormone (hGH). Students will be able to replicate the DNA of the hGH through the use of color coded paper clips. Click on the link for DNA Replication: Paper Clip Activity http://www.tiemanbiology.com/uploads/6/3/2/3/6323843/dna_replication_paper_clip_activity.pdf

When this activity is completed each pair of students should reflect on the essential questions and respond to them by providing evidence found from doing the activities.

Day Three

Objective:

Students will be able to explain the two-step process of protein synthesis (transcription and translation)

Essential Question:

How does protein synthesis work in the cell?

Ask the students to recall the importance of base pairing from the previous activity. Elicit the fact that base pairing allows for the correct replication of the DNA. The first step in the process is transcription. Transcription is the process where a certain gene within the DNA is copied to an mRNA molecule, which travels outside the nucleus into the cytoplasm where the ribosome translates the information in the mRNA molecule into a protein through the assistance of tRNA. tRNA brings the correct amino acid or each codon in the mRNA. The amino acids are strung together into a polypeptide. When complete the polypeptide is folded into a protein. Transcription and translation are two steps in the process of making a protein, which the body needs in order to function properly.

For a terrific simulation of this process, provide students with computers and have them click on the link to PBS: DNA workshop

(<http://www.pbs.org/wgbh/aso/tryit/dna/>) or to Learn Genetics: Transcription and Translation (<http://learn.genetics.utah.edu/content/begin/dna/transcribe/>)

After the practice simulations, it is time for some hands on work. Working with words to understand protein synthesis will help students to understand the process.

<http://www.accessexcellence.org/AE/ATG/data/released/0247-LynnWartski/index.html>

Assessment: Have students work in pairs to demonstrate their understanding of the protein synthesis process either through visual aids, software presentations or in essay form.

Day Four

Objective:

Students will explain the role of base pairing in translation.

Essential Question:

What role does base pairing play in translation?

This activity is from http://serendip.brynmawr.edu/sci_edu/waldron/-trans and will help the students understand translation by modeling the process. This process is particularly important for the students to understand how tRNA brings the anticodon to the mRNA, which is reading the codon, and adding another amino acid to the string forming a polypeptide chain.

Assessment

Have students revisit the essential question and utilizing the evidence from their modeling activity, have them answer the essential question.

Annotated Bibliography/Resources

Biology: Dna replication. (n.d.). Retrieved from

www.tiemanbiology.com/6/dna_replication_paper_clip_activity.pdf

This activity will help the students to understand how DNA replicates during the process of cell division. The directions are clear and easy to follow, and the application of the process through the manipulation of the color coded paper clips allows the student to visualize the process on the microscopic layer.

Bioman Biology Genetics, Virtual Labs and Activities,

<http://www.biomanbio.com/GamesandLabs/Genegames/genetics.html>

This website offers a variety of interactive games that take the student through the actual biological processes such as meiosis, mitosis, DNA replication, etc. The games are fun, informative and allow the student to manipulate each step in the process.

Brown, T. (2005). *Transcription, translation and replication.* Retrieved from

<http://www.atdbio.com/content/14/Transcription-Translation-Replication>

A website that offers clear explanations of the processes of replication, transcription, and translation. Accompanying the explanations are beautiful illustrations that show how one process is linked to the other processes through base pairing.

Campbell, N., & Reece, J. (2005). *Biology*. (7th ed.). New York, NY: Pearson Benjamin Cummings.

A textbook used in high schools and universities that is a wonderful resource for teaching biological concepts. It offers beautiful diagrams and illustrations while explaining the underlying the principles of the three processes in this unit.

Central dogma: From dna to proteins. (2003, March 24). Retrieved from <http://www.biology.iupui.edu/biocourses/N100/2k3ch13dogma.html>

Class notes which outline the important aspects of the three processes. It is short and quite to-the-point with some illustrations

Dna workshop. (n.d.). Retrieved from <http://www.pbs.org/wgbh/aso/tryit/dna/replication.html>

Interactive simulation for students to use to learn DNA replication. Visuals are bold and directions for the students are very clear

Dna learning center. (n.d.). Retrieved from http://www.dnalc.org/resources/3d/TranscriptionBasic_withFX.html

Transcription simulation for students to view and observe how this process begins and progresses to completion

Krogh, D. (2005). *Biology: A guide to the natural world*. (3rd ed.). Berkeley, California: Pearson/ Prentice Hall.

Graduate school textbook that explains the scientific concepts of replication, transcription, and translation. Illustrations and diagrams are clearly labeled and colorful.

Science Odyssey *DNA workshop* <http://www.pbs.org/wgbh/aso/tryit/dna/>

This is an interactive simulation for students to use to learn the process of DNA replication. Visuals are bold and directions for the students are very clear

Waldron , I. (2012). *Understanding the functions of proteins and dna*. Retrieved from <http://serendip.brynmawr.edu/exchange/bioactivities/protein>

This activity models the process of translation and allows the students to manipulate each step of the process in order to clarify their understanding.

