THE DEVELOPMENT OF AN ANIMATED TEACHING MODULE DESIGNED

TO INCREASE UNDERSTANDING OF THE BASIC CONCEPTS OF

DNA, RNA, AND PROTEIN SYNTHESIS AMONG

NINTH GRADE BIOLOGY STUDENTS

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DEDICATION

I would like to thank my thesis committee for their continual support and guidance: Kim Krumwiede, Angela Diehl, and Patrick Haney. Thank you to Richard Lankes for recording the script for my animation. Thanks to Medical Television for recording my audio and for your generosity.

Thank you to my family and friends for their help and support when I needed it most. Your comforting and encouraging words helped me tremendously. I could not have gotten this far without you all.

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by

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THESIS

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The University of Texas Southwestern Medical Center at Dallas, 2011

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Can a two-dimensional Flash animation be created to help teach about DNA? The goal of this thesis was to create a teaching module for DNA, RNA, and protein synthesis, designed for ninth grade students. The module contains animations created in Adobe Flash and quizzes after each section. It is to be used as a textbook and lecture supplement for high school students. Quantitative assessment showed an improvement in comprehension. Qualitative assessment showed positive feedback from both students and the teacher.

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CHAPTER ONE
Introduction

Thesis Research Problem

DNA, RNA, and protein synthesis is a difficult process for high school students to understand and apply while taking the state TAKS test. Lecture and textbook teaching has proved as an ineffective means of teaching these concepts for attaining comprehension (Texas, 3). Can a two-dimensional Flash animation be created to help increase comprehension about DNA, RNA, and protein synthesis among ninth graders?

Goal

The goal of the project was to create an educational animation that will aid in comprehension of DNA, RNA, and protein synthesis. The project will create a new explanation of existing subject matter of DNA. The animation will be used as a supplement to textbooks and lectures. The project is made for high school students, specifically ninth graders when these concepts are first introduced.

Objectives

There were several objectives that needed to be fulfilled in order to reach the goal. The first objective was to discover what the learning objectives for the animation needed to be. First I needed to determine which concepts of DNA the students in the Mesquite Independent School District (MISD) struggle with most and include those in the animation. Next was to determine what style would be most interesting and fun

for high school students. For this, research needed to be done to to find a popular and engaging style of animation for this age group. The third step was to design the animation so it could be used in a public school environment. Not all students in public school have access to personal computers, so it was necessary to design a module that could be viewed in the classroom by many students at once. Next was to define a method for testing comprehension. The final step was to evaluate comprehension of the students and the effectiveness of the animation by administering a pre- and post-test as well as a Likert scale survey.

Background and Significance

Since 2006, satisfactory results of the life science questions on the eleventh grade Texas exit exam have been recurrently lower than in the other sciences, with only 67 percent of items correct on the 2009 TAKS (Texas Assessment of Knowledge and Skills) test (Texas, “Spring” 1). Only 54 percent of students were able to correctly describe components of DNA and illustrate how information for specifying the traits of an organism is carried in the DNA. Only 48 percent could adequately explain replication, transcription, and translation using models of DNA and RNA (Texas, “Spring” 2).

Current teaching techniques include lecturing and assigning problems from textbooks. Static images are used for teaching these concepts. This is ineffective, due to the fact that DNA and organelles of a cell are three-dimensional and would be better taught with moving images. This project consists of two-dimensional Flash animation and quizzes. The animation shows what DNA is made of, what it looks like, how it is

replicated, and how it is used in transcription. The animation also shows the roles of RNA and how protein is formed. Analogies are used throughout the animation as a means to simplify these concepts for students.

Scope of the project

The scope of this project is limited to the learning objectives found in the current Texas Essential Knowledge and Skills (TEKS). The audience of this project is ninth graders but can be used for all grades of high school. The animation consists of three sections, split up with quizzes in between. The questions in the quizzes are answered using clips from the animation.

CHAPTER TWO
Review of the Literature

Introduction

The purpose of the literature review was to determine the requirements set forth by the Texas Essential Knowledge and Skills (TEKS) regarding DNA and protein synthesis, to discover the most-effective teaching method, to research available animations on the topic, and to determine the most appropriate style to use to design the animation.

Texas Essential Knowledge and Skills (TEKS)

It was imperative to determine what ninth grade biology students are required to know about DNA as stated in the Texas Essential Knowledge and Skills (TEKS). TEKS is a list of learning objectives made by the State Board of Education for Texas public schools. They contain objectives used in the Texas Assessment of Knowledge and Skills (TAKS) test. This test is taken at the end of the year to evaluate the students' success in learning the TEKS objectives. The student is expected to:

> (A) describe the stages of the cell cycle, including deoxyribonucleic acid (DNA) replication and mitosis, and the importance of the cell cycle to the growth of organisms; (B) describe the roles of DNA, ribonucleic acid (RNA), and environmental factors in cell differentiation; (C) identify components of DNA, and describe how information for specifying the traits of an organism is carried in the DNA; (D) recognize that components that make up the genetic code are common to all organisms; (E) explain the purpose and process of t

ranscription and translation using models of DNA and RNA; (F) recognize that gene expression is a regulated process; and (G) identify and illustrate changes in DNA and evaluate the significance of these changes.

From these learning objectives, Patrick Haney, the content advisor, decided to focus on the concepts most difficult for students to understand. These were A through E stated above.

Educational Search: The Use of Animation as a Learning Tool

Animation is "a sequence of images played in rapid succession such that to the human eye the result is apparent motion and is generally used in instructional materials for one of three purposes: attention-gaining/attention-direction, presentation, and practice" (Ausman, 49). Animation is not currently used as a teaching method by most teachers in public schools. Narrated animation uses two senses to engage the viewer: sight and hearing as opposed to lecturing or reading which only engages one sense each.

Educational psychologist, Allen Paivio, came up with the Dual Coding Theory. It claims that "images and verbal processes together determine learning and memory performance." According to Paivio, verbal queues trigger non-verbal queues and vice-versa, activating memories stored in the brain (Ausman, 49). Experimental psychologist and cognitive neuroscientist, Endel Tulving, has done extensive research on parallel processing or the ability for the brain to simultaneously process incoming stimuli. He hypothesizes that parallel processing can aid in transference of long-term

storage of information because it can be processed on various levels. It is also thought that animation can "reduce the overall cognitive load of the participant" which allows them to process the information more effectively and remember it later on (Ausman, 50).

