GENETIC MUTATIONS: A STARS SCIENTIFIC SUITCASE FOR 9th GRADE SCIENCE EDUCATORS

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DEDICATION

First, I would like to thank the force known as God. It takes a celestial force to keep this mind on track (chuckles).

To my father, Richard, for his granting me his notion of creativity and love of science. To my mother, Maria Guadalupe, for teaching me persistence, love and the joy of art. To my sister, Jennifer, for showing me that once you tread down a road, you can go as far as you want to. I would be nothing without any of you. Thank you!

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GENETIC MUTATIONS: A STARS SCIENTIFIC SUITCASE FOR 9th GRADE SCIENCE EDUCATORS

by

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GENETIC MUTATIONS: A STARS SCIENTIFIC SUITCASE FOR 9th GRADE HIGH SCHOOL SCIENCE EDUCATORS

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The purpose of this project was to design and produce a lightweight scientific suitcase teaching tool that ninth grade high school science educators may implement into their curriculum when teaching students the concepts about genetic mutations. Contained within the suitcase are an animation, card game, hands-on models, and display posters, along with a teacher's instruction manual. This scientific suitcase was created in an attempt to fill in the apparent lack of information over genetic mutations that is present in current Texas high school textbooks and resources. It may assist students in better preparing for standardized testing by giving their educators an all-in-one module that can give the classroom extensive information on genetic mutations, all in one easy to carry

suitcase. The suitcase components have been evaluated for their effectiveness and appeal by current educators, from 8th grade to college level, who specialize in multiple fields of science. The scientific suitcase's impact on students' performance and comprehension will be tested by STARS and DISD once it has been fully integrated into the science classroom curriculum.

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Deletion - The loss, as through mutation, of one or more nucleotides from a chromosome.

Duplication - The occurrence of a repeated section of genetic material in a chromosome.

Genetics - The branch of biology that deals with heredity, especially the mechanisms of hereditary transmission and the variation of inherited characteristics among similar or related organisms.

Genetic Mutation - Any event that changes genetic structure; any alteration in the inherited nucleic acid sequence of the genotype of an organism

Histone - Any of several basic proteins that, together with DNA, make up most of the chromatin in a cell nucleus.

Insertion - The addition, as through mutation, of one or more nucleotides on a chromosome.

Inversion - A chromosomal defect in which a segment of the chromosome breaks off and reattaches in the reverse direction.

Nucleosome - Any of the repeating subunits of chromatin, consisting of a DNA chain coiled around a core of histones.

Point Mutation - A mutation in which one nucleotide is added, deleted, or replaced by another. Point mutations include missense, nonsense, frameshift, and silent mutations.

Silent Mutation - Relating to a mutation that changes a nucleotide in a codon without a difference in the amino acid for which it is coded

Transition - A point mutation in which a purine is replaced by a purine, or a pyrimidine is replaced by a pyrimidine.

Translocation - A transfer of a chromosomal segment to a new position, especially on a non-homologous chromosome

Transversion - A point mutation in which a purine is replaced by a pyrimidine, or a pyrimidine is replaced by a purine.

CHAPTER ONE
Introduction

GOAL

The primary goal of this presented thesis project is to create a pragmatic, lightweight and portable scientific suitcase module which includes a hybrid card/board game, a short-length animation, hands-on physical model, demonstration video and full length posters that 9th grade science educators can utilize in teaching students basic and advanced concepts of genetic mutations. All components of this suitcase are contained within a small, flexible backup and carrying tube case. This suitcase is the sixth in a series of seven planned modules, produced for the Science Teacher Access to Resources at Southwestern (STARS) Science Triathlon. This program was developed with collaboration from the Department of Biomedical Communication and the University of Texas Southwestern Medical Center Graduate School, the Dallas Museum of Nature and Science, the Dallas Interdependent School District (DISD), and Advanced Placement Strategies (APS) program with funding provided through a sizable grant from the Howard Hughes Medical Institute. Additional support has been provided by the University of Texas Southwestern Graduate School, and the O'Donnell Foundation which specializes in strengthening math and science programs in Texas.

OBJECTIVES

The initial objective was to determine what information should be included to be presented to the target audience. To achieve this objective it was necessary to design interesting, visually appealing aids that simplified and clearly explained the basic and advanced mechanisms of genetic mutations. This led to the second objective of creating a dynamic 2-dimensional animation that delineated the known and theoretical mechanisms of genetic mutations, in a style that students would find appealing. The third objective was to create a hands-on model of a "nucleosome" that could be extensively manipulated by the educator and students. The purpose of the hands-on model was to teach the students the theoretical functions of a nucleosome in the process of genetic mutations, with emphasis in super-coiling. A fourth objective involved the creation of a game that would separate students into teams and place them into competition with one another, allowing students the opportunity to utilize their knowledge of genetic mutations to skillfully defeat the opposing team. The fifth objective was to create a schematic that educators could use to show students the vast difference in size that exists, even at the genetic level, between different genetic structures, such as nucleotides and a chromosome. The sixth and final objective involved designing all the individual components so they could be stored and carried in a small, lightweight case that could be easily moved and carried by an educator.

Focus

Overall, the primary focus was to create a lightweight, engaging scientific suitcase on genetic mutations that could assist 9th grade biology educators in enriching their science programs, possibly making the educational process more interesting and captivating for their biology students. This suitcase concentrates on basic and advanced concepts of genetic mutations, going beyond the singular concept of frame-shift mutation that is often seen in the TAKS testing samples. With this suitcase, it was my intention to create a flexible science module with engaging components that DISD educators could easily follow and implement successfully into their science courses through their daily lessons and class time. The potential of this science suitcase lays in the fact that with the recommended implementation it may help students better comprehend the different mechanism of genetic mutations and their results.

Background

Triathlon

In 2007, the STARS (Science Access to Resources at Southwestern) program designed a three-part science-enrichment program titled the *STARS Science Triathlon*. Currently an on-going project, the *Triathlon* is composed of three sections in which DISD teachers may participate. These events are held either during regular school semesters or over the summer months, and the information and activities from one event often tie over into

another event. The *Triathlon* spans a fifteen month period, and includes a twelve day summer workshop, mini-symposia held through the academic year and an eight-week research project held the following summer break where teachers participate alongside University of Texas Southwestern Medical scientists.

The *Triathlon* is generally offered to 10 participating teachers from DISD each year and covers the core scientific topics that are required by the Texas Education Agency. These topics are enumerated in the Texas Essential Knowledge and Skills (TEKS). Currently, the 2010-2011 TEKS covers scientific areas in aquatic science, astronomy, biology, chemistry, earth and space science, environmental systems, integrated physics and chemistry, and physics. This scientific suitcase, along with the previous five suitcases, has been designed to assist in the teaching of biological concepts, such as photosynthesis, enzymes, membranes, organelles, evolution, and mutations. The first *Triathlon* event consists of workshops where teachers are guided by specialized educators on how to hone their scientific skills for more effective use in the classroom, while emphasizing the core science topics listed in the TEKS. During the academic years, the selected educators will attend at least half a dozen mini-symposia that delve further into the core topics. The third and final event includes research conducted by the educators, alongside University of Texas Southwestern Medical scientists, where they utilize the experience and information gained from previous events and laboratories.

Integrated into the laboratory activities taught during the *Triathlon* are fully functioning, portable, scientific modules known as science suitcases. The suitcases have been

designed as portable exhibits that explain in-depth one of the core science topics found in the TEKS. The suitcases may contain animations, hands-on physical models, table-top and video games, demonstration videos and supplies for wet-lab experiments.

Student Learning Styles

A widely employed learning style that is currently utilized in educational settings is the VARK method. Proposed by Neil Fleming's 1992 work titled Not Another Inventory, Rather a Catalyst for Reflection, this learning style approaches teaching by proposing that teachers should help students find their learn pattern, the method which they learn best in an educational setting. VARK stands for Visual/Audio/Read/Kinesthetic. According to Fleming, students prefer learning through one of four methods. Some students will either prefer learning through a "preference for graphical and symbolic ways of representing information" manner, as seen in visual learners. Some students, the audio learners as they are known, will gravitate towards "a preference for "heard" information." Other students will prefer to learn through "preferences for information printed as words." These are the read learners. And finally, those that prefer a hands-on approach will be known as kinesthetic learners (Fleming).

Open Cooperation in the Classroom

Studies suggest that an environment of open cooperation, where students can support one another in the reaching of an academic goal, can be a very beneficial environment that may be conducive to the learning of science. Classrooms where learning is through social interactions, where there is open cooperation between students of the class while trying to

reach an academic goal, produces an environment that "can foster student engagement with topics that may not have previously held interest" for them (Olitsky). An avoidance of social interactions during the teaching of lessons could negatively affect the students' achievement and "reduce the likelihood they will seek out professions and/or interests that involve science" (Olitsky).

Texas Science Knowledge Requirements for High School Students

The Texas Education Agency (TEA) has developed an enumerated list of core science topics with expanded concepts that students should comprehend by the end of their final high school year (Texas Education Agency). Published as the Texas Essential Knowledge and Skills (TEKS), these concepts are tested in a state-wide standardized test required by the TEA. Known as the Texas Assessment of Knowledge and Skills (TAKS), students throughout the state of Texas test their knowledge of these core scientific concepts by periodically submitting to TAKS testing. Currently, students are given the TAKS test during their tenth, eleventh and twelfth grade school year. The questions are based on the knowledge that students should have acquired in previous years of education. As of this time, TEKS requires that students understand the changes that mutations can bring about to the existence of an organism, and how these changes can impact the affected organism.

Scope of the Project

The scope of this thesis was limited to level-appropriate learning materials for ninth grade students. The materials incorporated into the suitcase had to be easily replenished, with an initial production cost to not exceed $3500 total for fabrication. The cost to maintain the individual components for at least ten uses per year could not exceed $1000. The written material, such as game guides for educators and students, was made to be durable but also to be easily replicated on any black and white copier. The animation had to be formatted to run on a PC or Apple system, and on a DVD player, while still retaining a high quality of resolution so it could streamed directly from the internet. Optimally, the hands-on models had to be primarily light enough to not weigh down the carrying case and still have enough resistance to withstand handling by the students. The board game had to be flexible enough to withstand three years of use, and still fit into a compact case in a comfortable and easy to install manner. Lastly, it would be optimal to have all individual components within the suitcase resist breaking, tears or rough treatment, exposure to extreme temperature variations due to storage or transportation, and resist humidity if ever doused or soaked by any liquids.

Significance

The learning materials available to ninth grade students learning biology, specifically genetic mutations, have advanced considerably when compared to previous decades. Despite these advances, the visual materials often employed are ineffective, many times

confusing. Standardized Texas high school textbooks do not provide extensive, detailed animations on genetic mutations. They also lack updated information on certain scientific discoveries, such as the currently accepted functions of nucleosomes in epigenetics. Many classrooms do not have access to hand-on models, specifically models that are subject-specific (Carolina). Students would benefit from having access to hands-on models since a hands-on learning approach has "a substantial positive effect on science achievement." (Areepattamannil). Board games are an effective approach to teaching, either using a classic board game that has been modified for classroom use, or a subject-specific game designed specifically for a particular course. "New board games involve a sophisticated thought process that challenges kids to think critically," (Harris 2009) which can lead to greater comprehension of the material being taught.

This scientific suitcase could provide educators with a versatile resource that could aide them in teaching students complex biological concepts, while increasing the students' overall chance to retain the knowledge and exhibit a deeper understanding of the scientific processes being taught in the high school science classroom. Educators from DISD will have the option to utilize this scientific module, similar to any of the other scientific modules in the series, in their classroom and at no extra cost to them. The utilization of this suitcase can help better illustrate complex science concepts in a more effective, dynamic and appealing manner than most standardized current teaching materials permit. Specifically, this scientific suitcase can assist educators by providing resources that not only dynamically explain the basic and complex notions of genetic mutations, but that may in the long run help improve overall understanding of genetics

and the newer theories that are being widely accepted in this field of science. This goal may be reached with the components within, which include an animation, a fully designed board game, a malleable hands-on model and several full length posters.

As with all of the scientific modules in the STARS program, this suitcase will be maintained and distributed by the STARS program.

Evaluations

The scientific suitcase was shown to DISD educators in two separate symposia. The first exhibition of the suitcase showed the conceptual work in progress of the individual components, while the second exhibition showed the finished products and the intended manner of their use. Both exhibitions of the suitcase were done in two of the mini-symposia held during the academic school year. After each exhibition, educators then participated in an informal, non-scientific evaluation of this suitcase which included twenty-three questions for the first survey and twenty-eight questions for the second. The suitcase's influence on students' interest, performance and retention will be tested independently by DISD, and evaluated by STARS, once the suitcase has been fully incorporated into the DISD science curriculum.

CHAPTER TWO
Review of the Literature

GOAL

The overall purpose of the literature review was to find, with supporting evidence, the need for a scientific suitcase based on genetic mutations. Areas studied included Texas Essential Knowledge and Skills (TEKS) and its core concepts, current test results for high school science students who were administered the Texas Assessment of Knowledge and Skills (TAKS) exams, current educational books that deal with biology, literature based on designing animations and games for educational purposes, and informational studies on the success of animations, games and hand-on models in the science classrooms.

Relevant Literature

Starting Point

The previous theses posted by Brenda McArthur (McArthur) and Corbyn Beach (Beach) were invaluable initial research tools. Both projects provided sound and invaluable references that could be utilized in this scientific module since they too created scientific modules for the STARS program.

TEKS

TEKS enumerates the expected concepts that Texas students are expected to learn and comprehend. Under the section for high school biology, references to genetic mutations

are made and the concepts therein expected to be learned. TEKS states that students must "identify and illustrate changes in DNA and evaluate the significance of these changes" (Texas 4). It also states that students must comprehend how mutations can have an influence in the concept of evolution. Yet, examples of previous TAKS exams greatly favor questions about frame-shift mutation, an important phenomenon, but only one of at least six different basic types of genetic mutations. Questions over other types of genetic mutations are found to be at a minimum throughout recent TAKS examinations. Also noticeable is the lack of questions over histones, nucleosomes or any other genetic structure that could influence genetic mutations directly.

This could be an important note of interest should an educator decide to teach only those exact points expected to be asked in TAKS examinations, potentially omitting other important concepts of genetic mutations.

TAKS

The Texas Education Agency annually publishes the results of the Texas Assessment of Knowledge and Skills (TAKS) administered to Texas elementary, junior high and high school students. TAKS has a set standard goal, or minimum score, which students must reach to successfully complete the examination. The summary review for TAKS 2008 (Texas 2) test results showed that overall 64% of students had successfully met the standard goal set for the science portion of the TAKS. In the 2009, the summary review for TAKS (Texas 3) showed a slight improvement of 2%, with 66% of students successfully completing the science portion. The TAKS 2010 (Texas 4) test has shown a

significant improvement of 8%, with 74% of students successfully meeting the standard goal of the science portion. Also of interest, the summary reviews show that for 2008, 2009 and 2010, only 14%, 13% and 17% of students passed with a high enough TAKS science grade to be considered commendable, respectively. A commendable grade implies a higher than average test score.

Despite the large improvement in the latest summary review, state-wide 1 out of 4 students do not possess the needed scientific knowledge to properly pass the science portion of TAKS. Furthermore, a low percentage of those students actually passing had achieved a higher-than-average grade.

Researched Literature

Part of the motive for low comprehension by the students may be due to the lack of effective studying materials. This may include textbooks with limited information and visual aids, animations that have limited scope and quality, and lack of appropriate hands-on models or games that are appropriate or specific to the subject being taught.

Textbooks

Of previous use in Texas schools is the Holt Biology science text book. Revision of a past edition of this science book shows that roughly a page and a half is devoted to genetic mutations, with limited information provided for the different mechanisms of mutations. For example, the textbook notes that in "a deletion mutation, segments of a gene are lost, often during meiosis" (Johnson). This sentence is the extent of the text

devoted to the mechanism of the genetic mutation for that of deletion. Half of the known basic genetic mutations are mentioned, while others are omitted entirely.

The accompanying artwork for the section is a small series of static images, simple colors with arrows to indicate movement or alterations, with no clear flow or graphic legend. A study in which 393 students were shown either non-narrated animations or static graphics with or without legends showed that static figures with legends "enhances long-term memory retention," in comparison to those static images that do not provide legends (O'Day 2). This could assist in providing greater retention of information. Other texts dedicated to biological studies, such as Kimball's Biology (Kimball) online textbook, provides greater information on the varying types of genetic mutations, causes, mechanisms and consequences. Yet, the graphics that accompany the information are low-quality static images, with unclear legends and confusing orientation. This online book also lacks animations to help explain any of the mentioned processes.

Animations

The animated visual aids that accompany textbooks tend to be limited in scope or quality. "Most current biology textbooks contain CDs with animations that are flat, two-dimensional (2D) characterizations of complex processes. Because they are flat, important spatial relationships of the process are not captured" (McClean)

The 2-D animations are done with simple colors, limited dynamic movement and little to no accompanying narration.

Educational websites often utilize animations to educate. *Learn.Genetics*™ provides several animations on genetic mutations. One interactive animation titled "Gene Control" allows the viewer to tighten a DNA coil with nucleosomes that twist the DNA and eventually come together (Sorenson). While very well done with excellent graphics, the animation utilizes a symbolic representation of nucleosomes. Instead of a globular form with recognizable histones, nucleosomes are shown as cylinders with two small tails. This representation does not accurately portray the general form of a nucleosome.

Another educational website provides scientific animations about genetics, though several of the animations are simple 2-dimensional representations with little fluid motion, and high complexity in regards to the information presented to the viewer (McGraw-Hill). As an added distraction, these animations are presented with the narrated text provided in its entirety below the running animation, causing the viewer to read the narration instead of watching the animated sequence.

Researchers have noted that in interactive animations "certain processes in cell biology courses are more easily presented through the use of motion than with a static illustration," (Stith) leading to greater comprehension of biological activities. This supports the concept that animations do provide a deeper comprehension and greater information retention when compared to lectures using static, non-animated images. Because of this, animations should be high quality, presenting a mix of 2-D and 3-D aspects with a strong emphasis on spatial relations.

An important element of the animation is the vocal accompaniment. Utilizing a narrative style that is conventional and easy to understand can re-enforce the information presented to the students in the animation. A "narration is a valuable, if not essential, component in biological animations" (O'Day 2) since it may lead to increased student retention of the subject matter. This benefit may be appreciated even over non-vocal animations. The combination of animation and vocalization can be extremely effective. Research shows "that animation and narration lead to deeper learning than a narration in the form of a lecture," (McClean) utilizing only static images.