Wartski, L. M. (n.d.). *Protein synthesis and words*. Retrieved from <http://www.accessexcellence.org/AE/ATG/data/released/0247-LynnWartski/index.html>

An activity for students to perform in pairs that physically gets them moving as if they are the mRNA and the tRNA. By collecting the data and placing them in the correct order, they will make words. This activity simulates the mRNA and the tRNA in the process of protein synthesis.

Appendix

MAKING A MODEL OF THE DNA HELIX

The goal of this model is to use magnets that represent the 4 bases. By using the magnetic attraction created between two magnets of opposite poles, allows for the students to visualize how complementary base pairs are formed. I want the students to understand how cytosine pairs with guanine while adenine pairs with thymine.

This model can be made as a demonstration model or you may have students make their own models. The materials listed are for one model.

Materials:

40 small Styrofoam balls

100 toothpicks

20 sets of velcro

40 magnets (10 magnets should be slightly bigger than the other 30 representing guanine)

Paint (blue, yellow, red, green, purple)

Paintbrush

Preparation:

Paint 24 styrofoam balls purple

Leave 20 white

Magnets:

Before painting the magnets, make sure that you are painting the two sides which are polar opposite (N,S) and therefore have a strong magnetic attraction so that they attach.

Paint one side of 10 magnets blue

Paint one side of 10 magnets yellow

Paint one side of 10 magnets green

Paint one side of 10 magnets red (these should be the larger magnets)

When dry, glue back part of Velcro to each of the white Styrofoam balls

Glue the front part of the Velcro to the back of the each magnet (unpainted side)

Key:

Purple represents phosphate

White represents sugar

Blue represents adenine

Yellow represents thymine

Green represents cytosine

Red represents guanine

Making the model

Now it is time to build the model. The illustration is on the following page

Right side of helix

Place a toothpick in purple phosphate ball on the bottom left side

Attach it to the top right side of the white sugar ball.

Place a toothpick in the bottom right side of the white ball.

On the opposite end of the toothpick attach a purple phosphate ball

Place a toothpick on the bottom left side of the purple phosphate ball

Attach the white ball on the opposite end.

Continue the building this side down. See illustration.

Left side of helix

Place a toothpick in purple phosphate ball on the bottom right side

Attach it to the top left side of the white sugar ball.

Place a toothpick in the bottom left side of the white ball.

On the opposite end of the toothpick attach a purple phosphate ball

Place a toothpick on the bottom right side of the purple phosphate ball

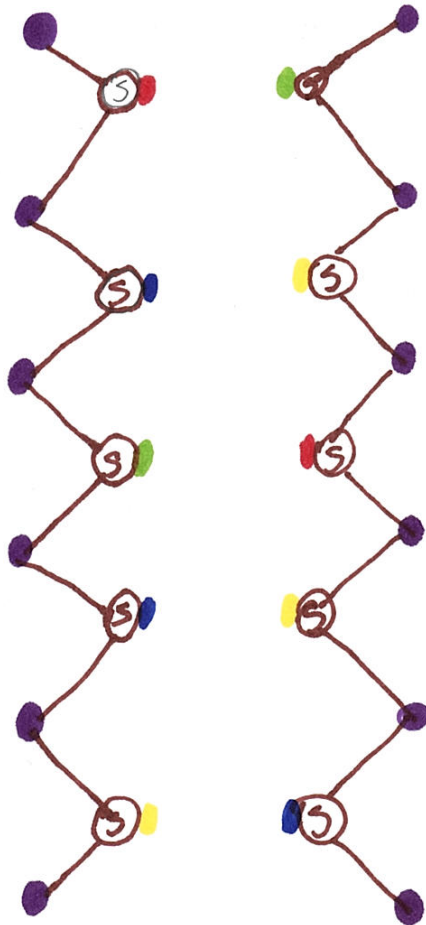
Attach the white ball on the opposite end.

Continue the building this side down. See illustration.

Take a magnet and glue one side of the Velcro to the magnet and glue the other side to the left side of the white ball on the right side and to the right side of the white ball on the left side. Let dry.

The magnetic force of the two base magnets will connect the two magnets (bases) together.

DNA Model Nucleotides



Magnets will attract and
attach to each other

Content Standards

Taken from Pennsylvania Dept. Education, Standards Aligned System

Biology

BIO.B.1.2.1: Describe how the process of DNA replication results in the transmission and/or conservation of genetic information.

3.1.B.A5: Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc). Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.

3.1.10.B3: Describe the role of DNA in protein synthesis as it relates to gene expression.

Scientific Models

S7.A.3.2.1: Make inferences based on scientific models (e.g., charts, graphs, diagrams)