The more engaged the participant is, the more learning will take place. Multimedia instruction enables deeper learning due to more meaningful instruction, also allowing enjoyment in the process (Faryadi, 1). Pictures and sounds are more easily comprehended than words alone (Faryadi, 2). When learners see a word, they make their own mental image, at times a wrong image of the concept presented. Therefore, when pictures and sound are used in animation, the learner is able to understand more completely and accurately the concept being presented. Behavioral psychologist, Qais Faryadi, claims that "by integrating multimedia technology in our curriculum, our teachers and instructors will have more flexibility and autonomy over verbal-only methodology of teaching in the classroom."

Available Animations on the Topic of DNA

I researched the existence of available animations that attempt to teach DNA to see if there was already a program that covered all the learning objectives and taught them effectively. After doing this, I found that this type of animation did not exist. Most animations were inaccurate in their representations, required too much interactivity for classroom use, contained no audio and/or too much text, were visually unappealing and uninteresting and none addressed all of the TEKS learning objectives

in one animation.

Brain Pop is a popular website used by students and teachers to teach and learn various topics, from English to Arts. Brain Pop addresses the TEKS learning objectives through multiple animations. The style is quite effective and interesting but often too stylistic for accuracy. The animations are good for classroom use and each animation includes activities that reinforce those concepts. However, Brain Pop requires a paid subscription of $195 per classroom; often not affordable for most schools. Also, although the activities seem fun and appropriate, they are too interactive for classroom use. The animation on DNA also focuses more on genetics and cloning than on DNA and protein synthesis.

Kahn Academy is another educational website containing hundreds of videos about various subjects. The videos are free to watch and the narrator does an effective job of presenting the material. However, the visuals are lacking. They are uninteresting and visually unattractive. The website contains exercises but these are too interactive for classroom use.

The Genetic Science Learning Center at the University of Utah has a website of Flash animations that available to the public for free. Although they are informative and use some good analogies, they contain inaccurate illustrations. Most of the illustrations also have too much text which makes it difficult to simultaneously read and listen to what the narrator is saying about the animation. I found some of the interactivity of

the animations to be fun and engaging, however impractical for classroom use.

Style Search

Next I did research on what cartoons high school kids watch to get an idea of what style appeals to them. I looked at the Cartoon Network, MTV, Adult Swim, and YouTube. The most popular ones were simplistic in style and their characters had a goofy factor.

Conclusion

According to my literature search, it was found that a new animation must be done to meet all the goals and objectives of this project. There were no existing animations that included all of the TEKS learning objectives. There was also no animation that had a fun style that was also scientifically accurate and could be used in the classroom by many students at once.

CHAPTER THREE
Methodology

Planning the Project

The goal of this project was to create an educational animation that will aid in comprehension of DNA, RNA, and protein synthesis. The project will create a new explanation of the existing subject matter of DNA. The animation can be used specifically as a classroom resource for teachers as a supplement to textbooks and lectures. This was achieved by meeting certain objectives.

In order for my methodology to be effective, I had to directly address my objectives and strive to find solutions to those objectives. My first objective was to discover what the learning objectives need to be. Upon talking to my content advisor, Mr. Haney, we decided to focus on a few of the science concepts taken from Texas Essential Knowledge and Skills (TEKS) learning objectives. Then we decided to only focus on the concepts most difficult for students to understand.

First, I wrote an outline based on my literature search and learning objectives (Figure 3-1). The outline went through a couple of revisions and wasn't finalized until it was approved by my committee.

OUTLINE

A. What is DNA?
- 1. Deoxyribonucleic Acid
- 2. Basic unit of hereditary stuff that makes us who we are
- 3. Main purpose: long term storage of information
- 4. Location
  - a. Nucleus of eukaryotes
  - b. Elsewhere in prokaryotes
- 5. Library of reference recipe books analogy
  - a. Can't be checked out (doesn't leave nucleus)
  - b. Can only be copied by copy machine (DNA polymerase)
  - c. These are recipes used for making protein (REPLICATION)
- 6. Genetic instructions used in the development and functioning of all cells
- 7. Codes all of our genetic information
- 8. Structure
  - a. Double helix, like a twisted ladder
  - b. Made up of nucleotides
    - **(1)** nitrogen-containing base
    - **(2)** a 5-carbon sugar (deoxyribose)
    - **(3)** a phosphate group
  - c. Bridges look like rungs (nitrogen bases)
    - **(1)** Adenine –purine, pairs w/ Thymine
    - **(2)** Cytosine –pyrimidine, pairs w/ Guanine
    - **(3)** Guanine –pyrimidine, pairs w/ Cytosine
    - **(4)** Thymine –purine, pairs w/ Adenine

B. How does DNA make RNA?
- 1. Transcription
  - a. DNA strands split up
  - b. 1 strand transcribes complementary mRNA strand
- 2. mRNA—messenger RNA
  - a. Bases just like DNA but uracil instead of thymine
  - b. Found in nucleus
  - c. Recipe analogy (recipe copied from recipe books in library)
  - d. Single-stranded
- 3. Protein Synthesis
  - a. mRNA detaches from DNA
  - b. mRNA leaves nucleus, goes to RER
  - c. In RER, mRNA attaches to ribosome made of RNAs
  - d. Translation
    - **(1)** Chef analogy: whatever recipe chef receives, that's protein made
    - **(2)** mRNA is used as a pattern to assemble proteins
- 4. Differences of DNA and RNA
  - a. DNA contains the sugar deoxyribose. RNA contains the sugar ribose.
  - b. DNA is double-stranded. RNA is single stranded
  - c. DNA contains the nitrogen base thymine. RNA contains uracil.
- 5. 3 kinds of RNA
  - a. messenger RNA (mRNA)
  - b. ribosomal RNA (rRNA)
  - c. transfer RNA (tRNA)

C. What are Proteins?
- 1. Chains of amino acids
  - a. 20 total
  - b. Proteins can be hundreds of amino acids long
  - c. 1 amino acid = 1 codon = set of 3 DNA bases
  - d. Codon chart
    - **(1)** Almost every amino acid has more than 1 codon
    - **(2)** STOP means there is no amino acid and tRNA will stop attaching to mRNA and protein-production will stop
- 2. tRNA
  - a. Truck analogy
  - b. Amino acid attaches which has code for codons in anti-codon
  - c. Anti-codon
    - **(1)** Group of 3 bases
    - **(2)** Enters ribosome and attaches amino acid to growing protein
    - **(3)** Then tRNA detaches
- 3. After translation, it's released from ribosome to cytoplasm and goes to Golgi then to final destination

Figure 3-1. Script Outline.

Creating the Program

After writing the outline, I wrote a script for the animation (Appendix A). Richard Lankes was the voice of my main character. I decided to hire a professional crew to record the script so I went to Medical Television, a group at UT Southwestern Medical Center at Dallas that specializes in video and audio production. They gave me the uncut version and I did all of the audio editing in Adobe Premiere Pro®.