An age-appropriate animation, with clear narration, high quality images that are theme-specific help create an effective educational scenario. "Animations that are well paced, stage-appropriate, focused, and narrated verbally with complementary visual text as appropriate can help students learn dynamic processes" (O'Day 1)

Hands-On Models

Hands-on models are considered to be an effective form of improving student education. A large scale review of nearly 14,000 fifteen year-old students in Canada showed that "science teaching using hands-on activities had a substantial positive predictive effect on science achievement" (Areepattamannil). In a smaller scale study where students were required to build model cars and test their movement, by building either a physical model or a virtual construct, "children learned equally well with either medium regardless of whether they were limited in the number of cars they could build or the amount of time they could spend on the task" (Klahr). From these studies, we may infer that hands-on

activities could produce a positive benefit for the science classroom, and that digital or virtual models can be just as equally effective as the real objects in educating science students. Unfortunately, educators many times lack access to theme-appropriate models, physical or digital, for use in their classroom. Despite their large selection of teaching tools, *Caroline* (Caroline) and *Sargent-Welch* (Sargent-Welch) may lack models that represent current or newer theories, thus further limiting what science educators may show use to educate their students.

Board Games

Games are often utilized teaching implements employed by teachers in all courses. But games may be limited by their scope, either because they are taken off store-shelves and insufficiently modified for the science classroom, or because they are limited in their size and flexibility. Designer games are board- and table top-games that are theme-specific, created for a particular classroom course, making them potentially more efficient since their subject matter is more closely related to classroom coursework than regular off the shelf games. As noted by an expert, "designer board games can be more effective than their digital cousins because they're often more closely aligned to library and classroom instructional needs" (Harris).

Conclusion

Ninth grade high school science students require educational elements that go beyond the information and visual presentation of actual science material for their age. Currently available material may be lacking on visual strength or information contained within. By contrast, research into other literature on genetic mutations may be too complex to be readily understood by high school students since the subject matter is prepared for older students. To assist these students, it would be advantages to provide a module that holds age-appropriate material that involves the use of a detailed animation, a theme-specific board game, and physical models that students may readily manipulate in order to understand difficult genetic concepts.

CHAPTER THREE
Methodology

Planning the Project

Purpose of the Project

As stated, the purpose of this scientific suitcase is to provide 9th grade high school science educators with a flexible, light-weight module on genetic mutations with innovative tools to utilize in the science classroom, providing up-to-date and current theoretical information that may be lacking in current high school science literature. Established parameters for the suitcase included being light-weight and easily carried, flexible enough to be included in a variety of school curricula and daily plans, produced and initially built for 3500 dollars and with a yearly maintenance/replenish cost of 1000 dollars for all included components.

Initial Project Selection

A list of open, undeveloped suitcase topics were presented to me. After reviewing them, I had decided on genetic mutations. My decision was based on several reasons. Though TEKS clearly states that students must understand the concept of changes to DNA and the consequences, it did not clearly mention or enumerate what those changes were. After researching Holt's Biology, the small amount of information devoted to genetic mutations was very apparent. After reviewing past samples of TAKS, actual and representative exams, I found only one question that clearly asked about different types

of genetic mutations, with two more questions on the mutation of frame-shift. Noting the lack of information presented as a whole for genetic mutations, and the lack of testing emphasis for the material, I put forward my request to build a scientific suitcase upon this subject matter. I wanted to provide educators with a resource tool that could help fill in the apparent information gaps on genetic mutations.

Initial Project Meeting

A meeting between gathered committee members and content specialists was held to determine the initial plan for the projected suitcase. Ideas were put forth as to what the scientific suitcase would benefit from the most. Proposed components included classroom labs, quizzes, animations, board games, word games, digital games and hands-on models. These options were eventually reduced to a few select components, taking into account time restraints, financial limits and the priority that the suitcase must be lightweight and easily carried.

Selection of Components

Before beginning production work of the suitcase, the advisory committee reviewed proposed materials for the scientific module. Chairman of the Biomedical Communications Graduate Program at UT Southwestern, Lewis Calver, and program associate professor Kimberly Hoggatt Krumwiede, were familiar with the proper techniques for focusing materials towards specific audiences. They also possessed extensive knowledge on artistic design and its implementation, effective writing techniques, 2-dimensional and 3-dimensional animation, and mixed media production.

Joel Goodman, Ph.D, Professor of Pharmacology at the University of Texas Southwestern, served as content expert for the suitcase. Dr. Goodman is also the current Director of STARS and coordinator of the Howard Hughes Medical Institute grant that supports the project. He oversaw general development of the suitcase, along with reviewing all content for scientific accuracy, and determined the extent of the information provided within. The project's second content specialist was Lynn Tam, the program coordinator of STARS, and an educator. As such, she provided valuable insight as to what teaching tools could be expected to be available in the classroom and which educational resources would be most beneficial. On behalf of the Dallas Museum of Nature and Science, Paul Vinson and Bill Smith provided their expert knowledge on physical constructs. Paul Vinson, the museum's Director of Exhibits and Theater Service, and Bill Smith, Exhibit Manager, have both participated in previous STARS suitcases. They have successfully coordinated and built many physical components for other modules, such as board games and hands-on models. They have access to a capable staff, on-site tools and an extensive workshop.

The advisory committee reviewed potential components and helped narrow the selection of components to include into the module. Due to the acceptance of previous suitcase animations, a decision was made to include a detailed animation into this project. The animation needed to include information on DNA, protein functions, genetic mutation mechanisms and epigenetics. For games, different designer game concepts were considered. Ultimately, a hybrid card/board game built around the mechanisms of genetic mutations was formulated. For a hands-on model the advisory committee

suggested the creation of a physical, malleable model of the nucleosome, a complex genetic structure that is difficult to spatially understand, both in form and function. A secondary hands-on teaching tool was eventually developed, as well. It would be a series of posters that functioned as a display portraying the size differential between a single nucleotide, the different stages of super-coiling and a chromosome.

Initial Project Survey

In collaboration with a fellow student Roshni Nelson who was also developing a STARS scientific suitcase on cell membranes and transport, I developed an initial project survey for educators. The survey was given to educators who were in attendance at a STARS workshop in June of 2010. Of the questions submitted to the teachers, many were geared towards inquiring what tools the educators had at their disposal, how effective they perceived these tools to be and what their personal preferences were in regards to teaching resources used in the classroom. Six educators answered the project survey, giving useful insight into what would be the most effective presentation for the suitcase components (Appendix A). The following is a sample of the questions asked.

1) Question: Do your students have access to computers and internet in class?

   Yes____ No____Don't know_____

2) What concepts about Genetic Mutations do you teach?

If any concepts, which seem to be difficult for the students to understand?

3) Do you currently use any kind of visual aids, models, animations or games to teach Genetics, Genetic Mutations or Cell Membranes?

Yes____ No____Don't know_____

Please list:

With regard to question number 1 we confirmed that all participating educators did have classrooms with access to computers and/or internet. Question number 2 on this sample list provided some very helpful insight. All teachers answered and most confirmed that they taught some level of genetic mutations. Some of the mutations they confessed to teaching included insertion, deletion, inversion and frame-shift. Some also added they prepared lessons on chromosomal alterations, such as monosomy, trisomy and genetic disorders, like sickle cell anemia. These answers exhibited the educators' tendency to expose their class to a greater amount of information about genetic mutations than what seemed readily available in current high school teaching material. Question number 3 provided answers over existing teaching tools. Though only four educators answered the question, most answered that they utilized simple DNA helix models or genetic animations since "genetic mutations has very little for models except worksheets."

Case Organization

All components of the science case were designed with economizing weight and spacing. A primary goal set for the carrying case was that its overall weight should not exceed ten pounds approximately. This should include the weight allocated for the case and carrying tubes. The case will consist of one central carrying unit and one carrying tube, together allowing transport of all flexible elements, such game boards and posters.

Shared Component Characteristics

A common underlying principle meant to be followed was that all components of the scientific suitcase share visual characteristics between them. A universal palette was generated utilizing soft-toned, mostly warm colors (Figure 3-1). These tones would be shared across as many components as possible, including the animation, hands-on models and card game. As a preference, highly saturated or vibrant tones were avoided as to not make any element of the suitcase appear too childish or visually distracting.

Figure 3-1. Sample of Universal Palette.

A second unifying concept was that all components be age-appropriate for the target audience. This meant that all elements had to be designed with an artistic style that would be perceived as interesting for a ninth grade science classroom, rather than appearing too infantile or boring. The final unifying concept stated that visual characteristics from one component be used in another. For example, the card game utilizes visual representations of nucleotides, as adenine or guanine. These exact same visual representations were carried over and are currently embedded in the animation. This technique would assist in creating an overall unified appearance for the scientific suitcase components.

Content Outline

A list of proposed components was generated. Since many of these elements would be designed, developed and produced simultaneously but most likely at different rates of speed, this list served as an invaluable key to help keep a smooth, organized work flow.

1) Card Game
2) Animation
3) Nucleosome Model
4) Posters
5) Teacher's Instruction Manual

Card Game

Success with previous games in other scientific suitcases, and the existence of literature positively favoring games in the science classroom as teaching tools, supported the idea of including a game into this project. The overall subject matter of the game would be genetic mutations. After various committee meetings a game was designed where students would have two main objectives. First, students in teams would attempt to build their own DNA helix, while simultaneously inflicting mutations on one another. This would permit students to learn or re-enforce the concepts of nucleotides, nucleotide pairing and the DNA helix itself. Second, it would also permit students to learn and practice the mechanical concepts of the different types of genetic mutation and how they conceptually alter a DNA helix.

Game Research

Researching different game types, a decision was taken to design a card game that utilized a game board. The reasoning for this decision may be predicated on multiple points. The commercial success of games like Pokemon©, Yu-gi-oh©, and Magic: The Gathering© has proven that card games are readily accepted. These games are geared towards junior high and high school students, and despite having complex rules, children quickly adapt to the system and learn the game in a short time. Cards are also a well-known game format that is easy to implement and reproduce. The standard American

poker card is 3.5 x 2.5 inches. This is a standardized playing card size and thus a nearly universal standard size. Most people recognize and are comfortable playing and holding cards of this size. Other dimensions, or card shapes, can prove to be harder to hold or replicate when needed. For these reasons, the cards for the game were set at 3.5 x 2.5 inches.

For the purpose of this game, several sets of cards were designed. The first set of cards would represent the four base nucleotides: adenine, guanine, cytosine and thymine. The second set of cards would be representative of six different types of basic genetic mutations. The third set of cards would indicate movement cards, those cards that allow teams to move upon the game board. And the final set of cards would compromise support cards with varying game functions.

Looking into game boards, Paul Vinson and Bill Smith were opposed to the proposed ideas of either a rotating DNA helix that would serve as a mat for the cards to be placed upon, or a board that could be hung from the wall of a classroom. The mechanics for the DNA helix were estimated to be too complex, and most likely, fragile. In their expertise they believed that a flat board, either a very sturdy board or very flexible, would be the best option. Also, special materials would be needed to create a large board that could be hung, and not retain any curvature once rolled up for long periods of time. The decision was made to use a flexible but smaller game board that could be rolled and placed into a tube for easy carrying and that could be set up on top of a regular sized table. The

smaller size and flexible construction material could help reduce rolling after periods of long storage.

Card Designs

The visual design of the cards required the use of Maya 2009®. Research was done into the configuration of nucleotides and the DNA phosphate-deoxyribose backbone. This information was used to build spatially accurate, 3-dimensional constructs of adenine, guanine, cytosine and thymine, as well as a short segment of the phosphate-deoxribose backbone (figure 3-2). Each particular nucleotide was assigned a base color from the universal palette, and specific atoms were also assigned their own tone i.e. gray for carbon molecules, blue for nitrogen, etc.

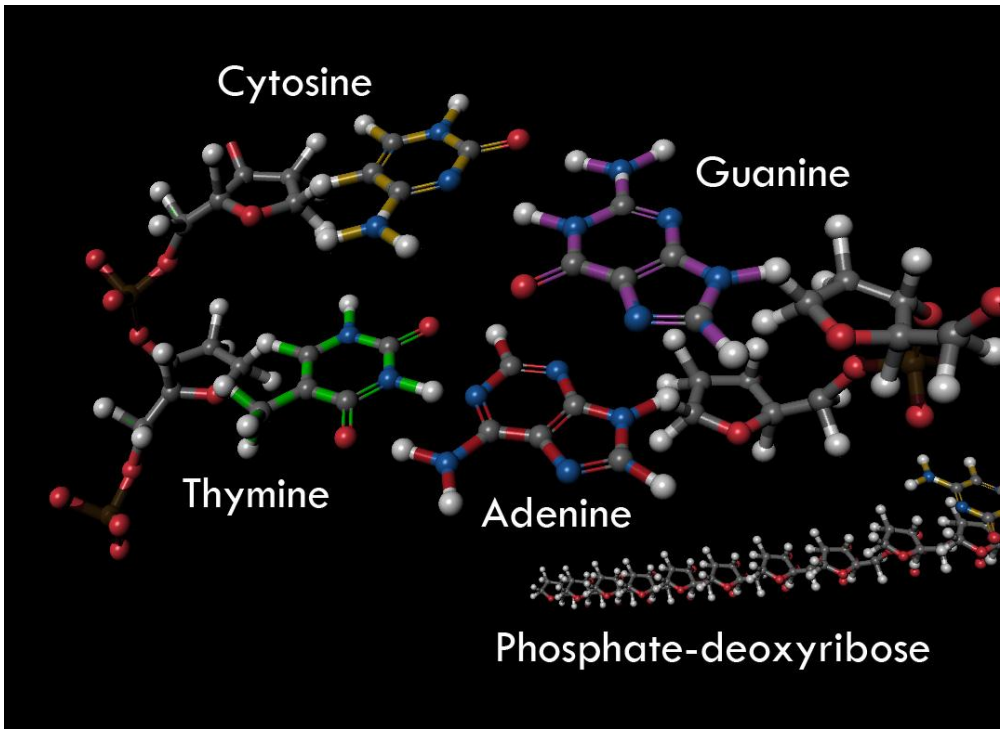


Figure 3-2. Maya constructs of nucleotides and phosphate-deoxyribose.

Nucleotide Cards

Each nucleotide was oriented into the desired orientation, and then exported as a 300 dpi .png file. The .png files were then used as templates to build the visual components of the nucleotide cards in Adobe Illustrator®. To differentiate nucleotides visually, each maintained the original Maya design color. *Arial* font was selected for use through all nucleotide cards, with a standardized font size for card titles and card name (Figure 3-3).

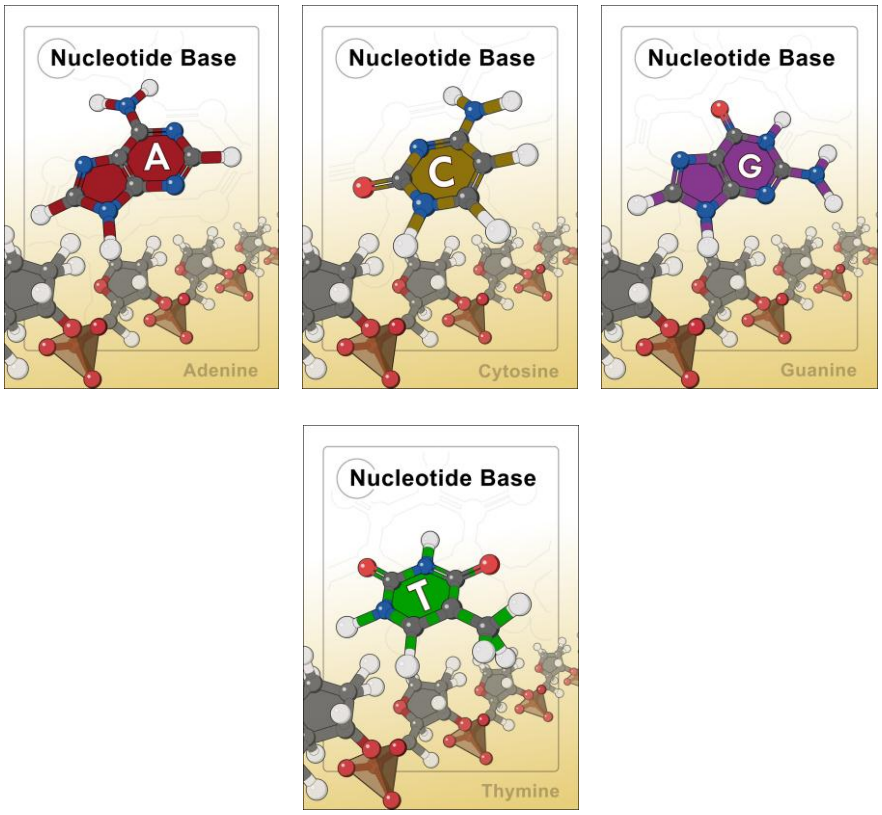


Figure 3-3. Nucleotide cards Adenine, Cytosine, Guanine and Thymine, respectively.

Mutation Cards

Every Mutation card shares the same background, a warm gradated color leading to white at the top, with color from the universal palette. The phosphate-deoxyribose backbone was scattered and reoriented throughout the background, with opacity between 5 to 30%. *Arial* font was selected for use through all mutation cards, with a standardized font size for card title, mutation description text, and card name (Figure 3-4).

Figure 3-4. Mutation cards for Deletion, Duplication, Insertion, Inversion, Silent and Translocation, respectively.

Movement Cards

Movement cards shares the same background, a cool gradated color from the universal palette leading to white at top. The phosphate-deoxyribose backbone is shown as a straight structure from front tapering back, from bottom to top. *Arial* font was selected for use through all movement cards, with a standardized font size for card title and movement points and card name (Figure 3-5).

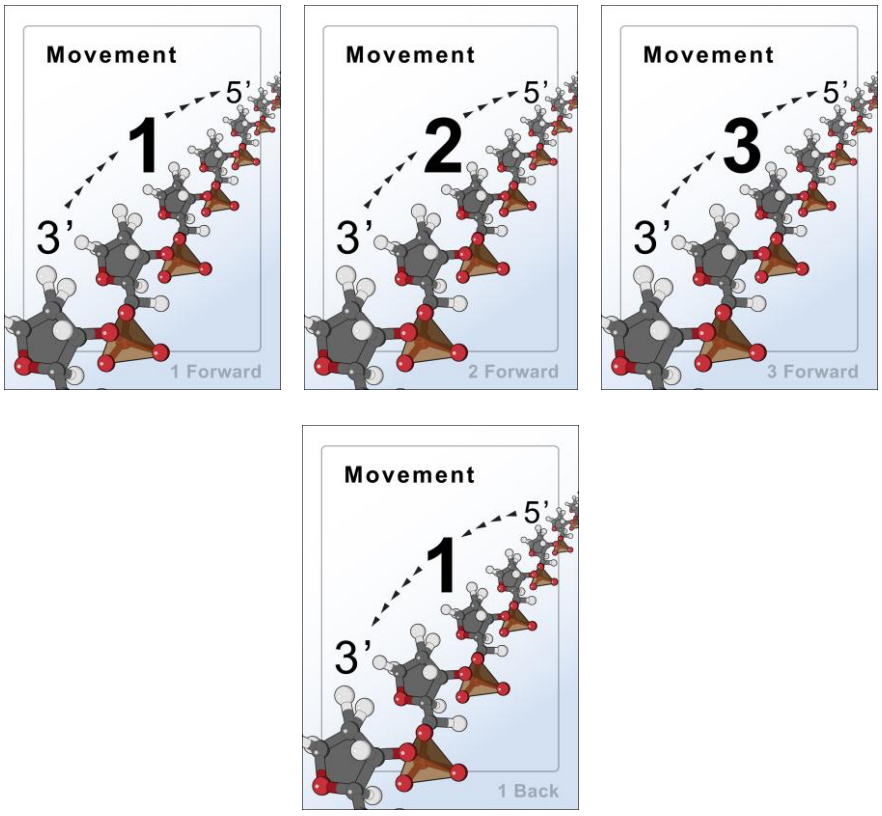


Figure 3-5. Movement Cards for 1, 2 and 3 points Forward, and 1 Back, respectively.

Support Cards

Support cards like Gene Therapy utilize a pronounced gradation as a background with a DNA helix through the middle of the card. *Arial* font was selected for use with this card. The game component card utilizes Arial text for both sides to list all game components. The background of each game card sports a standardized logo for the card game, with a

blue and amber tone selected from the universal palette (Figure 3-6). The official STARS logo is also present on the back of all cards.

Figure 3-6. Gene Therapy, Game Components and card back.

Game Boards and Guides

Team Boards

A large game board for each team was developed using Illustrator. At 40 x 22 inches in size, the boards are large enough to fit on top of most standard-sized tables. Team boards are identical expect for the coloring scheme. Each board has a section for building a DNA template strand, a DNA complimentary strand, and a mutation track where mutation cards may be played. All tracks are 14 cards long. Fourteen cards allow for a track short enough to be playable, and still provide enough spaces to visually emphasize the consequences of mutations during game play. (Figure 3-7). To differentiate visually

between team boards the blue and amber tones, taken from the universal palette and found in the game logo, have been utilized on the boards.

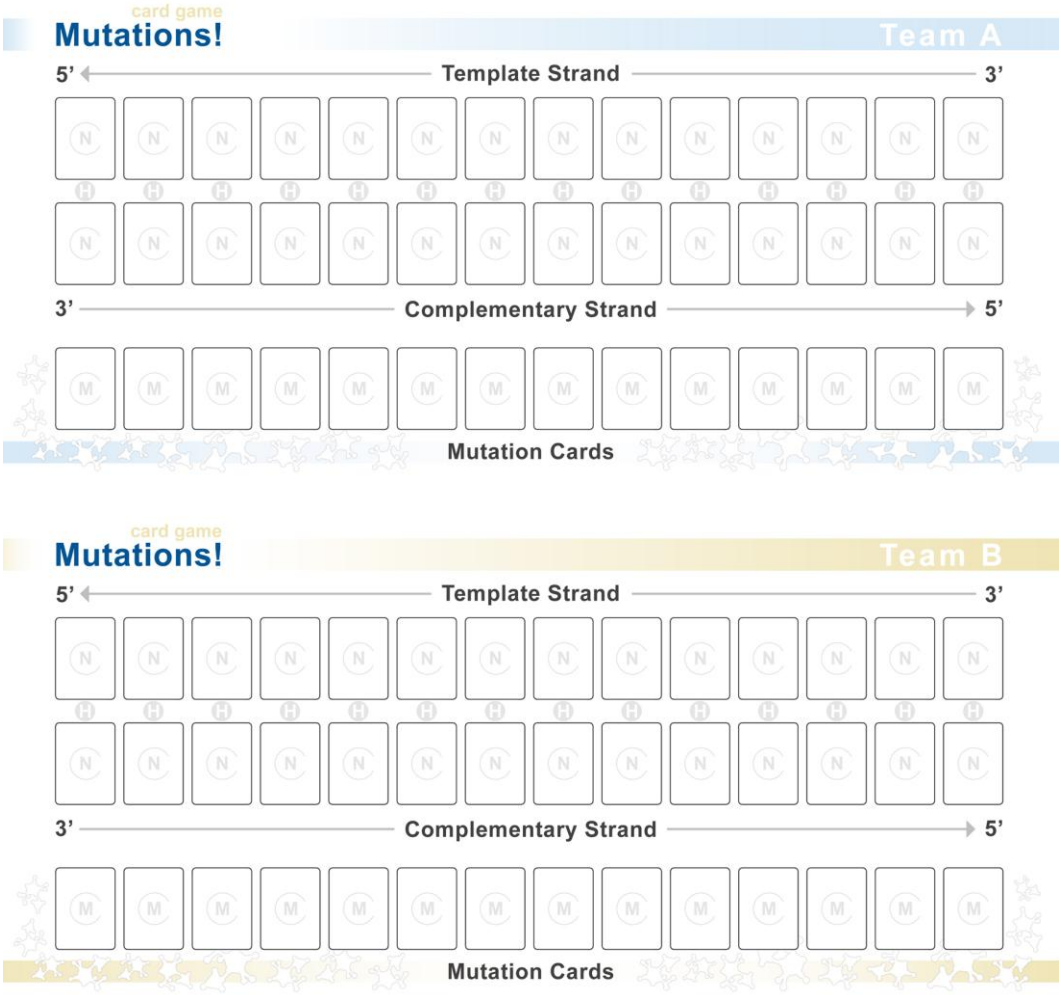


Figure 3-7. Team A and Team B game boards, respectively.

Deck Board

Support elements for the game include a deck board, a hard plastic 8.5 x 11 board designed to hold 3 different card decks during the game (Figure 3-8). The color scheme is identical to that utilized on both team boards.

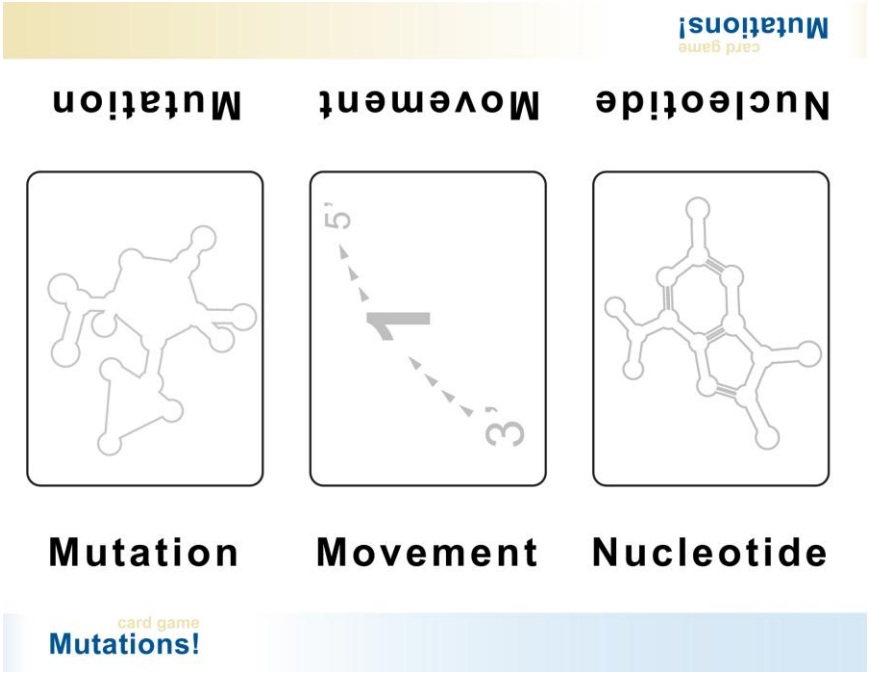
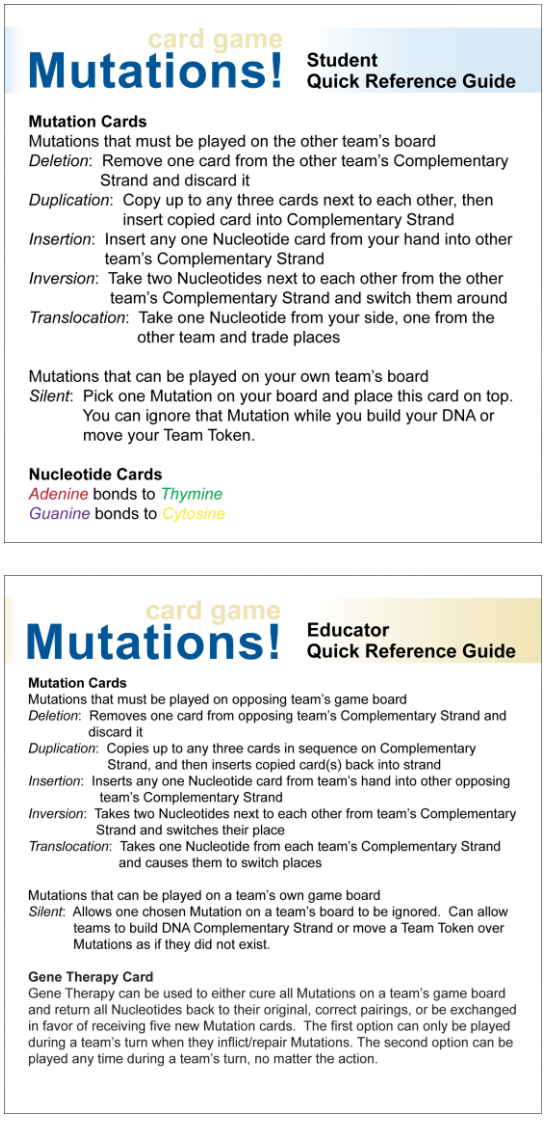


Figure 3-8. Deck board.

Guides

Also included are quick guides for both students and educators. These guides are 5.5 x 5.5 inches in size, easy to hold and with key concepts printed on them so students and educators can quickly look up key goals and the purpose of each cards type (Figure 3-9).

The guides contain game information and mechanics on both sides, and are colored according to use. An educator's guide is identified by text and an amber gradated band located at the top of each side, while the student's guide has a blue gradated band.



card game
Mutations! Student Quick Reference Guide

Mutation Cards
Mutations that must be played on the other team's board
Deletion: Remove one card from the other team's Complementary Strand and discard it
Duplication: Copy up to any three cards next to each other, then insert copied card into Complementary Strand
Insertion: Insert any one Nucleotide card from your hand into other team's Complementary Strand
Inversion: Take two Nucleotides next to each other from the other team's Complementary Strand and switch them around
Translocation: Take one Nucleotide from your side, one from the other team and trade places

Mutations that can be played on your own team's board
Silent: Pick one Mutation on your board and place this card on top. You can ignore that Mutation while you build your DNA or move your Team Token.

Nucleotide Cards
Adenine bonds to *Thymine*
Guanine bonds to *Cytosine*

card game
Mutations! Educator Quick Reference Guide

Mutation Cards
Mutations that must be played on opposing team's game board
Deletion: Removes one card from opposing team's Complementary Strand and discard it
Duplication: Copies up to any three cards in sequence on Complementary Strand, and then inserts copied card(s) back into strand
Insertion: Inserts any one Nucleotide card from team's hand into other opposing team's Complementary Strand
Inversion: Takes two Nucleotides next to each other from team's Complementary Strand and switches their place
Translocation: Takes one Nucleotide from each team's Complementary Strand and causes them to switch places

Mutations that can be played on a team's own game board
Silent: Allows one chosen Mutation on a team's board to be ignored. Can allow teams to build DNA Complementary Strand or move a Team Token over Mutations as if they did not exist.

Gene Therapy Card
Gene Therapy can be used to either cure all Mutations on a team's game board and return all Nucleotides back to their original, correct pairings, or be exchanged in favor of receiving five new Mutation cards. The first option can only be played during a team's turn when they inflict/repair Mutations. The second option can be played any time during a team's turn, no matter the action.

Figure 3-9. Front of quick guides for students and educators, respectively.

Simple round colored chips, identical for both teams, have been included to act as team tokens for the game.

Card Game Logo

Stamped on the back of all cards, team boards, guides and instruction manual is the game logo, a textual logo using tones from the universal palette (Figure 3-10).

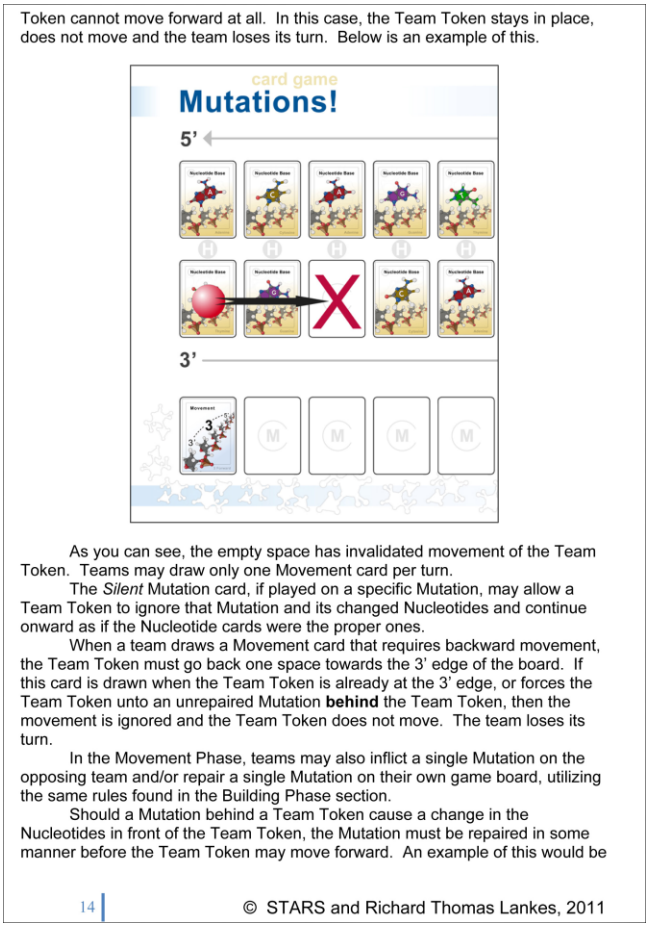
Figure 3-10. Card game logo.

Game Production

Jorge Escobar, graphic designer for the Dallas Museum of Nature and Science, offered multiple options for the lamination and coating of the game cards and boards. Since the game has over 200 individual cards, a simple lamination was chosen that coated both sides, was flexible and fully transparent. It would allow for easy stacking of cards and still protect the cards from wear and use. For the game boards a hard plastic coating was considered. But to manage the large team boards it would have been necessary to create

folds and cuts which would have allowed the boards to be folded and stacked in two different directions for storage. This process would have been complex and would have compromised the surface of each board. Instead, a simple, clear laminated coating was utilized. This lamination permits the team boards to be rolled up and stored comfortably in a carrying tube while maintain the surface integrity of each board. The student and educator quick guides were also coated in a similar fashion, since these were meant to be easily held and shared between teams. The deck board was the only board coated in a hard, transparent plastic on both sides. This was done since both teams will share the deck board during game play and it must support the weight of the card decks. Paul Vinson, Bill Smith and Jorge Escobar printed and laminated the game cards and boards.

A full-color, twenty-one page educator instruction guide for the game has been included (Appendix B). The guide lists all game rules, providing visual examples of game mechanics. The guide has been cold laminated to increase durability and resistance, with a spiral backing for easy of reading. The instruction guide in its entirety has also been included in the animation CD in a PDF format, giving educators access to a digital copy of the instruction guide (Figure 3-11).



Token cannot move forward at all. In this case, the Team Token stays in place, does not move and the team loses its turn. Below is an example of this.

As you can see, the empty space has invalidated movement of the Team Token. Teams may draw only one Movement card per turn.

The *Silent* Mutation card, if played on a specific Mutation, may allow a Team Token to ignore that Mutation and its changed Nucleotides and continue onward as if the Nucleotide cards were the proper ones.

When a team draws a Movement card that requires backward movement, the Team Token must go back one space towards the 3' edge of the board. If this card is drawn when the Team Token is already at the 3' edge, or forces the Team Token unto an unrepaired Mutation **behind** the Team Token, then the movement is ignored and the Team Token does not move. The team loses its turn.

In the Movement Phase, teams may also inflict a single Mutation on the opposing team and/or repair a single Mutation on their own game board, utilizing the same rules found in the Building Phase section.

Should a Mutation behind a Team Token cause a change in the Nucleotides in front of the Team Token, the Mutation must be repaired in some manner before the Team Token may move forward. An example of this would be

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Figure 3-11. Page 14 of the game instruction guide.

Animation

The initial step for creating the animation was to determine its purpose and key principle points. Through meetings with the advisory committee and content specialists, the following main points were established.

1) Clearly explain basic genetic concepts, such as DNA, nucleotides, histones and proteins
2) Clearly explain the fundamental concepts of histones, nucleosomes, super-coiling and epigenetics
3) Clearly explain basic mechanisms and different types of genetic mutations
4) Illustrate an example of an illness produced as consequence of genetic mutation

Scientific Script

A crucial step of the animation began with the formulation of a scientific script. Dr. Goodman, assisted by UT Southwestern Medical Center Genetics and Development graduate student Robert Borkowski, reviewed the script during its revisions to verify scientific accuracy. This step was essential since it would clearly set down the accuracy, and topics, that would be touched upon in the animation. Once the final version of the scientific script was determined and approved (Appendix C), it served as a template for the narrative script (Figure 3-12).

Scene 9	• Genetic mutations are changes in DNA sequence. • They can be caused by radiation, viruses, chemicals, errors during DNA synthesis • Improper protein expression, or the protein expression of the wrong sequence of can lead complications. • Location of mutation, length of affected DNA sequence, or how the protein is used are factors to determine whether mutations are undetected or fatal.
Scene 10	• Genetic mutations are either large scale or small scale. • Large scale mutations affect multiple genes, whole chromosomes or several chromosomes. • Small mutation affects a few nucleotides, or just one. Even the modification of one DNA base can produce a completely abnormal protein.

Scene 11	• Deletion mutations are accidental removal of bases. It can be on a large scale or small scale. • It generally affects the sequence in one chromosome. • Deletion generally leads to loss of function, and is the cause of a large number of genetic illnesses.

Scene 12	• Insertion is usually small scale mutation that may involve the addition of a single base, several bases, or even a segment from another chromome. • Chromosome A loses genetic material while chromosome B gains that genetic material. • Chromosomes do not need to be next to each other. DNA fragments can float from one chromosome to another. • Insertion is a strong example of a mutation that leads to gain and loss [Richard, what do you mean??] of function of a protein.

Scene 13	• Point mutation is a small scale mutation. • Point mutation affects one nucleotide only, on one chromosome. • A nucleoside is replaced with a different nucleoside. A nucleoside can also be deleted, or another nucleoside could be inserted. • A purine can be replaced with a pyrimidine, or a pyrimidine can be replaced with a purine, in a process known as transversion. [Richard: if you express this, it needs more information, since the paired base also must be changed.]Also, a purine can be replace with a purine, or a pyrimidine with a pyrimidine. This type of point mutation is called a transition. • A point mutation may be "silent" if the new codon still codes for the original amino acid; the resulting protein is not changed. Within point mutations, are several specific forms. Missense and nonsense mutations are two known forms. A missense mutation results in an altered amino acid, often leading to the creation of a protein that does not function properly. A nonsense mutation will cause protein synthesis to stop, generating a smaller unfinished protein that may not work at all.

Figure 3-12. Page 2 of scientific script.