My next objective was to determine what style would be most interesting and fun for high school students. So I created a storyboard to plan out what assets I would need and in what order I would use them.

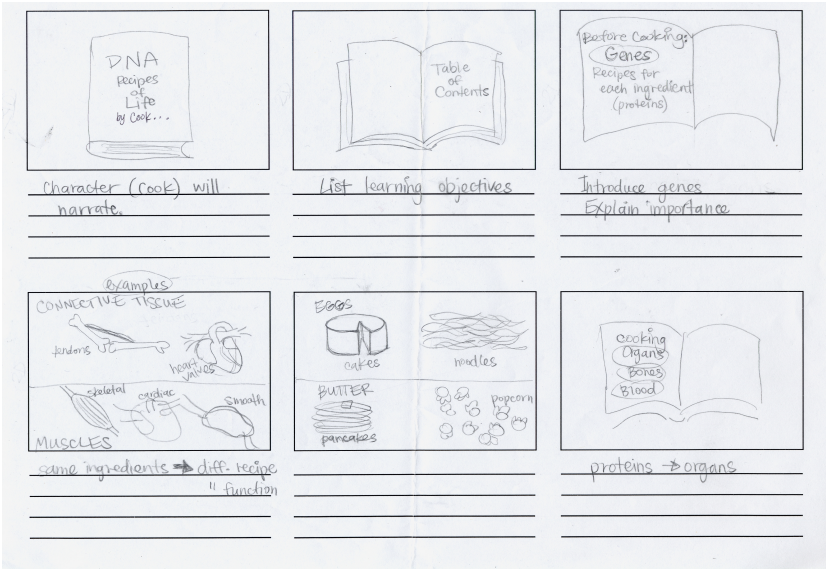

Figure 3-2. Original storyboard for recipe book section.

Next, I built my assets in Adobe Illustrator® and Adobe Flash®. I decided to use Flash because most of the popular cartoons online and on television use a vector-based style.

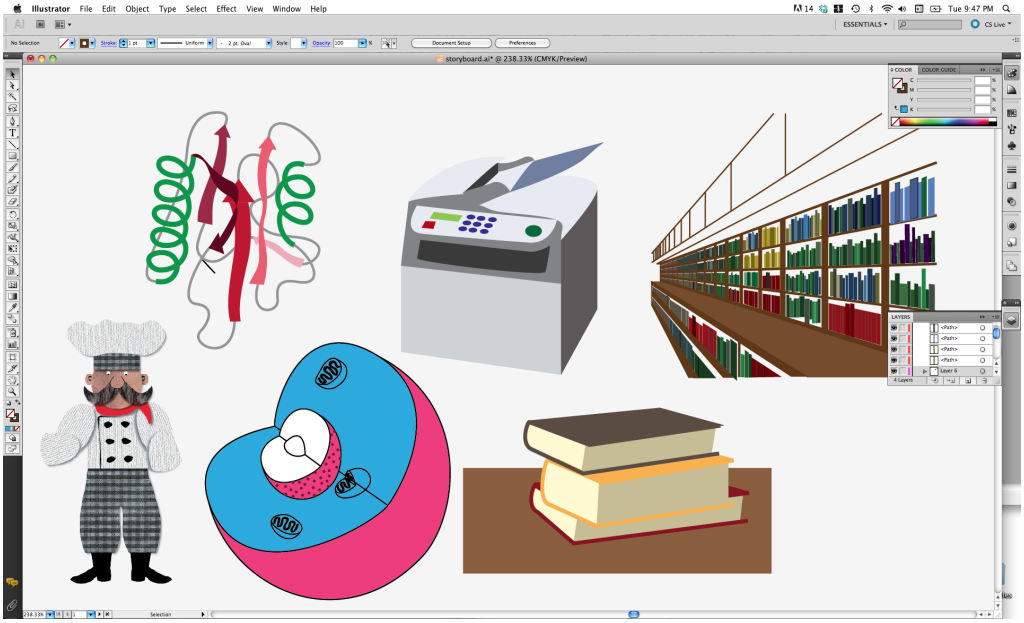

Figure 3-3. Screenshot of original assets in Adobe Illustrator®.

My next objective was to design the animation to be used in a public school environment. The public school this program was made for didn't have computers for each student. Because of this, I decided to make it available in DVD form so it could be used as a supplement to classroom instruction or used independently by students as a study aid.

Next, I needed to define a method for testing comprehension. I decided to intersperse short quizzes after every 2 to 3 minutes of animation. These quizzes included answers to questions using clips from the animation. These quiz questions could be used to illicit classroom discussion or to be answered silently by the students on their answer sheet.

The next step was to put together my animation. My animation was created and

assembled entirely in Adobe Flash®. First, the audio was imported. Then the assets were animated on the Flash timeline and synched to the audio.

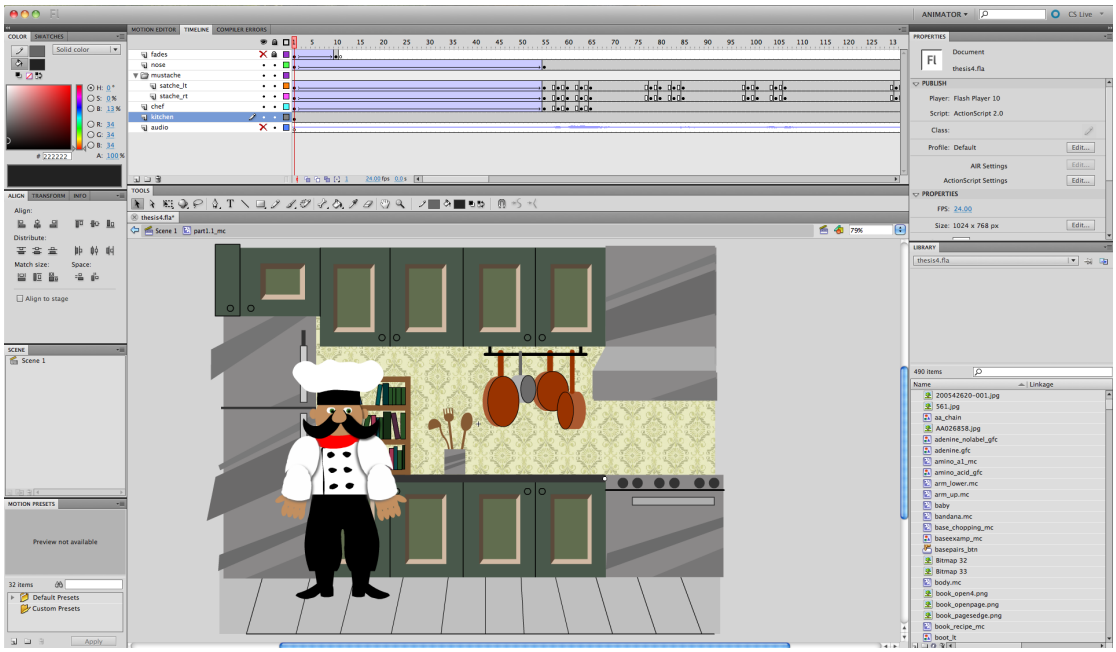

Figure 3-4. Flash working file.