Narrative Script

A key component of the narrative script and animation involved the creation of a principal protagonist, a scientist that would narrate the animation and serve as a visual key for the target audience. After multiple discussions with the committee members it was determined that for ethnic diversity, a female of Hispanic or ambiguous ethnic appearance should be cast in the primary role. This female scientist would eventually be named "Isabella."

Kim Hoggatt Krumwiede assisted in making the narrative script age-appropriate for the target audience of 9th grade high school students, while Dr. Goodman continued to review and oversee the script to maintain scientific accuracy and terminology. Because the animation utilizes a central animated narrator, it was important to craft the narrative in a format that could be read afterwards, word for word, by a professional actress. With this in mind, the narrative script reads as a monologue given by a presenter.

Below is a sample page of the narrative script (Figure 3-13)

Scene 3	*Isabella:* "You might wonder what function or jobs proteins do in a human? Proteins assist our cells in many ways!" "They let cells talk to one another." "They allow cells to fight infection." "Proteins help cells grow and divide." "They allow our body to digest food." "Proteins can help the body create energy." "They even assist cells in holding their shape." (Pause) "All in all, these are just a few of the things that proteins can do in the human body!"
Scene 4	*Isabella:* "Despite their many functions, proteins are fragile. Any change, even just one amino acid out of the many that make up a protein, can alter the entire protein. It's like changing one brick in a wall. Change the wrong one and the whole wall might even fall! In proteins, the change of one amino acid could change its entire form!" (Pause) "This change could mean the protein stops working like it was intended."
Scene 5	*Isabella:* "Amino acids can be changed, added or removed from proteins in different ways." (Pause) "The most common change is called 'loss-of-function.' The protein loses a part, or all, of its functions. All in all, this means the protein stops working correctly. Cells will often remove these useless or disabled proteins."
Scene 6	*Isabella:* "A rare type of change can make proteins too good at what they normally do! They can become super-efficient. Or they can do jobs they couldn't do before." (Pause) "By becoming super-efficient or acquiring a 'gain-of-function', these proteins can become an advantage to the cell."
Scene 7	*Isabella:* "But changes to proteins do not just occur to their sequence of amino acids." (Pause) "A protein can be normal, but too much or too little of a protein could lead to severe complications for the cell. Maybe even death of the cell. Because of this, it is important to have the right amount of protein, not just a well-made one."
Scene 8	*Isabella:* "Protein synthesis is tied directly into our genetic material, to our DNA. DNA, also known as Deoxyribonucleic Acid, is essential in the formation of proteins. (Pause) Think of DNA as the plans for building a house. With these plans, cells know what amino acids, the bricks, are needed to create a specific protein, the house. Without the instructions given by DNA, a cell would not know how and which amino acids to use to make a specific protein."
Scene 9	*Isabella:* "Looking closely at our DNA, we can see it is made up of several different units. DNA is physically formed by two separate strands that twist around on another. This is known as a double helix. Yet, the most important units found in DNA are the millions of nucleotides that form each strand." (Pause) "A nucleotide has three parts: One of four 'bases', a molecule of sugar called 'deoxyribose,' and the mineral known as phosphate."

Figure 3-13. Page 2 of narrative script.

With committee approval of a final version of the narrative script (Appendix D), storyboarding was begun. Initial small sketches of selected scenes, highlighting intended

flow and an artistic style was created. These sketches also served to show intended animated points of interest, such as interactions between different elements and the visual approach to each scene. Figure character sketches were submitted as well, emphasizing different artistic styles ranging from a very comical, unnatural look to a more realistic orientation (Figure 3-14).

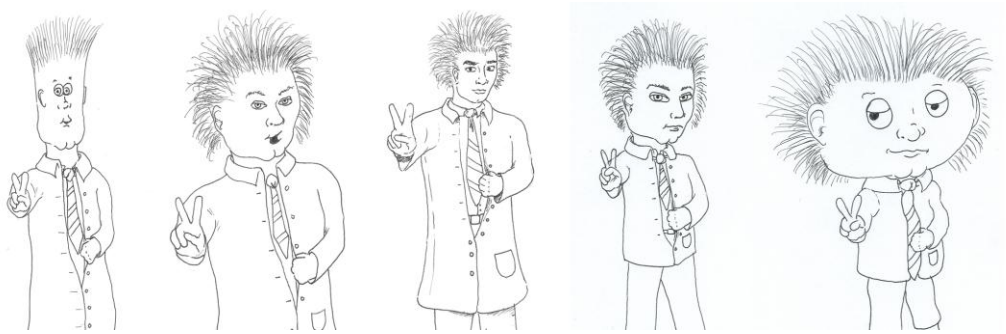

Figure 3-14. Figure character sketches.

After evaluation by program department members, character design number 3 was chosen for its partially realistic presentation and assumed appeal for a ninth-grade audience.

Story Board

A digitally-drawn preliminary storyboard was manually generated. It was directly based on the narrative script, visually representing the actions described within. Lewis Calver reviewed the script for artistic flow and style, Kim Hoggatt Krumweidi checked artistic

style and age-appropriateness, and Dr. Goodman verified the scientific accuracy. Through multiple revisions of the script, a finalized storyboard was created (Appendix E). Adobe Illustrator® proved to be an excellent tool for this purpose since it allowed quick changes, was easy to navigate and allowed for object manipulation, such as resizing, without loss of color or detail (Figure 3-15). By exporting .jpg files, inclusion of story board images directly into the narrative script provided side-by-side visual and textual components.

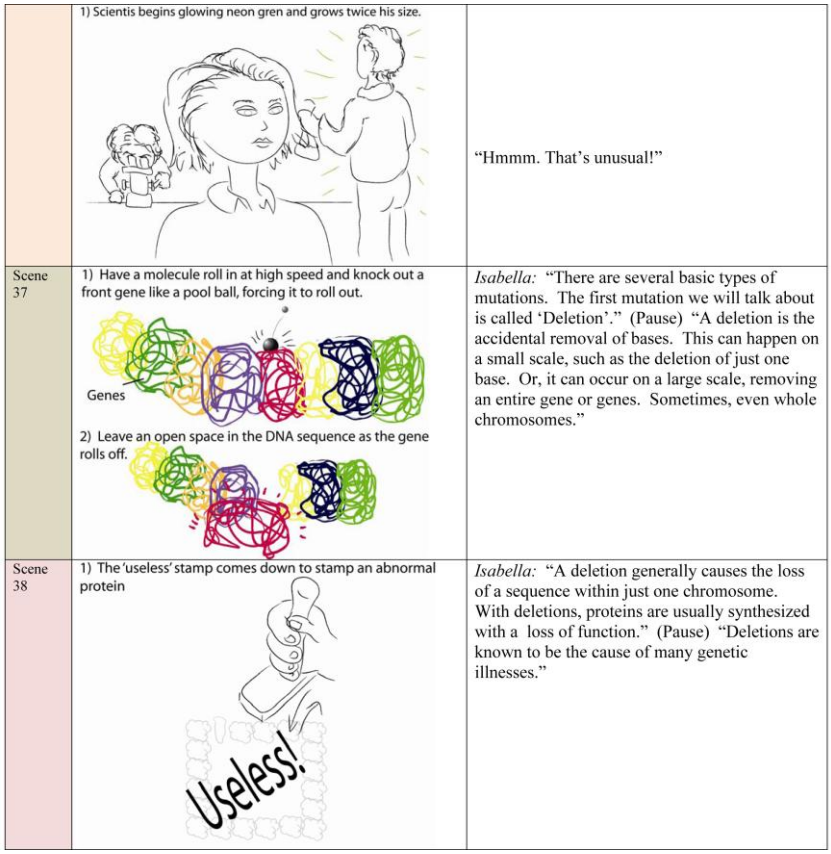

Figure 3-15. Page 21 of narrative script with story board.

Animation Elements

Character design for the animation was achieved through implementation of Adobe Illustrator®. The same properties that made the program an excellent choice for the story board also applied for creating the visual components of the animation. Quick modifications and different shading techniques were facilitated by the program. Maya 2009® was also used for the creation of two key animation elements.

With regard to basic animation components, Illustrator fulfilled all requirements. Two-dimensional tonal representations of cellular characters with anthropomorphic traits were created. A standardized cell with a vague humanoid form and mouth was designed for multiple uses. The cell would fulfill several roles, and as such had multiple sets of components created for each use. For example, the cell in one scene would act as a sheriff with a flamethrower, while in another scene it would be a mechanized bulldozer (Figure 3-16). Thus, each role utilized different sets of tools. To facilitate animation, all of the visual components created in Illustrator were designed separately and exported as their own .png file at 300 dpi. This would permit each element to be animated on its own separate layer and thus allow for a more fluid motion.

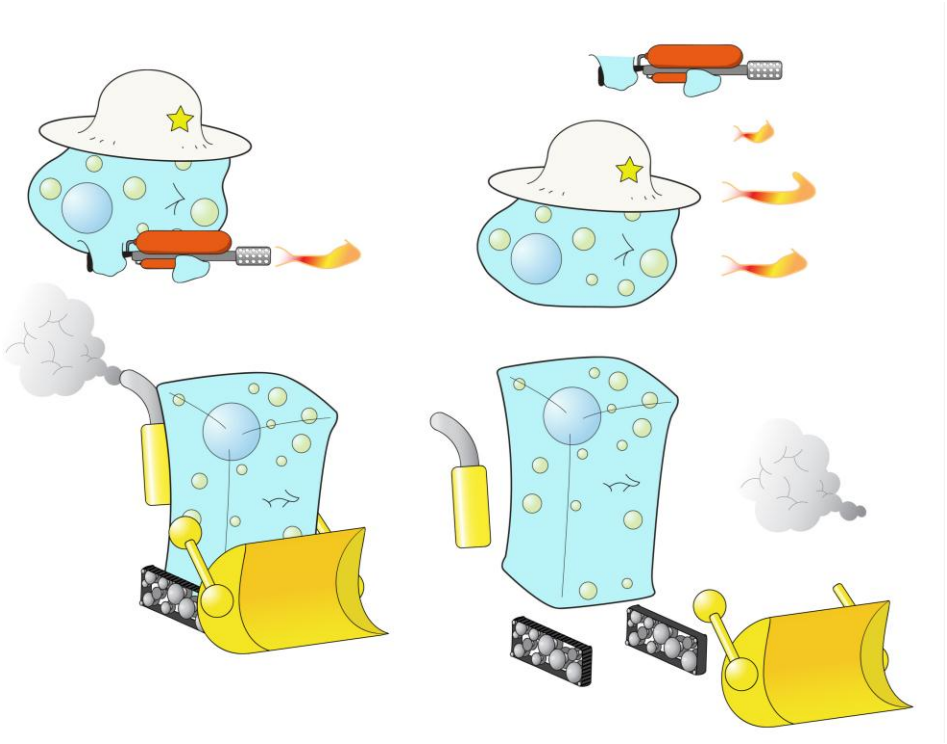

Figure 3-16. Cellular sheriff and cellular bulldozer, respectfully.

Other designed components included biological structures, such as amino acids, human characters in the form of background scientists, and support elements, such as factories, locks and magnifying lenses. Biological processes were created with no humanlike traits. Instead, they were made utilizing organic shapes that they could be readily recognized as molecular forms. Protein strands were built from individual amino acids set into a needed configuration, producing any needed protein form (Figure 3-17). Nucleotides were imported as whole figures from the visual sets created for the card game through the use of Illustrator.

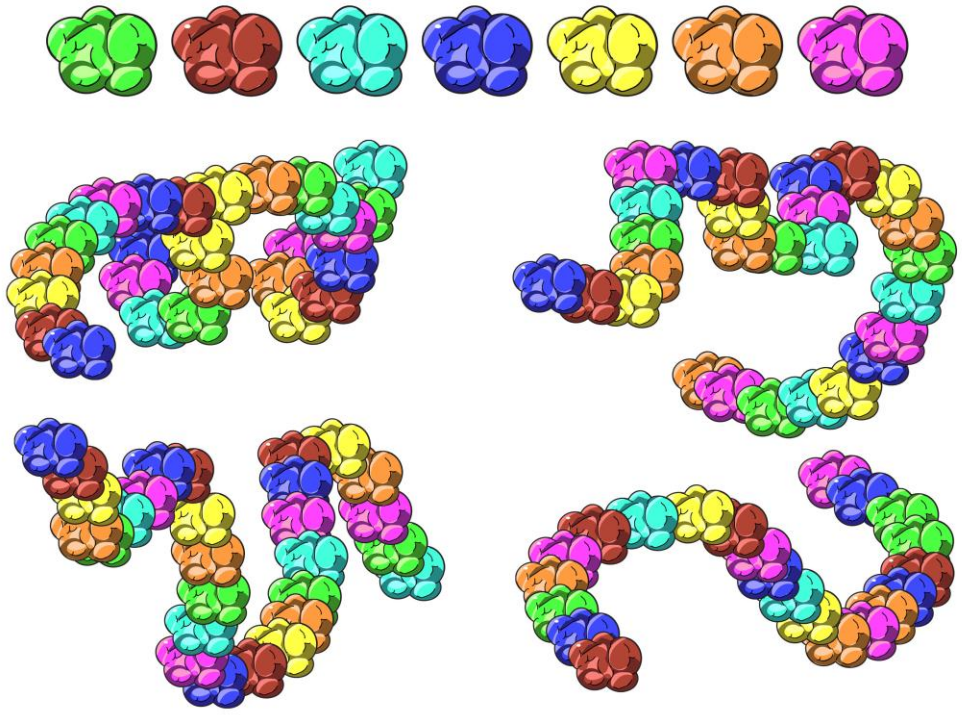

Figure 3-17. Amino acids and protein strand configurations.

Supporting elements, such as human scientists meant to be active in the background, were portrayed as both male and female personas of varying ethnicities. As with other elements of the animation, these scientists were built from individual components to allow them to move their heads and arms (Figure 3-18).

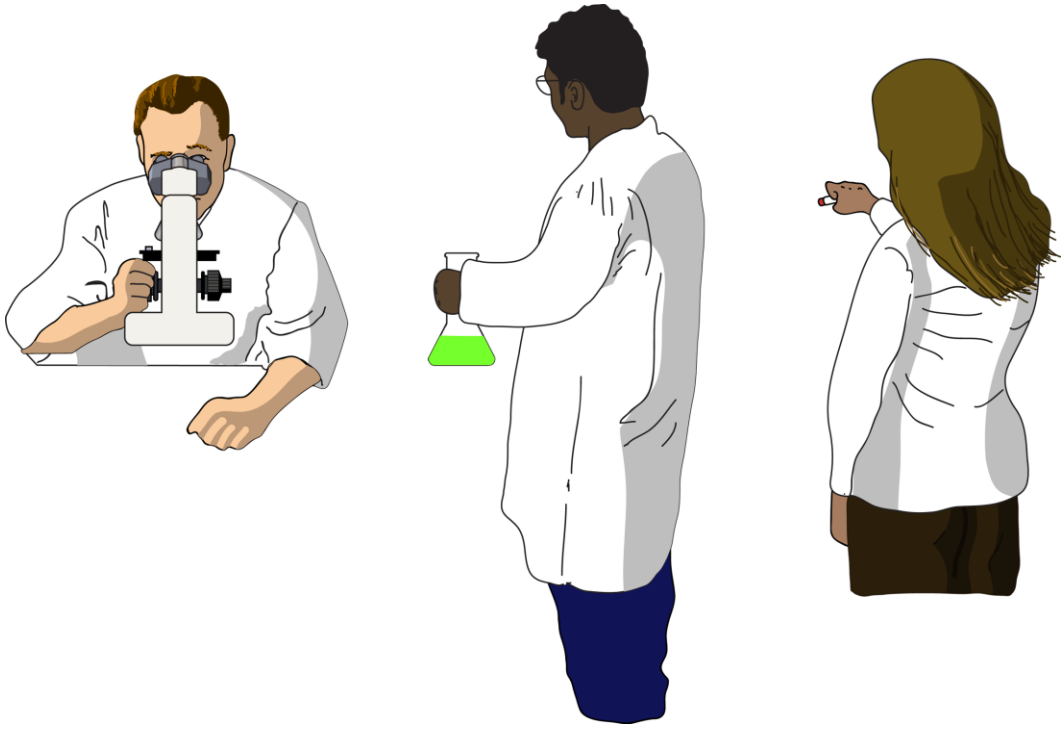

Figure 3-18. Background scientists.

Isabella

The creation of two key elements of the animation required a different method. Maya 2009® played a key role in this regard. First, the protagonist of the animation, Isabella, needed to be created. Isabella is based on *The Andy Rig* (jdouble), a downloadable Maya creation from CreativeCrash. *The Andy Rig*, or simply *Andy*, is a fully rigged, gender-ambiguous digital construct that may be fully animated. Kim Hoggatt Krumweidi and Dr. Goodman both suggested a female scientist, so *Andy* fulfilled this requirement since it could be redesigned as either a male or female. *Andy* also has the appearance of an older teenager or young adult with an artistic style similar to that previously chosen for the

animation style, so it was an appropriate choice for Isabella. Some changes were necessary though for full gender and ethnic reassignment, though (Figure 31-9).

Figure 31-9. Unmodified *Andy Rig.*

Andy's texture map was taken, imported into Adobe Photoshop® and redrawn (Figure 3-20). It was given the appearance of wearing a white lab coat, purple blouse and dark purple jeans. Make-up was applied to the face to convey a feminine appearance, and skin tone was darkened to appear as of Hispanic descent (Figure 3-21). The color scheme was based on the universal palette.