My next objective was to design the animation so it could be used in a public school environment. It needed to be viewed by many students at once because students don't have access to their own computer. To do this, I decided that creating a DVD would be the best option. I used Adobe Encore® to format and create the DVD.

CHAPTER FOUR
Results

Evaluation of the Program

My last objective was to evaluate comprehension and the effectiveness of the animation. I administered a pre-test and post-test that included the same questions (Figure 3-5). The correct answers are marked with an asterisk. I also administered a evaluation based on the Likert scale to students and the teacher. I did evaluations at John Horn High School in Mesquite, TX. Because it was during summer school, the class consisted of sixteen tenth through twelfth graders (meaning they will start that grade this year in September). Some students were making up credits while others were taking summer classes in order to graduate early.

The pre-test was given immediately before viewing the animation. The post-test was taken after each section of the animation, 3 to 4 questions at a time. The Likert Scale evaluation was given at the very end.

The Likert Scale evaluation consisted of 12 statements (Figure 3-11). The Likert Scale answers were evaluated on a 5-point Likert Scale ranging from Strongly Agree to Strongly Disagree. Respondents were asked to indicate their level of agreement. The last evaluation statement asked if there were other scientific concepts that would be helpful to be learned in this way. This was followed by space for additional comments.

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   ★b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   ★c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   ★c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   ★a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   ★b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   ★b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   ★a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   ★a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   ★d. Amino Acids

10. What is a codon?
    a. A group of amino acids
    ★b. A group of 3 DNA bases
    c. A group of 5 DNA bases
    d. A group of RNAs

Figure 3-5. Pre-Test and Post-Test Quiz.

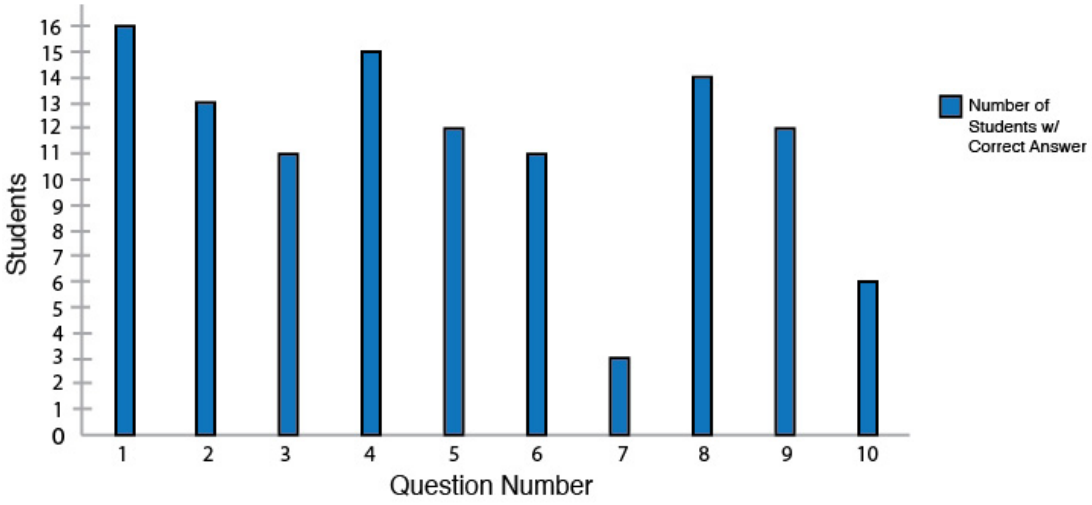

Figure 3-6. Pre-Test Results.

The most missed questions were numbers 7 and 10. Most students answered on 7 that "lysosomes" was the correct answer. On number 10, most students answered "group of amino acids."

On the post-test, the same 10 questions were asked in order to effectively evaluate comprehension before and after viewing the animation. Again, the questions were not answered all at once, but after each section.

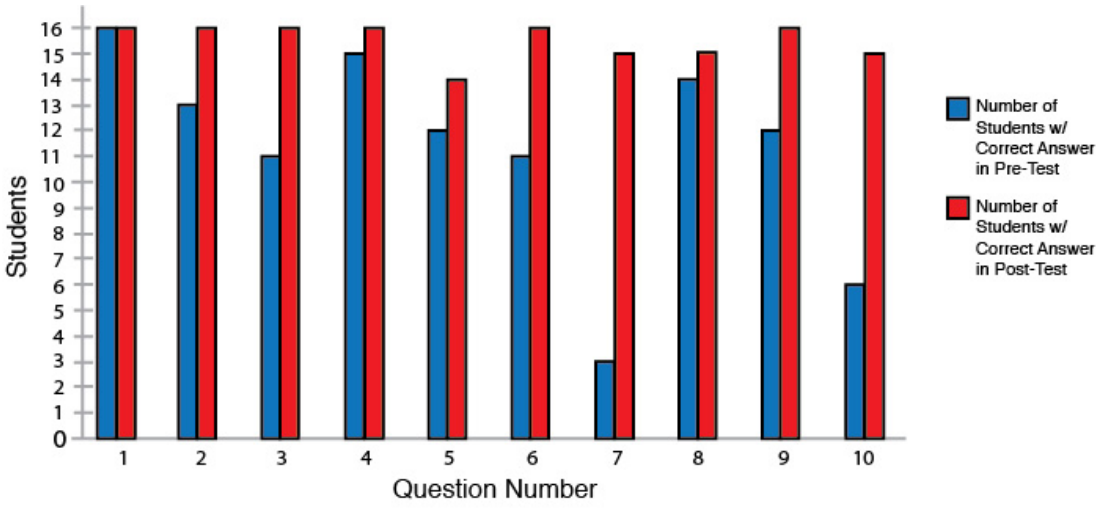

Figure 3-7. Pre-Test and Post-Test Results.

The question with greatest improvement was number 7 which asked, “Where does mRNA go once it leaves the nucleus?” Most students chose “lysosome” for the answer instead of the “Rough Endoplasmic Reticulum”.