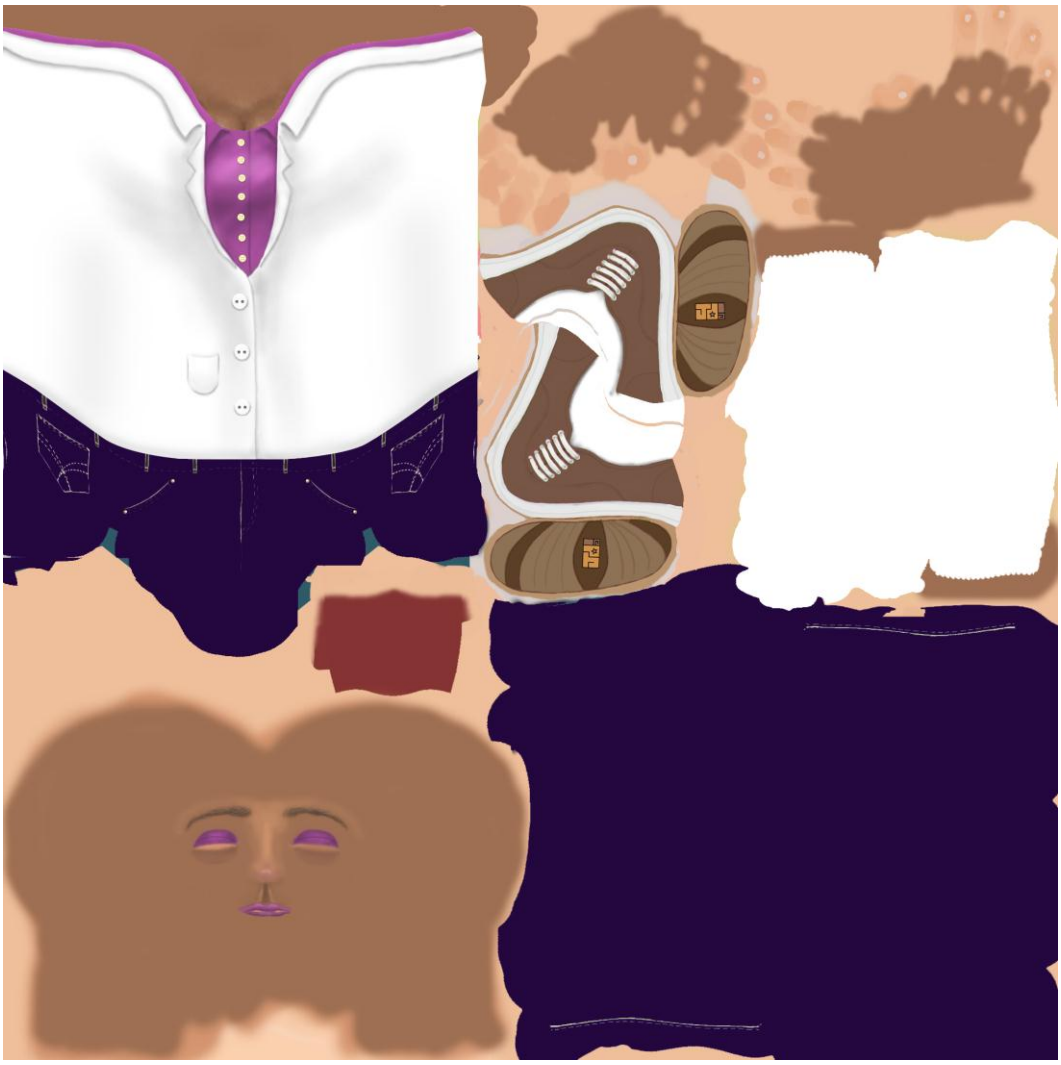

Figure 3-20. *Andy Rig* texture map redesigned.

Figure 3-21. Modified *Andy Rig* now designed as Isabella.

Because of the pre-rigging of *Andy*, Isabella could be fully animated. By setting key points in Maya, different animations of Isabella were created. These scenes included walking, tilting of the head to both sides, shrugging of the shoulders and movement of the hands, swaying of the body and eye movement to the side. By creating a rotating camera in the program, a sequence showing Isabella walking onto the stage from the left hand side of the screen, walking to the center and then turning to face the audience was programmed (Figure 3-22). All these motions were animated and exported as a sequence of .png files.

Figure 3-22. Sample images of Isabella in different positions.

Isabella's primary function is to serve as narrator for the animation. For this purpose, Illustrator was used to create a small series of mouths that would be useful in an animated sequence to give Isabella the appearance of conversing. A closed mouth, one partially opened and one fully opened were designed (Figure 3-23). These would then be superimposed unto Isabella in a post-production program and timed to a voice track to give the appearance of her talking.

Figure 3-23. Isabella's Mouth.

Nucleosome

The second key element to be designed in a 3-dimensional format was the accurate scientific representation of a nucleosome. Utilizing the Protein Data Bank, a .pdb file containing the precise molecular configuration of a nucleosome was downloaded. A Maya plug-in titled Molecular Maya Toolkit (Barry) was downloaded and installed. This plug-in allows Maya to directly read a .pdb file and extrapolate a precise molecular construct of any given molecule contained by the .pdb file. For this project, a .pdb of a nucleosome was used to generate a particle nucleosome in Maya (Figure 3-24).

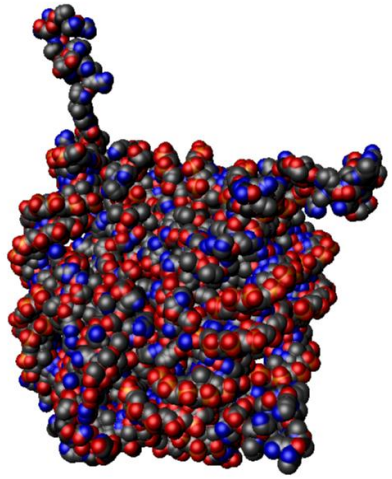

Figure 3-24. Particle nucleosome in Maya.

Molecular Maya allows for direct manipulation of generated particle constructs, allowing different visual representations. This particle model had been considered as a potential template to be used in the creation of a hands-on nucleosome model. However, several

obstacles presented themselves. Paul Vinson recommended against it because the intense spherical nature of the particles present throughout the model would have made it a very difficult construct to replicate. In his estimation, it would have required extensive, and expensive, molding and modeling techniques. For the purpose of the animation, the particles would have been harder to animate and manipulate, requiring much more time and computational resources. By utilizing Molecular Maya, the particle model was changed. Going into the main tab in Molecular Maya, under meshing, the check box for "mesh vis" was activated. This turned the particle model into a mesh model. The benefits of this were that the model was more globular in appearance, hence looking more organic. Also, this meant that there were only eight pieces to manipulate, instead of the hundreds of individual particles found in the original model. The mesh model was further adjusted by manipulating the "smooths" slider to 7, "blobby rad" value to 1.200 and the "threshold" value to .0100. These changes made a smoother, more organic and less bumpy mesh model. Finally, the color of each histone of the nucleosome was selected and changed to better reflect the universal palette (Figure 3-25). The original .pdb nucleosome had a DNA helix that wrapped around the histone octamer. For the animation, the DNA helix (the blue and purple strands) were removed, leaving only the exposed histones underneath.

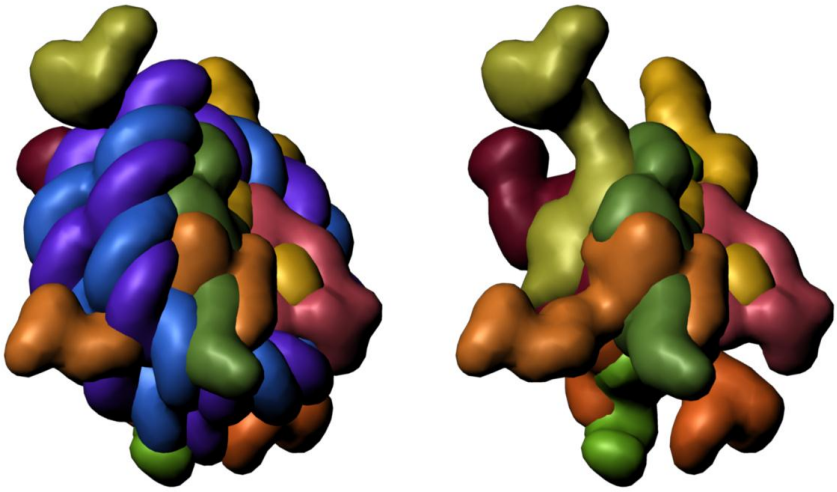

Figure 3-25. Mesh model nucleosome with and without DNA strand, respectively.

Animation of the nucleosome was accomplished by selecting a series of vertices and applying a bend distorter to a histone tail or keying movement to individual histones. In one sequence, histones fly together from the edges of the screen. This was accomplished by keying the 8 individual histones over a 10-second sequence and bringing the histones into a central core. (Figure 3-26). This animated movement was exported as a sequence of .png files.

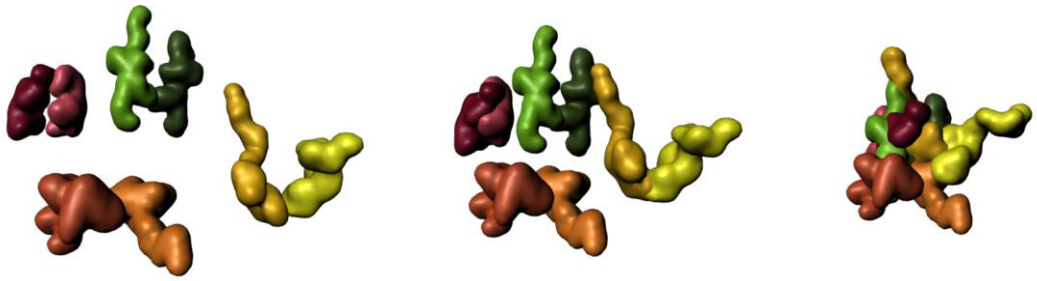

Figure 3-26. Animation sequence of histones.

Animation Audio

Professional voice actress Brina Palencia provided the voice for Isabella. Brina has worked with the STARS program on past science modules, loaning her voice to those projects. Her energetic and clear-toned voice, along with gentle disposition, complimented the Isabella character quite well. David Bullock, senior producer at Medical Television on the UT Southwestern Medical Center campus, coordinated an audio session with Brina at his studio. The recording session was held December 16th, 2010, and yielded roughly an hour and a half of raw audio. This preliminary track was edited afterwards in Adobe Soundbooth®, creating over sixty smaller audio tracks of varying lengths. The total of these newly edited audio tracks was about 40 minutes in length. All audio files were saved as .wav format, at 48 KHz, 16-bit mono (Figure 3-27). Due to the professional nature of the equipment studio where the session was initially held, there was no need to run any type of audio filter to improve sound quality.

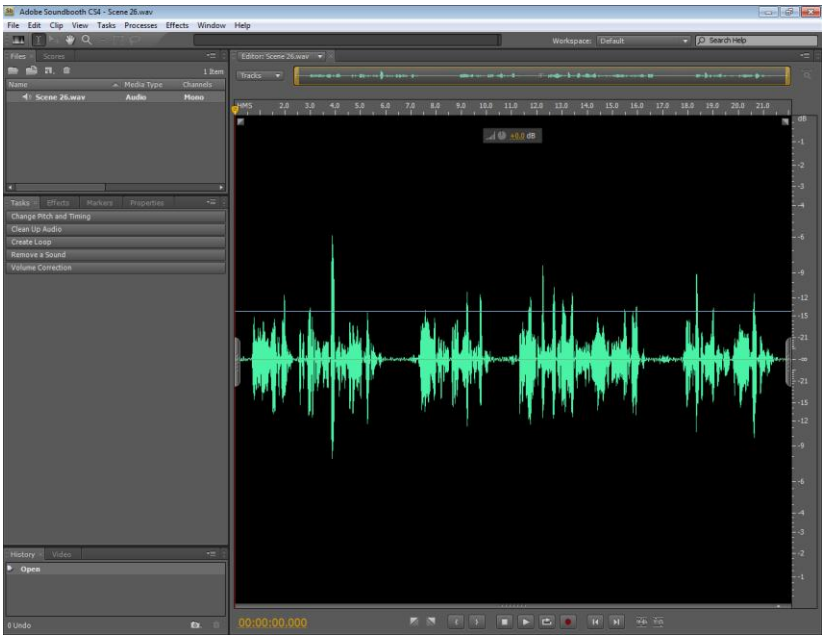

Figure 3-27. Soundbooth editing of audio session with Brina Palencia.

Animation Editing

All files needed for the animation were imported into Adobe After Effects®. This included .png files and edited audio tracks. Scenes were either built singularly or in pairs at a dimension of 720 x 480 pixels, 300 dpi and video format NTSC. The reason for building the scenes individually or in pairs was to conserve computer resources since post-production audio and animation editing can consume large quantities of computer memory.

In After Effects a scene would be selected and its corresponding audio track was set down first, since the animation would have to be timed to the vocals. Secondly, all respective .png files that correspond to the particular scene are loaded and organized. This could involve multiple copies of the same file, depending on the needs of each scene. By carefully timing all movement to the audio track, a fluid, dynamic series of motions were created throughout the animation (Figure 3-28). Texts were also timed to the audio track, so key words or concepts would be shown at the moment the word or phrase was uttered, and then would quickly fade out. This was done to re-enforce key words and concepts. *Twentieth Century* font was the standard font utilized throughout the animation scenes.

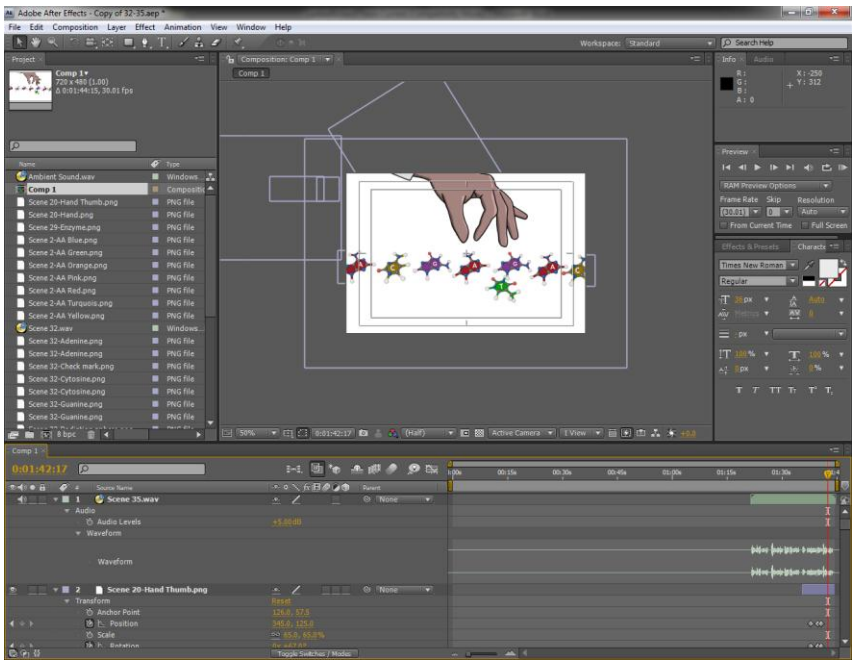

Figure 3-28. Screenshot of After Effects editing.

With regards to the character of Isabella and the nucleosome, it was necessary to import the animated sequence of stills and time the beginning and ending of their movements to the audio tracks. This was of an upmost importance with regard to the points of the animation where Isabella "talked" to the audience. By importing the .png files of Isabella's mouth created in Illustrator, then embedding them upon her character, the mouth was then to change its appearance every so many frames. This would create the appearance of opening her mouth and talking during the moments that speech could be heard on the audio track. By contrast, when there was no speech, Isabella's mouth was keyed to look closed (Figure 3-29).

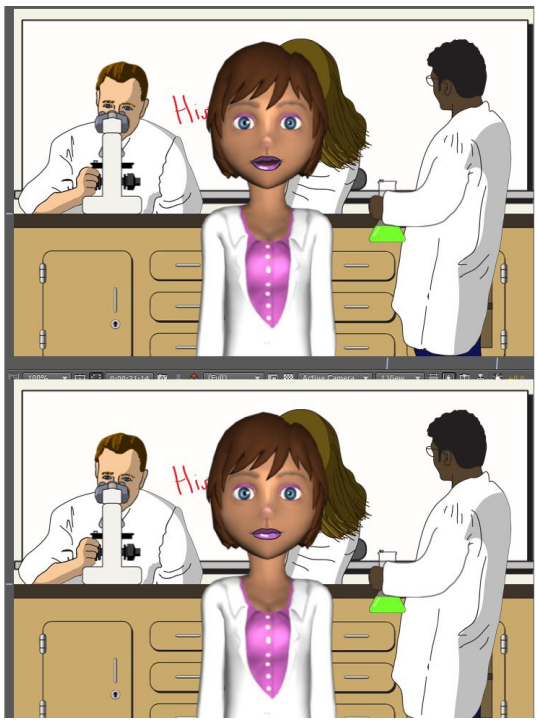

Figure 3-29. Screenshot of After Effects editing of Isabella talking.

After each animated scene was constructed, secondary sound effects were embedded into them if needed. These audio snippets came from royalty free websites and included a variety of sounds, including a man yelling, flies buzzing, mechanical springs, a hello and a wrench closing. Secondary sound effects were toned down as to not clash with the narration. All finished scenes were exported as Quicktime .mov files, set to H.264 video compression.

For final video editing, each individual scene was then imported into Adobe Premier Pro®. In this program each scene was set into a video track, positioned into the correct order. Dissolve transitions were applied between scenes where necessary. A final movie was then exported in a H.264 compression format, with audio compression type ACC with 48 hkz, mono, high audio quality. (Figure 3-30).

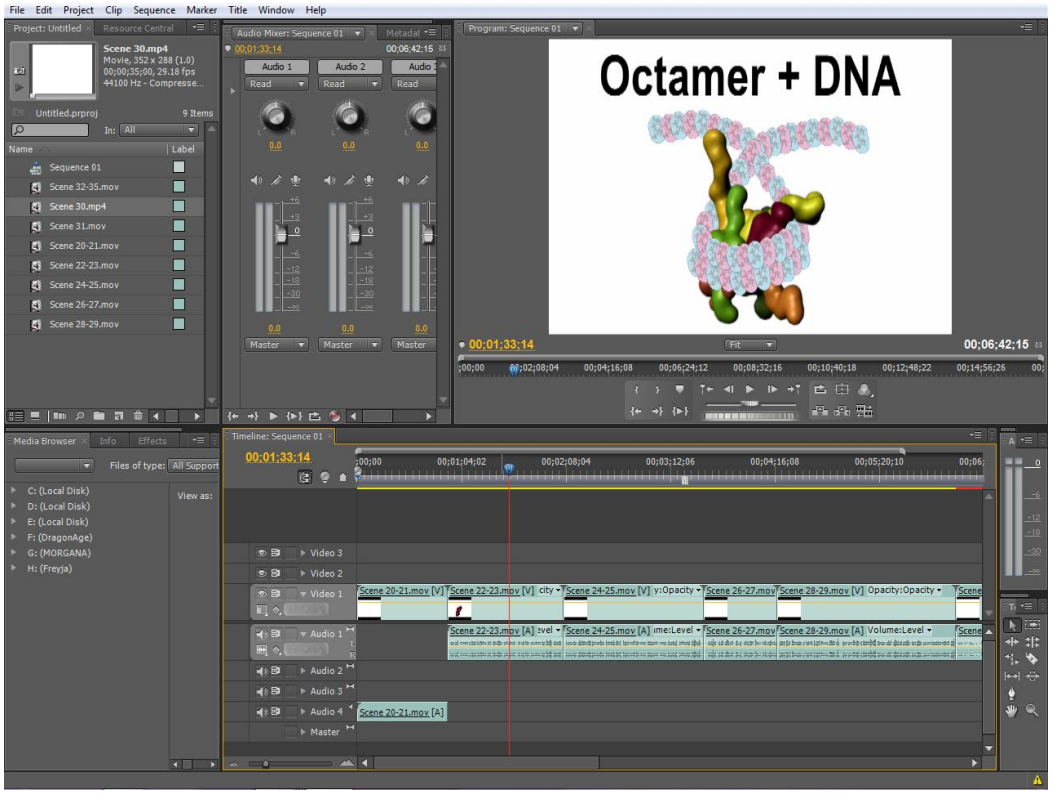

Figure 3-30. Screenshot of editing in Premiere Pro.

The final animation was imported into Adobe Encore®. Within Encore, a Photoshop file was imported that served as the principal menu for the Animation DVD (Figure 3-31). The DVD background was taken from a portion of the animation itself, portraying a cell holding up a sign for the viewing public.

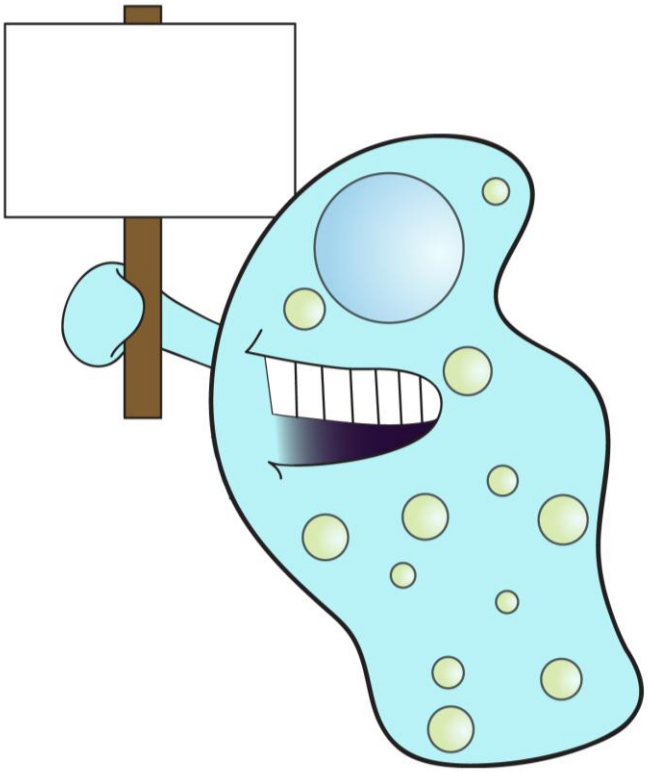

Figure 3-31. Animation DVD background menu image.

The cell's sign serves as the primary "Play All" button for the animation menu. The animation itself had chapters set at the beginning of each section so educators could skip to the beginning of each section. Jumps to sub-chapter points within each section were also generated. The following chapters and subchapters were created by clicking on the timeline at specific points, right clicking and choosing the "Add Chapter Point." Access to these subchapter points is achieved through the Subchapter and Extra menu found at the bottom of the Main Menu.

1) Section I: Proteins, DNA and Codons
2) Section II: Supercoiling and Epigenetics
3) Section III: Basic Genetic Mutations
4) Subchapters and Extras
    a. Section I
        i. Proteins
        ii. DNA
        iii. Codons
    b. Section II
        i. Supercoiling
        ii. Epigenetics
    c. Section III
        i. Basic Mutation Mechanisms
        ii. Deletion
        iii. Insertion
        iv. Frame-shift
        v. Point
        vi. Inversion
        vii. Translocation
    d. Extras
        i. Nucleosome Model
        ii. Posters
        iii. Credits

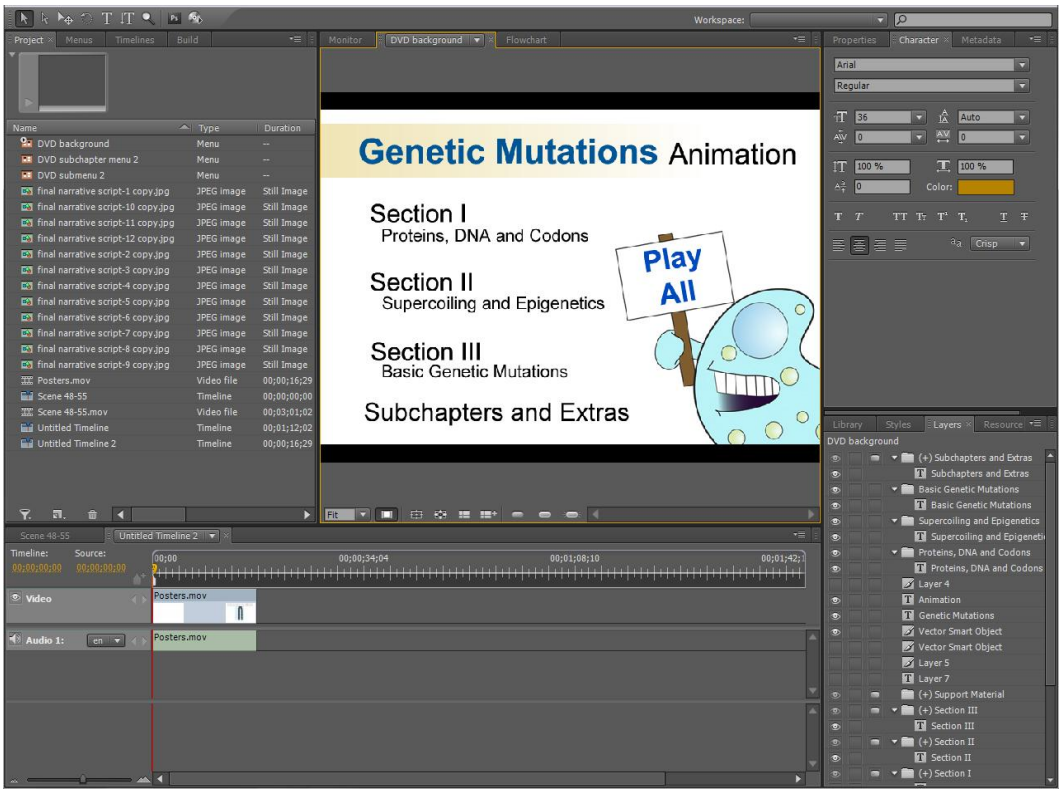

Figure 3-32. Screenshot of editing in Encore.

Nucleosome Model

Conceptual Design

Dr Goodman suggested the inclusion of a nucleosome as a hands-on model. Since nucleosomes "modify the activity of the genes that they store" (Goodsell) they are an essential component in the mechanisms of genetics, not to mention genetic mutations. After multiple revisions, it was determined that an octamer should be shown interacting with a DNA helix through the use of their tails. This is an important concept, since enzymes "chemically modify these tails to weaken their interactions" (Goodsell) with DNA, allowing DNA to be used in protein synthesis. This concept was brought to Paul Vinson and Bill Smith at the Dallas Museum of Nature and Science. They were presented with a digital model of a particle nucleosome (Figure 3-24) and asked if a hands-on model could be constructed. Initial meetings concluded with the belief that the particle model of a nucleosome would be too difficult to replicate. Its multi-spherical nature would require great expense and time to properly model the form. An attempt was made to create a nucleosome from scratch, by building via Maya 2009 a ribbon nucleosome, where the histones are represented by plastic coils and held in place by acrylic rods (Figure 3-33) surrounded by a thick plastic tube representing DNA. This idea was rejected because the sheer weight of the plastic and base to hold the entire structure together would have been excessive. Moreover, it could not properly show how the histone tails interact with DNA.

Another noted point was whether or not to make the model separable, such that nucleosome could be taken apart into its individual histones. This proved to be a difficult concept to manage because the original histones in the .pdb file are so integrated that it would have been extremely difficult to create anything that would have meshed as perfectly as the original digital construct. Also, it was determined that to make the histones integrate properly, they would have to be solid components. This would mean no flexibility and as such we would not be to show how the histone tails move to interact with a DNA strand. As such, flexibility was a more important point in this model.

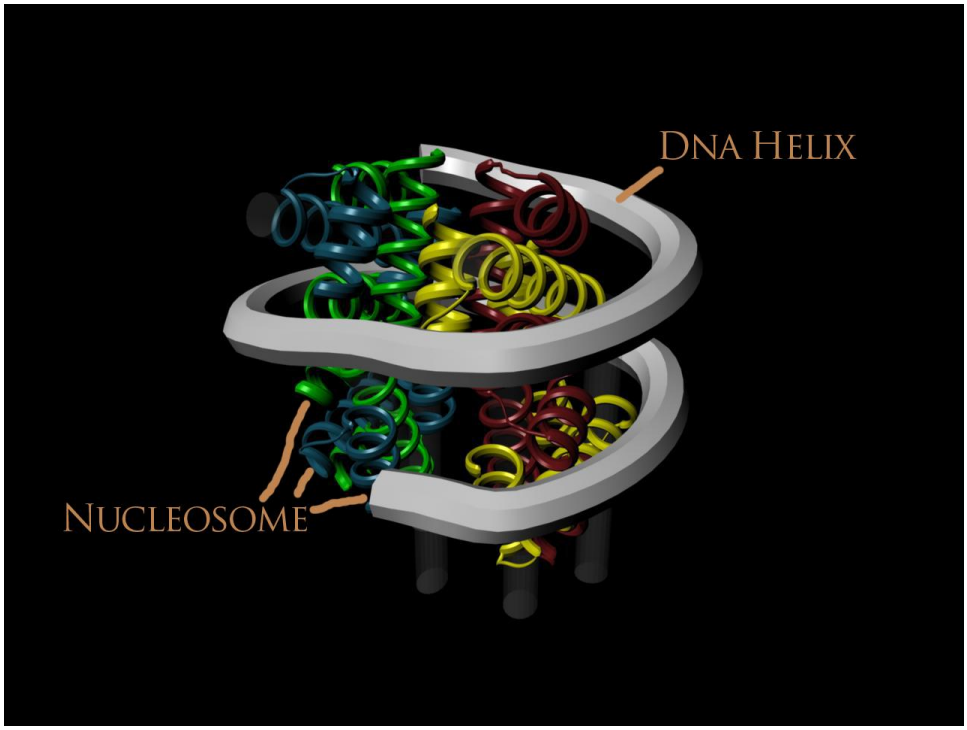

Figure 3-33. Ribbon nucleosome.

Paul suggested a globular form instead, which would be easier to construct and manipulate since it would only be 8 pieces, and could be fabricated quickly with a simple mold. For these reasons, the mesh nucleosome used in the suitcase animation was also utilized as a template to create a hands-on model (Figure 3-34.)

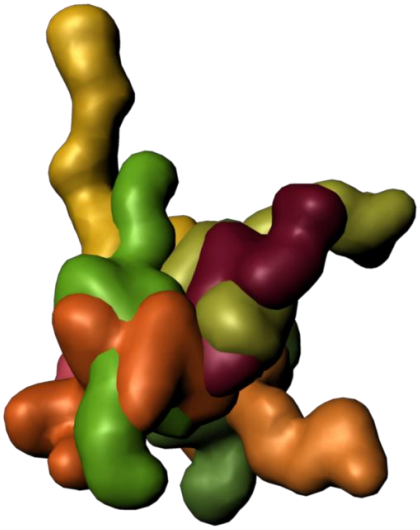

Figure 3-34. Mesh nucleosome.

Production of Model

Managing to get the tails of the histone to be readily flexible, while still being sturdy enough that it could resist wear and use by a classroom greatly, limited the available options for constructing the nucleosome. This was further complicated by the fact that it would have been much more difficult to build the model out of two or more different materials, or having the tails built out of a flexible component while the body of the

nucleosome was rigid. The model would have to be produced as one piece. Kenneth and George Mecca, proprietors of Mecca Design, were called in as specialists for this project. The technique for creating the nucleosome required the use of individual images, where each individual histone of the octamer was separated (Figure 3-35) from the others and then viewed from six different orientations.

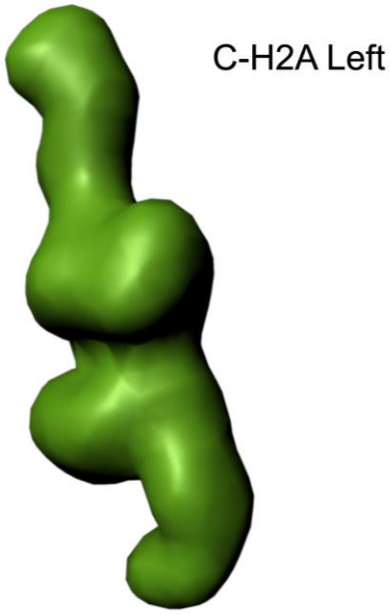

Figure 3-35. Left view of histone H2A.

From these images Ken and George Mecca then hand carved a block model from specialized memory foam. This form may be compressed to a paper-thin thickness between the fingers, and will recover its shape once released. To help identify the individual histones, and to add a stronger, sturdier shell to the model, the nucleosome was

coated in a strong, flexible rubber coating. This coating permits the user to twist and bend virtually any portion of the model and have it return to its original position (Figure 3-36). The model is extremely light-weight, flexible in virtually all directions, and is resistant to liquid spills since it is coated in rubber. The final product is 12 inches along its longest axis, weighs less than a pound and sports colors derived from the universal palette. For DNA, it was determined that smooth, flexible tube or nylon rope would work well, since it would be easy manipulate when tying around the nucleosome center. Also, a smooth rope or flexible tube would not scrape the rubberized surface of the model.

Figure 3-36. Nucleosome model squeezed and relaxed, respectively.

Posters

Conceptual Design

After meeting with members of my advisory committee, it was decided that a display showing the size difference from a nucleotide, through super-coiling, to a chromosome would benefit a students in a science classroom. Taking into account that students apparently struggle with size differentials at a genetic level, it was felt that these posters could help them better understand. For example, a common misconception is that a gene is the same size as a chromosome, or that DNA is not that much smaller than gene. The scientific truth is that a nucleotide is 50,000 smaller in size than a chromosome. If a nucleotide were as thick as a 1 millimeter pen stroke, the chromosome would have the height of a fifteen story building.

Poster Design

First, the nucleotides designed for the card game were opened in Illustrator, and slightly modified to remove any text or identifying markers. Utilizing the 3-dimensionsal nucleosome created via Maya 2009®, it was imported as an octamer into Illustrator where a 2-dimensional DNA strand surrounding it was created (Figure 3-37). A straight DNA strand was also created to associate with the nucleosome. The nucleosome was then imported into Adobe Photoshop®. One of the primary components created in

Photoshop is the tetramer, a four-nucleosome structure that is involved in super-coiling (Figure 3-38).

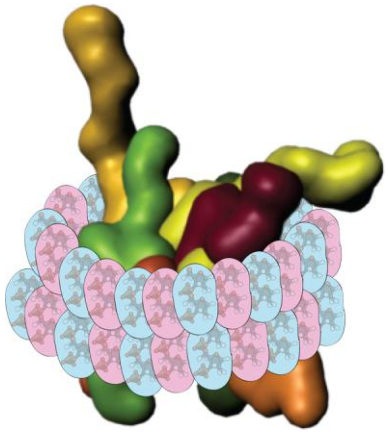

Figure 3-37. Nucleosome with DNA strand.

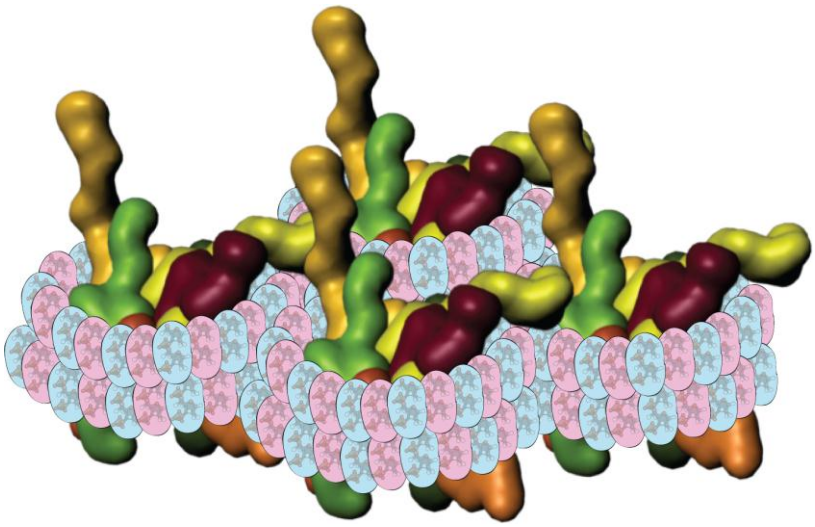

Figure 3-38. Tetramer.

Three posters were created in Photoshop. Poster 1 begins by showing the accumulation of nucleotides in the upper left corner, where it slowly turns into DNA. From here, it begins to wrap around octamers forming nucleosomes, which in turn tighten in formation. Near the bottom, the nucleosomes have formed the tetramer formations (Figure 3-39). Poster 2 shows the wavy, tightened and irregular form of DNA during super-coiling (Figure 3-40). In this poster, a small red dot located to the left center of the poster is projected. This red dot is instead to show the area that is displayed by all of Poster 1. In Poster 3, we see the lower arms of a chromosome. Just as in Poster 2, a small red dot highlighted by an arrow may be seen. This red dot symbolically shows the area that would be occupied by Poster 2. At the bottom left of each poster is a number, 1, 2 or 3. These numbers are meant to help the educators put the posters up in the right order. All text is *Arial* font, set to opacity of 10%. Posters 2 and 3 have arrows designed to highlight red dots present on each. These arrows have both been set to an opacity of 10%, so as to not clash with the imagery of the poster.

Originally, the posters were designed with multiple areas of text and magnified images of key points along the DNA strand. But I decided the principal point of highlighting the differences in size was more important. Unnecessary text and any enlarged images were removed, so as to not add any unnecessary distractions.

A short sixteen-second animated video was also designed to show the integration of these posters within one another (Figure 3-42). This short poster animation may be found on the Animation DVD.