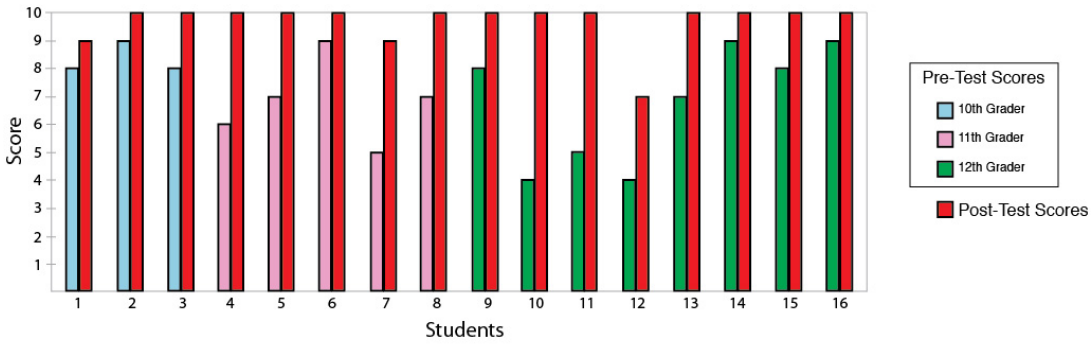

Figure 3-8. Individual Pre-Test and Post-Test Results.

As indicated in Figure 3-8, every student improved their score. There was no decline in scores on any question. This shows actual comprehension of learning objectives and that not a lot of guessing was taking place overall.

It is interesting to note, that although there were only 3 tenth graders tested, their pre-test scores were better than the eleventh and twelfth graders, on average. This could be because they were just taught the material in the previous year so it was still somewhat fresh in their minds.

Also, because it was summer school, it's important to note that there was a mixture of honors and remedial students. In the end, all scored very high, with the lowest test

score being student 12 with score of 7 out of 10. and the second lowest score being 9 out of 10 from 2 students. The rest earned ten out of ten!

A Likert scale evaluation was given to students after viewing the animation and taking the quiz to evaluate their perceptions and what they thought about the animation overall. It was important to not only see if their knowledge improved, but to also get feedback from the students about what they perceived to be the most effective parts of the program. I also hoped it would be helpful for future Master's degree candidates to help them decide how they should create their program.

NAME:_____

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5Strongly Agree

1. I like the cartoon style used in the animation.
2. I like the analogies used in the animation.
3. I think the analogies used helped me understand about DNA, RNA, and proteins.
4. I know more about these concepts after viewing the animation.
5. The quizzes helped me better figure out what concepts I knew and didn't know.
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer.
7. I think it was helpful to take quizzes in between the parts instead of at the end.
8. The analogies didn't confuse me.
9. If I had a DVD of this animation, I would use it on my own to study before a test.
10. If this animation were online, I would use it on my own to study before a test.
11. The animation made me interested/excited to learn about DNA, RNA, and protein.
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
_____

Comments:

_____

_____

Figure 3-9. Likert Scale Evaluation.

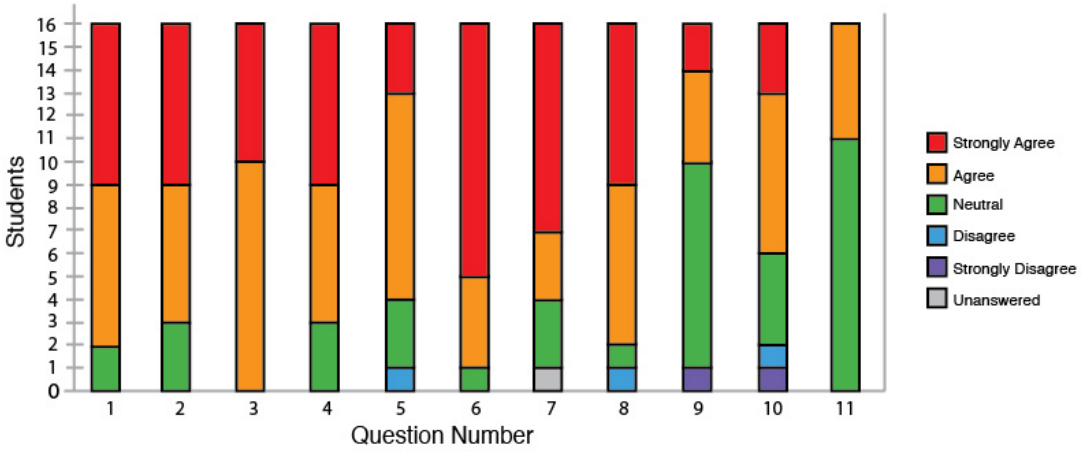

Figure 3-10. Likert Scale Evaluation Results.

As indicated in Figure 3-10, overall there was a positive response to all of the questions. Statement number 5 was “The quiz helped me better figure out what concepts I knew and didn't know.” Only 1 disagreed.

Number 8 was “The analogies didn't confuse me.” One person disagreed.

Numbers 9 and 10 had a lot of neutral and a couple negative responses. The statements were “If I had a DVD of this animation, I would use it on my own to study before a test” and “If this animation were online, I would use it on my own to study before a test.”

Number 11 had a lot of neutral responses. The statement was “The animation made me interested/excited to learn about DNA, RNA, and protein.” Even though the animation didn't necessarily make them more interested in the subject matter, based

on the post-test results there is no doubt they learned it.

Number 12 asked “Was there any other scientific concepts you can think of that

would be helpful to learn in this way? The responses were:

- “Body systems”
- 'Wavelength”
- “Osmosis”
- “No. Just all science I guess.”
- “Physics”
- “Possibly animal-related”
- “It would help a lot with my chemistry that I didn't get last year. Sometimes there is so much info at once it is hard to test after a whole video. I definitely think this type of video would have helped me.”

Then I had a comment section. There were no negative comments. Some of the

responses were:

- “I'm used to watching videos like this one but this video was exceptionally good.”
- “I love science so this was fun for me.”
- “The vid was cool. Love the Italian chef and how he related it to a recipe. Good studying tactic and made answering the questions easier to answer.”
- “Good!”
- “This could really help if you needed it.”
- “This video is good for people that do not know!”
- “Funny animation!”
- “It was a cute animation. Better to understand than just teaching from a book.”
- “It was a pretty good animation and would be good for teaching. I would not use them to study only because I never really study.”
- “It was fun; not just information.”
-”Best way to learn.”

The teacher said:

“I could tell the students were engaged. The results of the post-test are impressive. I would definitely use this animation to teach again. I could see a similar program being used to teach pretty much any concept but specifically life science on the molecular level.”