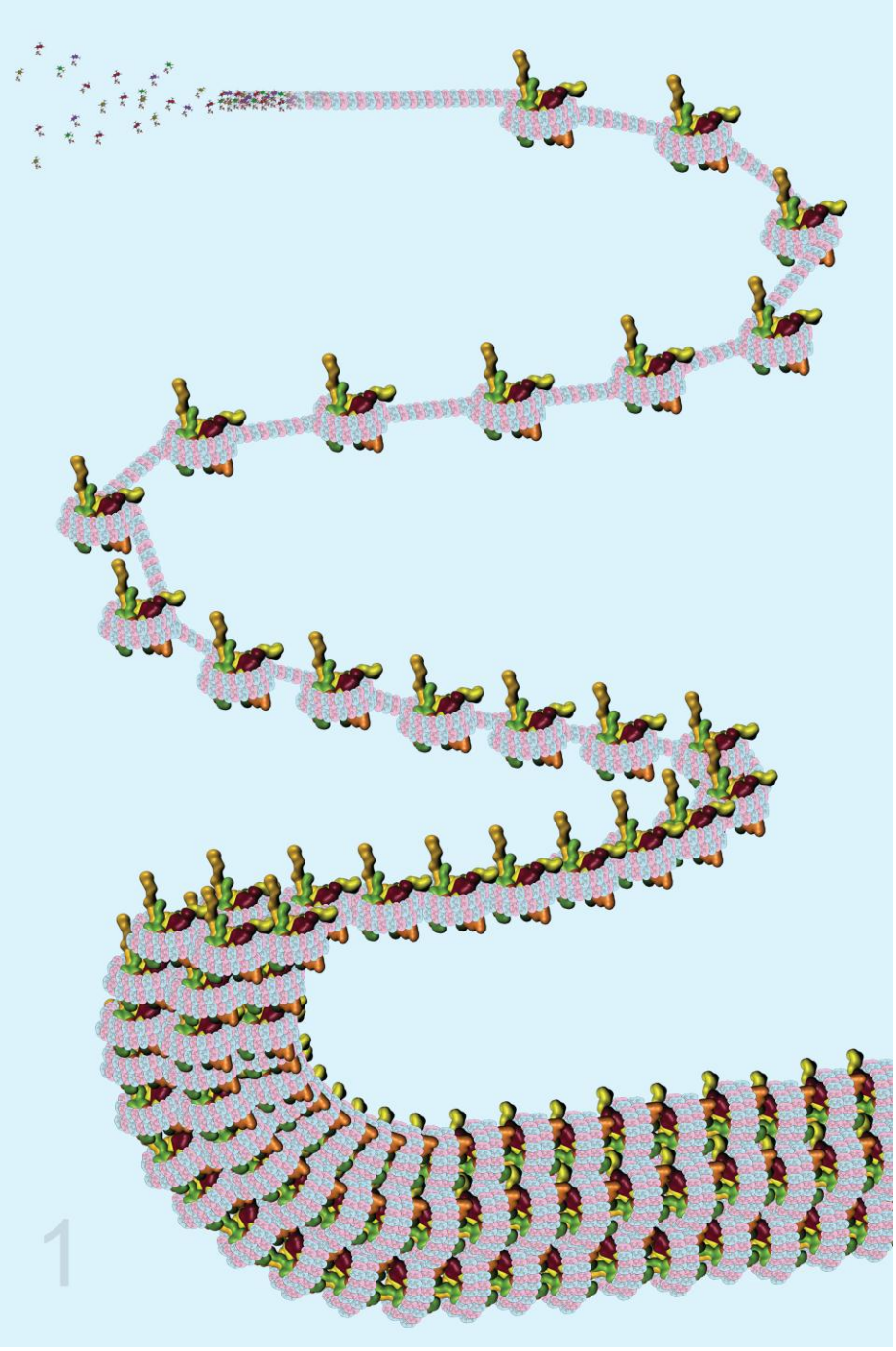

Figure 3-39. Poster 1.

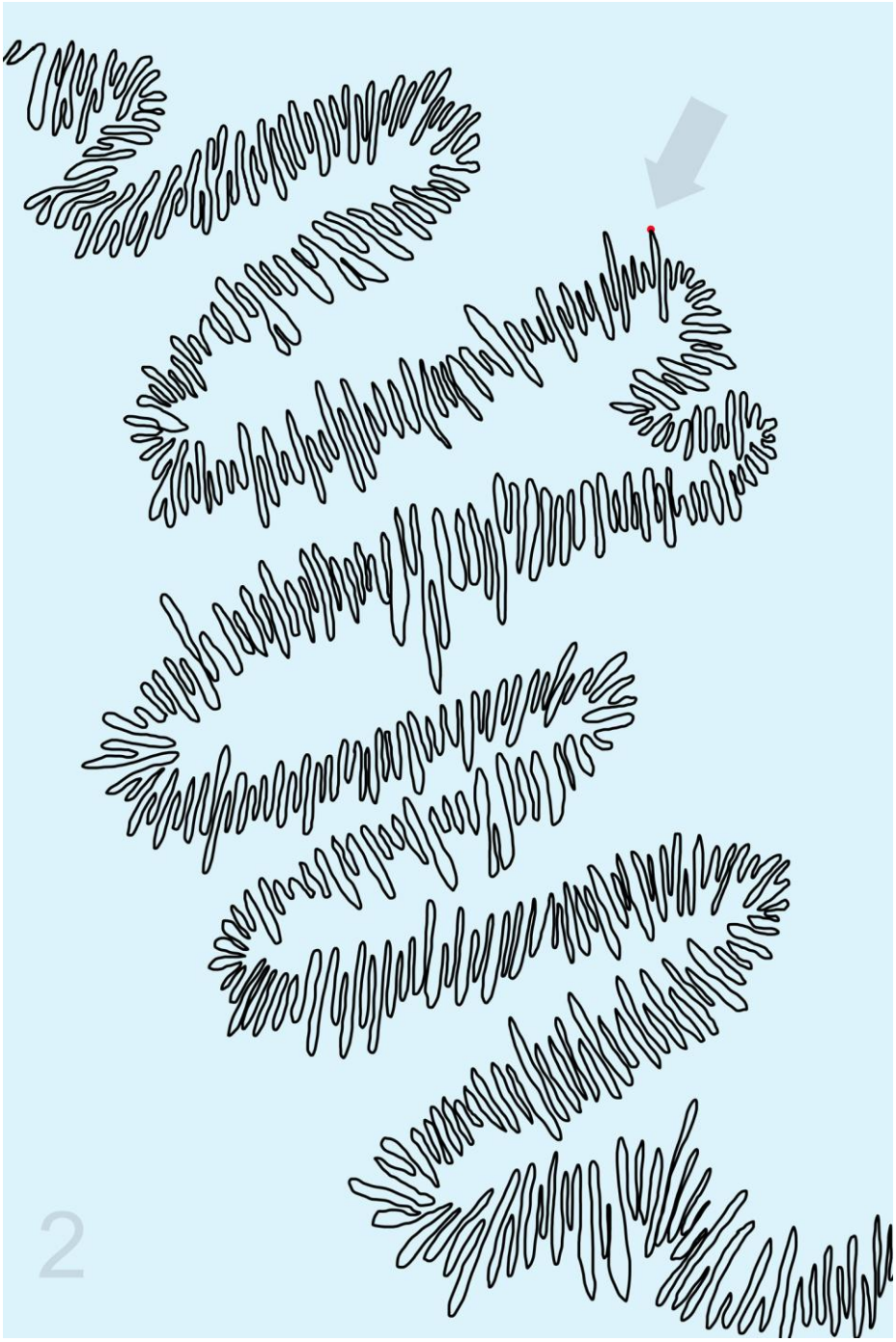

Figure 3-40. Poster 2, with red dot showing the area of Poster 1.

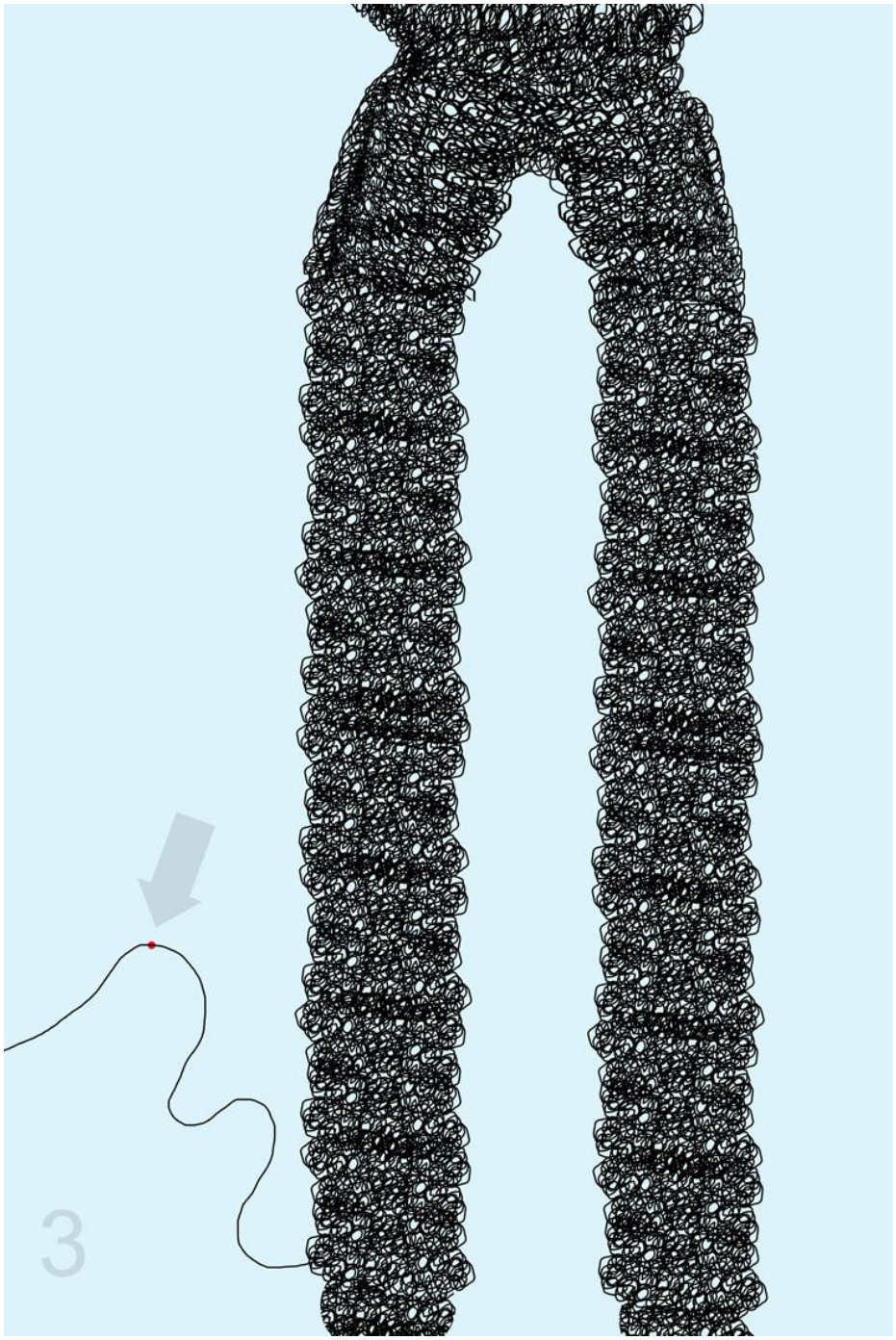

Figure 3-41. Poster 3, with red dot showing the area of Poster 2.

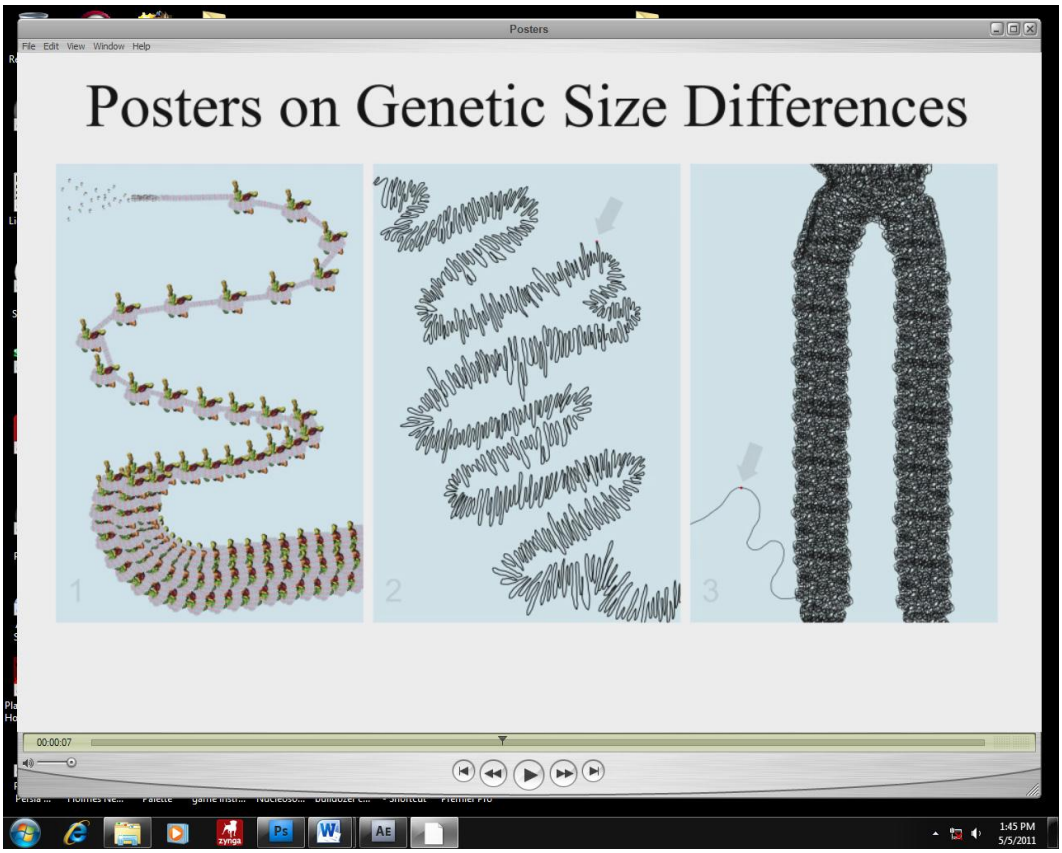

Figure 3-42. Screenshot of poster animation.

Teacher's Instruction Manual

Included within the suitcase is a hard-copy and digital copy of the Teacher's Instruction Manual, an instruction manual on how to properly utilize the components within the suitcase. The guide covers the use of the animation, nucleosome and posters and a quick overview on how to setup the card game. The instruction manual does not address the card game mechanics itself, since that one has its own guide. A digital copy of the

Teacher's Instruction Manual will be present on the Guide DVD. *Arial* font was used for this guide, following the font style used in the card game manual. Both Adobe Illustrator® and Microsoft Word® were used in conjunction to create the guide. As with all other components, this manual also follows the color scheme set down by the universal palette. In this case, it follows the card game manual in design, even applying the gradated amber toned band in the upper edge of each page, with the section name in the blue tone used for the card game logo (Figure 3-43).

Guide DVD

Provided within the scientific suitcase is a Guide DVD, a storage disk that contains:

1) The instruction manual for the Mutations! Card Game in a PDF format
2) The Teacher's Instruction Manual in a PDF format
3) The Nucleosome demonstration video in a Quicktime® format
4) The Genetic Posters animation in a Quicktime® format
5) Digital copies of the Genetic Posters in .jpeg format

In this manner, the Guide DVD will allow educators to have a digital copy of essential components, as well as having hard-copy versions available to them.

Genetic Mutations Animation DVD

The Genetic Mutation DVD included in the scientific suitcase contains several components that may be freely utilized in a Biology classroom (Figure 1-1). The primary component of the CD is a short form animation that is over twenty five minutes long. The animation is divided into several primary sections that may be shown together or separately. The principal purpose of the DVD is to serve as a resource tool that shows students basic genetic concepts, such as DNA, nucleotides and codons. It also explains more advanced concepts, such as nucleosomes and their function in both supercoiling and epigenetics. And finally, the DVD covers in detail the concepts of genetic mutations, their causes and the basic forms of genetic mutations found in nature. It is suggested that the DVD be shown first, as an introductory course into genetic mutations. It will provide students with information that they may use subsequently in the other activities presented in the science suitcase.

Figure 1-1. Genetic Mutations Animation DVD

Figure 3-43. Page from the Teacher's Instruction Manual.

CHAPTER FOUR
Survey Results

Post Production Project Survey

Survey Design

With components of the scientific suitcase completed or almost completed, a quick and informal presentation of the components was given for over 30 educators present at a STARS mini-symposium in April of 2011. This presentation involved playing and showing multiple components, such as the genetic mutation animation, card game, a demo video on the use of the nucleosome model and the nucleosome model itself, and the posters. To get feedback on the components, a one page survey was developed (Appendix G) using Microsoft Word®.

Twenty-seven questions were presented with answers in a 5-point Likert scale ranging from Strongly Disagree to Strongly Agree. The survey was divided into four sections, one for each of the following: Animation, card game, nucleosome and posters. Within each section, questions asking about perceived class effectiveness, appeal for the student, teacher willingness to use the resource and student comprehension over the resources, were asked. The back of each page was turned into an open comment section where educators could feel free to include any observations or pose questions of their own.

Survey Results

Twenty seven individuals answered the survey. Most were biology teachers, representing grades from 8th to 12th. Some were also college educators, and one junior high student was present and answered the survey. Teachers who also teach AP Science, Chemistry, Physiopathology and Forensic Sciences also participated in the survey. This represents a wide array of teaching levels and scientific fields. The aggregated results were calculated for each question, and a side bar graph was generated comparing results (Table 4-1) between all the questions asked.

Additional comments were also reviewed and posted (Appendix G).

I present the following analysis of the individual questions.

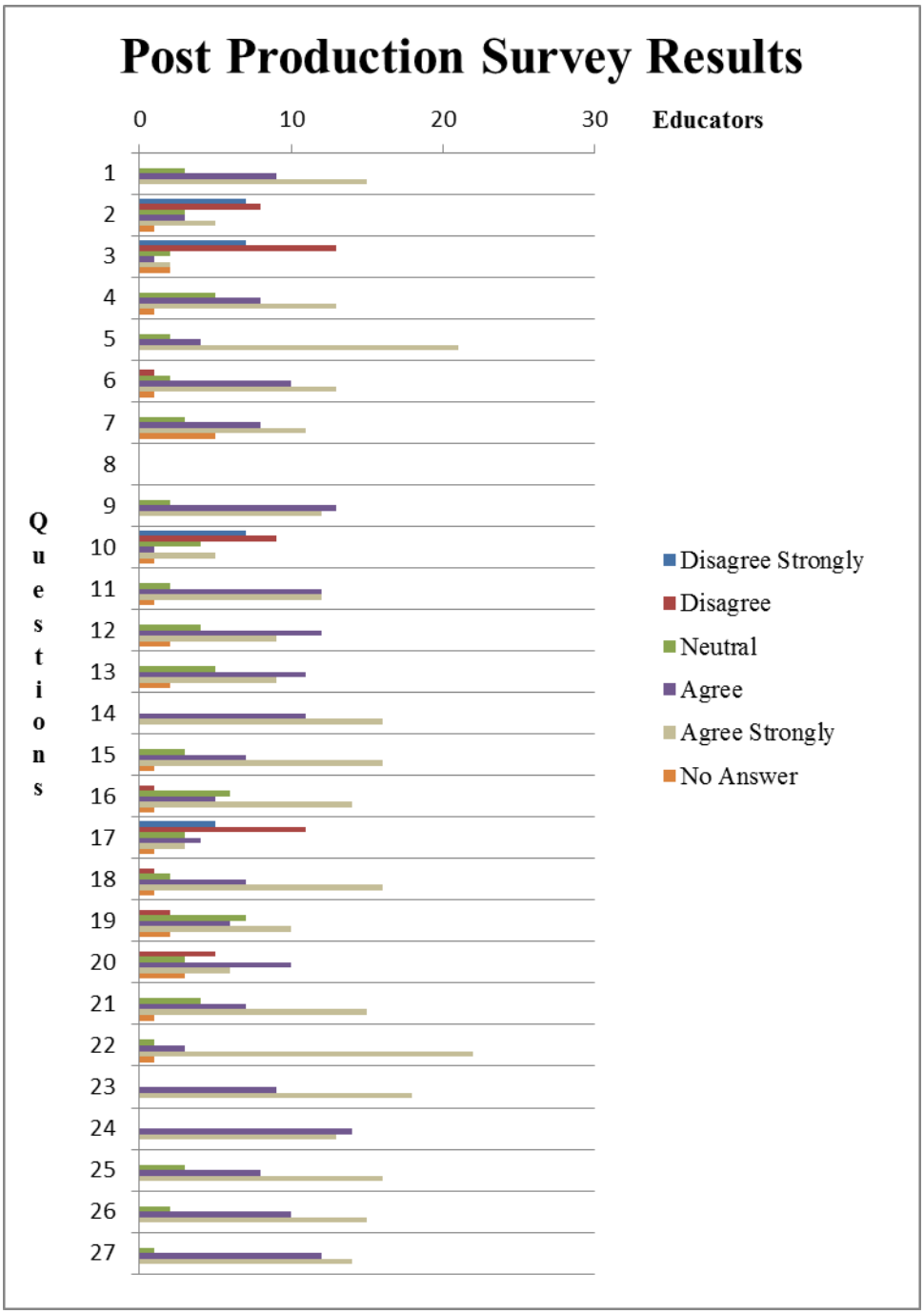

Table 4-1. Post production survey results.