CHAPTER FIVE
Conclusions and Recommendations

Goal and Objectives

The goal of this thesis project was met: to create an educational animation that will aid in comprehension of DNA, RNA, and protein synthesis. The project created a new explanation of existing subject matter of DNA. The animation can be used as a supplement to textbooks and lectures. The project is specifically made for high school students, specifically ninth graders when these concepts are first introduced. The success of the program depended on improvement in comprehension among sixteen high school students who viewed and evaluated it.

Successes

Looking at the post-test results alone show that the animation succeeded in multiple areas. It increased knowledge of the learning objectives presented from pre-test to post-test. Overall, the responses of the Likert Scale Evaluation were positive. The students' perception of the program was that it aided in comprehension, the use of analogies were effective, and that this method of teaching would be helpful in other areas of science.

Problems

There were no major apparent problems with the program. Something that could have been investigated further is why so many neutral responses were given to statement 11 on the Likert Scale Evaluation. It is not clear whether the students found the

animation a little boring or if they are just not too interested in the subject matter.

Recommendations for Further Study

More advanced concepts based on the learning objectives could be incorporated into this program in the future.

Different Testing Methods

Instead of administering a pre-test only minutes before the animation is showed, it could be helpful to see if similar results could be reached if the pre-test was given a week or even a month before. This would better judge the students' knowledge before and after viewing the animation. Also, a more extensive quiz section could be created with more questions of varied difficulty. Testing a larger group to see if similar results would be reached could be done also. And, finally, it would be important to find out if the students who used this animation had better TEKS scores than those who did not.

Test Long-Term Knowledge Retention

A summative test could be given, testing the same students a year later to see if they retained what they learned. A control group who didn't use the program could be tested with the students who had viewed the program a year before. This would effectively evaluate the long-term effectiveness of the program.

APPENDIX A
Script

Hello! My name is Lorenzo. Today, we are going to talk about DNA. All right! Let's get cooking!

DNA stands for Deoxyribonucleic Acid. DNA is the hereditary stuff that makes us who we are! DNA's main purpose is long term storage of information. In eukaryotes, this information is found in the nucleus of the cell. Think of DNA as a library of recipe books. Just as a recipe book contains instructions on how to cook a lasagna or bake a pie, DNA contains the genetic instructions used in the development and functioning of all known living cells that turn into proteins. These proteins make up all organisms. DNA is the basic unit of heredity. It's what codes all of our genetic information. It's what makes our hair black, our eyes green, and our nose like our mother's!

These instructions are held in the reference part of the library. These recipes can't be checked out. They can only be copied. Similarly, DNA never leaves the nucleus. It can only be copied by DNA polymerase. This DNA polymerase is like a copy machine, making copies of the recipes that will be needed to make the proteins. This process of copying DNA is called replication.

How does the information get stored in the molecule and how does that turn into the proteins that make up our enzymes, our organs, fingernails, etc.?

As I said before, DNA is found in the nucleus in eukaryotes. Prokaryotes don't have nuclei, so their DNA is found elsewhere. DNA's structure is a double helix that looks like a twisted ladder. The helices are intertwined with one other and are connected by bridges that look like rungs of a ladder. The sides of the ladder are made up of nucleotides. A nucleotide is made up of a (1) nitrogen-containing base, (2) a 5-carbon sugar (in this case, deoxyribose) and (3) a phosphate group. The sugar and the phosphate are on the outside of the DNA molecule, so they combine to form the sugar-phosphate backbone of DNA. This backbone allows the DNA to maintain its shape.

What allows us to code information are the parts that make up the rungs of the ladder. The rungs are made up of 4 different molecules called nitrogen bases. These molecules are adenine, thymine, guanine, and cytosine. Thymine and cytosine are pyrimidines, which contain one ring of carbon and nitrogen atoms. Adenine and guanine are purines because they contain 2 rings of carbon and nitrogen atoms.

Adenine pairs with thymine. This is called a complementary base pair. Then you have guanine and it pairs with cytosine. These pairs code information. They are held together by weak hydrogen bonds.

If you have one of them then BAM! You have all of the information for the other.

This is because each strand of DNA is able to serve as a pattern for copying the sequence of bases that will be passed on to the next generation of cells.

When these base pairs code or transcribe information, these 2 strands split up and one of these strands transcribes a complementary mRNA strand. mRNA stands for messenger RNA. The bases are just like the bases in DNA but instead of thymine, there's uracil. So instead of a T, there's a U. The mRNA strand that makes genes that code for proteins is found in the nucleus of the cell. Remember our recipe analogy? mRNA is the recipe! It's the recipe that is copied from the recipe books in the library (DNA), using the copy machine (DNA polymerase).

RNA is a single-stranded molecule. The mRNA detaches itself from the DNA it was transcribed from, leaves the nucleus, and goes to the rough endoplasmic reticulum (RER). Inside the RER, the mRNA attaches to a structure called a ribosome. A ribosome is a complex made of RNAs and proteins that hold all of the molecules together and organize the process. It is like a chef, like ME!, that receives the recipe. In the ribosomes, the mRNA is used as a pattern to translate and assemble proteins. Whatever recipe the chef receives, that's the protein that will be made. The process of proteins being made from mRNA is known as translation.

DNA and RNA have 3 major differences:

1. DNA contains the sugar deoxyribose. RNA contains the sugar ribose.
2. DNA is double-stranded. RNA is single stranded.
3. DNA contains the nitrogen base thymine. RNA contains uracil.

There are 3 kinds of RNA that are involved in making a protein. There is messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA, (tRNA). To understand how each of these works together to make a protein, you must first understand what a protein truly is. DNA and RNA are chains of nucleotides, and proteins are chains of amino acids.

Everything we are is made up of proteins! Amino acids are the building blocks of protein. There are 20 amino acids that make up the structure of our protein. Proteins can be hundreds of amino acids long.

Amino acids are identified by each 3 letter sequence in the mRNA. This sequence is known as a codon. So 1 codon equals 3 DNA bases.

Using the codon chart, you can see almost every amino acid has more than one codon. This is to prevent mutations from changing a protein. Stop on the codon chart means there is not an amino acid that goes with these special codons. This means that the tRNA molecules will stop attaching to the mRNA. This causes the production of the protein to stop! The protein is then released from the ribosome and floats through the cytoplasm to do its job. Remember, the cytoplasm is the aqueous solution of nutrients that fills every cell.

The messenger RNA or mRNA contains the instructions for the protein. RNA is like the recipe copied from the DNA to make protein. At the ribosomes, an mRNA molecule acts as a template or pattern for tRNA molecules. tRNA is transfer RNA. tRNA molecules are the trucks for the amino acids. These amino acids will be attached to tRNA molecules which has the code for the codons in an anti-codon which are groups of 3 bases. The anti-codon enters the ribosome and attaches its amino acid to the growing protein. Hydrogen bonds form the base pairs. Once the tRNA molecules have pulled up and attached to the mRNA strand the amino acids bond to each other and the tRNA when they're close together. Then the tRNA detaches. The chain of amino acids fold and form complex, intricate 3d patterns.

The protein is sent across the cell to the Golgi apparatus. Inside the Golgi body, the protein is modified by adding sugars or lipids, and then it is sent to its final destination whether it's muscle, skin, or another organ.

APPENDIX B
Pre-Tests

NAME: Bradley Jahri GRADE: 10

QUIZ

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   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

NAME: Torrence GRADE: 10

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NAME: Nicole Johnson GRADE: 11

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4

NAME: Purple Thursdays GRADE: 11

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NAME: Grace GRADE:____

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6

NAME: Mac Miller GRADE: 11

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7

NAME: DJ. Newsom GRADE: 12

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NAME: Nizo Villarreal / Future Ruler of the World GRADE: 11

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Chivas suck!!

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NAME: Alexa Shaffer GRADE: 12

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NAME: Liri GRADE: 12

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12

Twilight

NAME: [illegible] GRADE: 12th

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NAME: Israel Garcia GRADE: 12

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NAME: Janette GRADE: 12

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3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

15

NAME: Kade Lunsford GRADE: 12

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

16

NAME: Robin Morgan GRADE: 12

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

APPENDIX C
Post-Tests

NAME: [illegible] GRADE: 10

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

2

NAME: Torrence GRADE: 10

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

3

NAME: Grace GRADE:____

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

NAME: Purple Thursdays GRADE:____

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
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   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

5

NAME: Nicole Johnson GRADE: 11

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
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   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

NAME: Mac Miller GRADE: 11

QUIZ

1. What do the initials DNA stand for?
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   d. Cytoplasm

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   d. Corkscrew

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   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
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   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
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9. What are proteins made of?
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   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
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7

NAME: _____ GRADE:____

QUIZ

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   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
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9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

NAME: Mr. Awesomness GRADE: 11

QUIZ

1. What do the initials DNA stand for?
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   d. Deoxygenated Acid

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   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

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   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

9

NAME: D.J. Newsom GRADE: 12

QUIZ

1. What do the initials DNA stand for?
   - a. Deoxynucleic Acid
   - b. Deoxyribonucleic Acid
   - c. Ribose Acid
   - d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   - a. In the cytoplasm
   - b. In the cell wall
   - c. In the nucleus
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   - a. Cell Membrane
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   - a. Double Helix
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   - d. Corkscrew

5. What does mRNA stand for?
   - a. Merry Ribonucleic Acid
   - b. Messenger Ribonucleic Acid
   - c. Mono Ribonucleic Acid
   - d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   - a. A,C, T, and O
   - b. A, G, C, and U
   - c. A, G, C, and T
   - d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   - a. Rough Endoplasmic Reticulum
   - b. Cell Membrane
   - c. Lysosome
   - d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
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   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
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   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

10

NAME: Alexa Shaffer GRADE: 12

QUIZ

1. What do the initials DNA stand for?
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   b. Messenger Ribonucleic Acid
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6. The nitrogen bases of RNA are:
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   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

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   a. mRNA, tRNA, rRNA
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   d. mRNA, cRNA, rRNA

9. What are proteins made of?
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10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

NAME: Lili GRADE: 12

QUIZ

1. What do the initials DNA stand for?
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5. What does mRNA stand for?
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   b. Messenger Ribonucleic Acid
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6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
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   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
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9. What are proteins made of?
   a. Milk
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10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

12

NAME: twilight New moon GRADE: 12th

QUIZ

1. What do the initials DNA stand for?
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10. What is a codon?
   a. A group of amino acids
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   c. A group of 5 DNA bases
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13

NAME: Israel Garcia GRADE: 12

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
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2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
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   c. Nucleus
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   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

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   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

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   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
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   c. A group of 5 DNA bases
   d. A group of RNAs

NAME: Janette GRADE: 12

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

NAME: Kade Lunsford GRADE: 12

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

NAME: Robin Morgan GRADE: 12

QUIZ

1. What do the initials DNA stand for?
   a. Deoxynucleic Acid
   b. Deoxyribonucleic Acid
   c. Ribose Acid
   d. Deoxygenated Acid

2. Where is DNA found in eukaryotes?
   a. In the cytoplasm
   b. In the cell wall
   c. In the nucleus
   d. In the hair

3. What do eukaryotes have that prokaryotes don't have?
   a. Cell Membrane
   b. DNA
   c. Nucleus
   d. Cytoplasm

4. What is the structure of DNA?
   a. Double Helix
   b. Single Stranded
   c. Straight ladder
   d. Corkscrew

5. What does mRNA stand for?
   a. Merry Ribonucleic Acid
   b. Messenger Ribonucleic Acid
   c. Mono Ribonucleic Acid
   d. Mischievous Ribonucleic Acid

6. The nitrogen bases of RNA are:
   a. A,C, T, and O
   b. A, G, C, and U
   c. A, G, C, and T
   d. G, C, U, and O

7. Where does mRNA go once it leaves the nucleus?
   a. Rough Endoplasmic Reticulum
   b. Cell Membrane
   c. Lysosome
   d. Golgi Apparatus

8. What are the 3 types of RNA involved in making a protein?
   a. mRNA, tRNA, rRNA
   b. mRNA, tRNA, bRNA
   c. tRNA, rRNA, sRNA
   d. mRNA, cRNA, rRNA

9. What are proteins made of?
   a. Milk
   b. RNA
   c. Chicken
   d. Amino Acids

10. What is a codon?
   a. A group of amino acids
   b. A group of 3 DNA bases
   c. A group of 5 DNA bases
   d. A group of RNAs

APPENDIX D
Likert Scale Evaluations

NAME: [illegible]

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 5
2. I like the analogies used in the animation. 3
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation. 5
5. The quizzes helped me better figure out what concepts I knew and didn't know. 5
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 5
8. The analogies didn't confuse me. 5
9. If I had a DVD of this animation, I would use it on my own to study before a test. 4
10. If this animation were online, I would use it on my own to study before a test. 2
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 4
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
No, I'm used to watching videos like this one but this video was exceptionally good.

Comments:

NAME: Torrence

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 5
2. I like the analogies used in the animation. 5
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 5
4. I know more about these concepts after viewing the animation. 3
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 4
8. The analogies didn't confuse me. 4
9. If I had a DVD of this animation, I would use it on my own to study before a test. 4
10. If this animation were online, I would use it on my own to study before a test. 5
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 4
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    it was fun not just information

Comments:

I love science so this was very fun for me

NAME: Nicole Johnson

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

5 1. I like the cartoon style used in the animation.

4 2. I like the analogies used in the animation.

5 3. I think the analogies used helped me understand about DNA, RNA, and proteins.

3 4. I know more about these concepts after viewing the animation.

3 5. The quizzes helped me better figure out what concepts I knew and didn't know.

4 6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer.

5 7. I think it was helpful to take quizzes in between the parts instead of at the end.

5 8. The analogies didn't confuse me.

4 9. If I had a DVD of this animation, I would use it on my own to study before a test.

4 10. If this animation were online, I would use it on my own to study before a test.

3 11. The animation made me interested/excited to learn about DNA, RNA, and protein.

12. Are there other scientific concepts you can think of that would be helpful to learn in this way?

Comments:

The vid. was cool, Love the Italian chef & how he related it to a recipe. Good studying tactic & made answering the questions easier to answer.

Hope it goes well, GOOD LUCK!

NAME: Purple Thursdays

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 5
2. I like the analogies used in the animation. 4
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 5
4. I know more about these concepts after viewing the animation. 4
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 5
8. The analogies didn't confuse me. 5
9. If I had a DVD of this animation, I would use it on my own to study before a test. 1
10. If this animation were online, I would use it on my own to study before a test. 1
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    Not that I can think of

Comments:

NAME: Gavan

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 4
2. I like the analogies used in the animation. 5
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 5
4. I know more about these concepts after viewing the animation. 5
5. The quizzes helped me better figure out what concepts I knew and didn't know. 3
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 3
8. The analogies didn't confuse me. 4
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3
10. If this animation were online, I would use it on my own to study before a test. 3
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way? physics

Comments:

NAME: Mar Miller

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 5
2. I like the analogies used in the animation. 3
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation 4
5. The quizzes helped me better figure out what concepts I knew and didn't know. 2
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 3
7. I think it was helpful to take quizzes in between the parts instead of at the end. 3
8. The analogies didn't confuse me. 5
9. If I had a DVD of this animation, I would use it on my own to study before a test. 5
10. If this animation were online, I would use it on my own to study before a test. 5
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    Best way

Comments: Good!

NAME: D.J. Newsom

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 4.
2. I like the analogies used in the animation. 3.
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4.
4. I know more about these concepts after viewing the animation. 3.
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4.
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5.
7. I think it was helpful to take quizzes in between the parts instead of at the end. 5.
8. The analogies didn't confuse me. 5.
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3.
10. If this animation were online, I would use it on my own to study before a test. 4.
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3.
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
No. Just all science I guess.

Comments:

NAME: Nico Villameal

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 3
2. I like the analogies used in the animation. 5
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation. 5
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 4
7. I think it was helpful to take quizzes in between the parts instead of at the end. 4
8. The analogies didn't confuse me. 4
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3
10. If this animation were online, I would use it on my own to study before a test. 3
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 2/3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    Osmosis?

Comments:
This could really help if you needed it

NAME: [illegible]

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 4
2. I like the analogies used in the animation. 4
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation. 5
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 3
8. The analogies didn't confuse me. 3
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3
10. If this animation were online, I would use it on my own to study before a test. 4
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?

Comments:

this video is good [illegible] not [illegible]

NAME: Alexa Shaffer 12

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 5
2. I like the analogies used in the animation. 5
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation. 5
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 5
8. The analogies didn't confuse me. 4
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3
10. If this animation were online, I would use it on my own to study before a test. 4
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 4
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    none that I can think of.

Comments:
It was a cute animation. Better to understand, than just teaching from a book.

NAME: Liri

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 5
2. I like the analogies used in the animation. 5
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 5
4. I know more about these concepts after viewing the animation. 5
5. The quizzes helped me better figure out what concepts I knew and didn't know. 5
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 4
7. I think it was helpful to take quizzes in between the parts instead of at the end. 5
8. The analogies didn't confuse me. 5
9. If I had a DVD of this animation, I would use it on my own to study before a test. 4
10. If this animation were online, I would use it on my own to study before a test. 4
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    Wavelength

Comments:
Funny animation!

NAME: Twirlisha

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 4
2. I like the analogies used in the animation. 5
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 5
4. I know more about these concepts after viewing the animation. 3
5. The quizzes helped me better figure out what concepts I knew and didn't know. 3
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 5
8. The analogies didn't confuse me. 2
9. If I had a DVD of this animation, I would use it on my own to study before a test. 5
10. If this animation were online, I would use it on my own to study before a test. 5
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 4
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    NO

Comments:

NAME: Israel Garcia

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 3
2. I like the analogies used in the animation. 4
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation. 4
5. The quizzes helped me better figure out what concepts I knew and didn't know. 5
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 4
7. I think it was helpful to take quizzes in between the parts instead of at the end.
8. The analogies didn't confuse me. 4
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3
10. If this animation were online, I would use it on my own to study before a test. 3
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    Possibly animal related.

Comments:

NAME: Janette

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 4
2. I like the analogies used in the animation. 4
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation. 4
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 5
8. The analogies didn't confuse me. 4
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3
10. If this animation were online, I would use it on my own to study before a test. 4
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way?
    study guide

Comments:

NAME: Kade Lunsford

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 4
2. I like the analogies used in the animation. 4
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation. 5
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 4
8. The analogies didn't confuse me. 4
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3
10. If this animation were online, I would use it on my own to study before a test. 4
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 3
12. Are there other scientific concepts you can think of that would be helpful to learn in this way? 4

Comments:

It would help alot with my chemistry that I didn't get last year. Sometimes there is so much info at once it is hard to test after a whole video. I definately think this type of video would have helped me

NAME: Robin Morgan

1 Strongly Disagree — 2 Disagree — 3 Neutral — 4 Agree — 5 Strongly Agree

1. I like the cartoon style used in the animation. 4
2. I like the analogies used in the animation. 5
3. I think the analogies used helped me understand about DNA, RNA, and proteins. 4
4. I know more about these concepts after viewing the animation. 3
5. The quizzes helped me better figure out what concepts I knew and didn't know. 4
6. Answering the quiz questions with parts of the animation was more effective than just giving me the answer. 5
7. I think it was helpful to take quizzes in between the parts instead of at the end. 5
8. The analogies didn't confuse me. 5
9. If I had a DVD of this animation, I would use it on my own to study before a test. 3
10. If this animation were online, I would use it on my own to study before a test. 3
11. The animation made me interested/excited to learn about DNA, RNA, and protein. 4
12. Are there other scientific concepts you can think of that would be helpful to learn in this way? body systems

Comments:

It was a pretty good animation and would be good for teaching. I would not use them to study only because I never really study.

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