Question 1: The animation would be an effective tool in the teaching of genetics and genetic mutations?

Twenty seven educators answered the question. *Three neutral, 9 agreed and 15 strongly agreed.* The educators agreed that the animation would be an effective teaching tool.

Question 2: The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students?

Twenty six educators answered, one did not. *Seven strongly disagreed, 8 disagreed, 3 neutral, 3 agreed and 5 agreed.* Educators slightly favored the notion that the animation would be understood by their students.

Question 3: The section of the animation dedicated to genetic mutations would be too complex to be understood by your students?

Twenty five answered, two did not. *Seven strongly disagreed, 13 disagreed, 3 neutral, 1 agreed and 2 strongly agreed.* The majority of educators did not believe the section dedicated to genetic mutations would be too difficult for their class.

Question 4: The is animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within?

Twenty six answered, one did not. *Five neutral, 8 agreed and 13 strongly agreed.* The majority of educators believe that ten-minute segments do give enough time to prepare, review and discuss the information within.

Question 5: The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling?

Twenty seven answered. *Two neutral, 4 agreed and 21 strongly agreed.* The majority of the educators believed the section for super-coiling is clear.

Question 6: The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics?

Twenty six answered, one did not. *One disagreed, 2 neutral, 10 agreed, 13 strongly agreed.* Only one educator disagreed that the section dedicated to epigenetics was clear, while the majority supported the notion.

Question 7: The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations?

Twenty two answered, five did not. *Three neutral, 8 agreed and 11 strongly agreed.* The majority of educators believe the introduction to genetic mutations was clear.

Question 8: In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All

Twenty four answered, three did not. Multiple choice question. More than one choice could be selected. *Five preferred CD or DVD, 11 internet, 1 preloaded to a computer, 10 said all methods work.* Though roughly 10 picked all methods, the internet seems to be the single most elected method of delivery. This leads us to believe that at least delivery via internet should be implemented.

Question 9: The card game would be an effective tool in the teaching of genetics and genetic mutations?

Twenty seven answered. *Two neutral, 13 agreed and 12 strongly agreed.* The majority of educators believe the game would be an effective teaching tool for genetic and genetic mutations. This supports the notion that the game could be a valuable tool.

Question 10: The card game is too complex to be understood by your students?

Twenty six answered, one did not. *Seven strongly disagree, 9 disagreed, 4 neutral, 1 agreed and 5 strongly agreed.* An approximate ratio of 3 to 1 of educators do not believe the card game is too complex for their students.

Question 11: The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation?

Twenty six answered, one did not. *Two neutral, 12 agreed and 12 strongly agreed.* The majority believe the section of the game dedicated to building a DNA helix would be an effective teaching tool for nucleotides, DNA orientation and formation.

Question 12: The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause?

Twenty five answered, two did not. *Four neutral, 12 agreed and 9 strongly agreed*. The majority of educators believe this section of the card game would be an effective tool for teaching genetic mutations.

Question 13: I would use this card game in my classroom?

Twenty five answered, two did not. *Five neutral, 11 agreed and 9 strongly agreed.* The majority of educators would use this card in their class.

Question 14: Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach?

Twenty seven answered. *Eleven agreed and 16 strongly agreed.* The majority of educators do believe that sectioning the game allows for greater choice in what concepts to teach. This may be interpreted as an approval for the idea where a section of a game can be selected to teach a particular concept only.

Question 15: The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations?

Twenty six answered, one did not. *Three neutral, 7 agreed and 16 strongly agreed.* The majority of educators believe the card game does reflect the changes in genetic mutations.

Question 16: The model would be an effective tool in teaching genetics and genetic mutations?

Twenty six answered, one did not. *One disagreed, 6 neutral, 5 agreed and 14 strongly agreed.* On educator did not believe the model would be an effective teaching tool.

Question 17: The model would be complex to be understood by the students of your classroom?

Twenty six answered, one did not. *Five strongly disagreed, 11 disagreed, 3 neutral, 4 agreed and 3 strongly agreed.* In a ratio of approximately 2 to 1, educators did not believe that the model would be too complex for their students to comprehend. This still leads to an appreciable number who do think that the model could be beyond the comprehension of their students.

Question 18: The model has been presented in an artistic manner that would be interesting to your students?

Twenty six answered, one did not. *One disagreed, 2 neutral, 7 agreed and 16 strongly agreed.* A majority of the educators believe the artistic manner of the model would appeal to their students. This question was of importance because the actual construction of the model was done by a third-party.

Question 19: The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics?

Twenty five answered, two did not. *Two disagreed, 7 neutral, 6 agreed and 10 strongly agreed.* A large majority of educators believe the model could be an effective teaching tool for supercoiling and epigenetics.

Question 20: The model would be an effective teaching tool presented in a purely digital manner?

Twenty four answered, three did not. *Five disagreed, 3 neutral, 10 agreed and 6 strongly agreed.* A large majority of educators believe the model could function as a teaching tool in a digital presentation.

Question 21: The model's flexibility effectively allows for the teaching of nucleosome functions?

Twenty six answered, one did not. *Four neutral, 7 agreed and 15 strongly agreed.* The majority of educators believe the nucleosome's flexibility allows for effective teaching of its functions.

Question 22: To be effective the model should be designed to be handled by the students?

Twenty six answered, one did not. *One neutral, 3 agreed and 22 strongly agreed.* Virtually all educators that answered do believe the model should be designed to be

handled by the students. This indicates that the model should be redesigned to be stronger, or find another way to present the model to the classroom as a whole.

Question 23: The posters would be an effective tool in the teaching of size differences in genetics?

Twenty seven answered. *Nine agreed and 18 strongly agreed.* Virtually all of the educators believe the posters would be an effective teaching tool for showing size differentials. This supports the effectiveness in the classroom with regard to their subject matter.

Question 24: The posters would be academically understood by the students of your classroom?

Twenty seven answered. Thirteen agreed and 14 strongly agreed. The virtual majority of educators believe the posters would be understood by their students.

Question 25: The posters would be an effective tool in a digital format?

Twenty seven answered. *Three neutral, 8 agreed and 16 strongly agreed.* The majority of educators believe the posters would be an effective tool if shown in a digital presentation. This supports the notion of having the short demo video and digital presentations of the posters included.

Question 26: The posters would be an effective tool in a physical format?

Twenty seven answered. *Two neutral, 10 agreed and 15 strongly agreed.* The majority of educators believe the posters would be an effective tool if shown in a physical presentation.

Question 27: The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome?

Twenty seven answered. *One neutral, 12 agreed and 14 strongly agreed.* The majority of educators believe the posters would be an effective tool for showing the difference in sizes between varying genetic structures.

Additional Comments

In reference to the animation, one educator wrote, "As far as the animation topics are concerned, we have yet to delve that deeply into the mechanics and structure of nucleosomes and histones in general biology, especially when the in-depth information is NOT included on any of the assessments, districts or statewide. The information is great, but may be too much for general classes. I am not sure, but believe it would be better utilized by the AP class." This led me to believe that for this educator, who is a 9^{th} grade teacher, the information may be too complex for her class. Yet, her comment also re-enforced my own observation that the amount of information present at the high school level may be very limited.

In reference to the card game, one educator asked if "the cards could be made available w/o the suitcase? – for use as a free standing activity." Another educator stated "Excellent idea-great game."

For the nucleosome model a few interesting points were observed. "The model, while nice, would be too distracting for the majority of my students." This would lead me to infer that perhaps in this case a digital model would perhaps serve a better purpose than a hands-on model in this teacher's particular class. Another educator noted that for 8th grade class, "students would enjoy putting the nucleosome together piece by piece (lots of excitement in finding out how the parts fit together.)" This is a valid point, but in a physical model it did prove to be too difficult to successfully manage. Fortunately, a digital model does exist in the animation, where students can see the histone components of the nucleosome come together. A third educator noted that though "histone model also work as demo" the physical model is more important because "hands-on manipulation often beats digital virtual exploration b/c kids remember handling manipulatives."

For the posters an educator noted "your poster sequence was very good. My students would understand that – and be amazed." This educator teaches an 8th grade class, so if in her estimation her class would understand the poster concept than so should a 9th grade science class.

Other comments included “I absolutely love this suitcase and cannot wait until it is available to teachers. Wonderful job!”

“Animations and card game are fantastic!”

“Great job!”

One particular comment I believe holds a lot of merit reads “Digital CGI graphic representations are great-better than a textbook lesson, but w/limited kinesthetic learning, I don’t think student recall is as good!” This point is important. It stresses the educator’s need for a physical model that may help to improve the student’s general understanding of a concept. And with such complex ideas, such as those in genetic mutations or epigenetics, hands-on models could potentially be a must.

CHAPTER FIVE
Conclusions and Recommendations

SUMMARY AND CONCLUSIONS

Summary

The goal of this project thesis was to create a lightweight scientific suitcase that 9th grade science educators would be able to utilize in their classroom environment as a resource tool when teaching about genetic mutations. To this end, multiple visual aids were created based on 2-dimensional and 3-dimensional art styles.

A primary component, the animation, was a mixture of 2-dimensional and 3-dimensional artwork put together through the use of multiple programs. Maya 2009® and Adobe Photoshop Illustrator® served as the primary tools for creation of elements in the animation, while Adobe Soundbooth was utilized for properly editing the audio tracks acquired from a studio session. Adobe After Effects®, Adobe Premier Pro® and Adobe Encore were then implemented to create the animation sequences, create a long form video and burn to a DVD, accordingly. The animation was designed to help students better understand the basic mechanisms of genetics, genetic mutations, super-coiling and epigenetics.

The card game, created so students may utilize their acquired knowledge of genetic mutations in a competitive game, was designed with the almost exclusive use of Adobe Illustrator®, with support material made by Maya 2009®.

The nucleosome, an important hands-on model, was created to help students comprehend the functions of histones and DNA. Downloaded, modified and manipulated through Maya 2009® and built by specialists, the nucleosome is created from specialized foam capable of extreme flexibility and coated in a rubberized paint, allowing the whole model to be fully manipulated. This model can assist students understand how the histones of the nucleosome can interact with DNA, ultimately allowing or inhibiting protein synthesis.

The posters were initially created through Adobe Illustrator® and then put together in Adobe Photoshop®, where a sequence of three posters was designed. These posters can help students understand the great size difference that exists between genetic structures, such as a nucleotide and a chromosome.

A Teacher's Instruction Manual built via Adobe Illustrator® and Microsoft Word® was included to assist teachers properly utilize the components within.
Finally, demo videos of some of the components, such as the nucleosome, has been included to give a quick reference on how to utilize the material.

Conclusions

The project surveys returned with generally positive reviews over the different components, with a large support for the posters and animation, specifically the portion

on nucleosomes. And though some educators did express concern that the information may be a bit too complex for their class, others did state that their own classes would understand it, and most supported the components and their presentations. Educators expressed interest in utilizing the card game and some even requested if the cards could be provided as a stand-alone activity. Initial survey results indicate this scientific suitcase will successfully assist teachers in helping to educate their class over genetic mutations.

Recommendations

A suggestion for future research might include testing this case at different educational levels. Not just AP in high school, but perhaps middle school or early college courses. Another suggestion would be the translation of the material within to Spanish, a quickly rising language in the United States of America. A final suggestion would be to do a study over a few years, specifically on genetic mutations, to see if students are benefiting from the material within the suitcase.

APPENDIX A
Initial Project Surveys

Collaborative Survey for Roshni Nelson and Richard Thomas Lankes for the *STARS* science suit project.

If you wish, you may answer this document in Microsoft Word or another document editor and e-mail the survey document back to us, or you may print it, fill out by hand and return to the STARS program. You may return to the following e-mails:

richard.lankes@utsouthwestern.edu
roshni.nelson@utsouthwestern.edu

Beforehand, thank you for taking this survey. Your answers will help sculpt the types of animations, games, physical models and interactive material, if any, that will be used in a STARS science suitcase. We fully understand that your time is precious, so any answered questions will be greatly appreciated!

Survey

Are you a teacher? Yes__x__ No____
Substitute? Yes____ No____
Aide? Yes____ No____
Student Teacher? Yes____ No____

Do you teach or practice within DISD? Yes____ No__x__ Don't know_____

Do you teach Science as your primary lessons? Yes__x__ No____
If "No", what do you teach?

Do you have access to a TV and DVD player in class? Yes_x___ No____

Do your students have access to computers and internet in class?
Yes__x__ No____ Don't know_____

Do they have access to computers and/or internet outside of class?
Yes__x_ No____ Don't know_____

Do you have access to a centrifuge in your classroom/lab? Yes__x__ No____

What concepts about Genetic Mutations do you teach? Harmful, helpful, silent, contributions to genetic variation leading to new traits, genetic disorders such as sickle cell and cystic fibrosis, gene mutations such as point mutations and frameshift mutations, chromosomal mutations (aneuploidy, nondisjunction in meiosis), loss of cell cycle control leading to cancer, causes of mutations (environmental, genetic)

If any concepts, which seem to be difficult for the students to understand? Freshman level have a hard time understanding gene mutations and nondisjunction. Some can't grasp how a chromosome is constructed!

What concepts about Cell Membranes do you teach? Circle or list additional concepts:

Compartmentalization of the Cell \ Fluid Mosiac Model \ Membrane Fluidity \osmosis & diffusion\Membrane Transport\ all of these freshman level
Lipid Rafts \ Cell to Cell Communication only in AP Biology

If any concepts, which seem to be difficult for the students to understand?
Membrane transport, some have trouble understanding structure of membranes, many can't grasp osmosis (hypotonic, isotonic, hypertonic)

Do you have time to teach material about Genetics, Genetic Mutations or Cell Membranes that may go beyond the established guidelines found within the TEKS requirements?
Yes____ No__x__ Don't know_____ (we are a private school and follow National Standards, but still don't have time!)

Do you currently use any kind of visual aids, models, animations or games to teach Genetics, Genetic Mutations or Cell Membranes? Yes__x__ No____ Don't know_____

Please list: Cell membranes: animations using the textbook's website, one model of a phosopholipid bilayer, a demonstration using soap bubbles, and several worksheets to draw and color cell membranes. We do a potato core osmosis lab using soda vs water, sometimes gummy bears to show diffusion. Genetic mutations has very little for models except worksheets.

Do you think that visual aids, models, animations or games are useful in teaching Genetics, Genetic Mutations or Cell Membranes? Yes__xxx!!!__ No____ Don't know_____

If "Yes", in what order, from most useful to least, would you place each item?
Please list the following: Visual Aids, Models, Animations and Games
Most Important:Models, preferably ones that students must construct themselves!
Second Most Important: games – our students LOVE these!
Third Least Important:animations
Least Important: Visual aids

From these items of Visual Aids, Models, Animations and Games, are there any you have never used before? Yes____ No__x__ Don't know_____

If "Yes", please list which:
I've used all of these types, but not many available and some are not good for an "inquiry" based curriculm.

Have you ever used interactive media animations, such as a comprehensive 3D animation, to teach a class? Yes____ No_x___ (although our textbook has online activities that incorporate animations, but most aren't satisfactory and certainly not 3-D).

Have you ever used such animations to teach Genetic Mutations or Cell Membranes?
Yes____ No___x_

Would you use, or be willing to use, an animation to teach Genetic Mutations or Cell Membranes?
Yes__xxx!__ No____ Don't know_____

Would you find a hands-on model demonstrating the Hydrophobic Effect useful?
Yes__XXX!!__ No____ Don't know____

Have you ever used a game to teach Genetic Mutations or Cell Membranes?
Yes____ No__x__.

Would you be willing to use such to teach Genetic Mutations or Cell Membranes?
Yes__XX!__ No____ Don't know_____

Do you feel you have time to use games to teach Genetics in class?
Yes___x_ No____ Don't know__
(If the game can be used as an inquiry method we would make time for it)

If you would use games, would you feel you have the time to read the instructions on how to use the games properly? Yes__x__ No____ Don't know_____
(see above comment)

What level of complexity would you accept in a game for classroom use?
Simple: Yes____ No__x__
Moderate: Yes__x__ No____ (for freshman level)
Complex: Yes__x__ No____ (for AP Bio level)

What type of game would you prefer for teaching Genetic Mutations or Cell Membranes?
Interactive games: Yes__x__ No____
Board games: Yes__x__ No____
Card games: Yes__x__ No____
Communication games: Yes__x__ No___
(Shout-out games)
Word games: Yes__x__ No____
Memory games: Yes_x___ No____
Matching games: Yes_x___ No____
Physical models: Yes__x__ No____
Combination:
A game that is integrated into a usable model: Yes_xx___ No____
Others: Yes____ No____
List them please: students love to play any "competition" type of game, like Who's Smarter than a 5th grader, Jeopardy, Password, Cash cab, etc. If prizes are awarded they absolutely love it! Just look at the game shows on TV for examples.

Would you prefer a game that can be played quickly in one day, or that can be played across several days? One day___X___ Two or more days_____

That has few pieces but simple, or more pieces but a more complex game?

Few pieces_____ More pieces_____X____

That follows a standard well known game, like Chutes and Ladders, or is different from what most students have played? Standard_____X_____ Different_____
The more familiar they are, the easier it is to explain it and get it going in class.

Please list any idea or concept you think we could utilize to help you in teaching Genetics, Genetic Mutations or Cell Membranes more effectively? For mutations and cell membranes this survey pretty much covered it, but for genetics in general, models of Punnett squares, chromosomes, and alleles on chromosomes would be helpful.

Collaborative Survey for Roshni Nelson and Richard Thomas Lankes for the *STARS* science suit project.

If you wish, you may answer this document in Microsoft Word or another document editor and e-mail the survey document back to us, or you may print it, fill out by hand and return to the STARS program. You may return to the following e-mails:

richard.lankes@utsouthwestern.edu
roshni.nelson@utsouthwestern.edu

Beforehand, thank you for taking this survey. Your answers will help sculpt the types of animations, games, physical models and interactive material, if any, that will be used in a STARS science suitcase. We fully understand that your time is precious, so any answered questions will be greatly appreciated!

Survey

Are you a teacher? Yes_x___ No____
Substitute? Yes____ No____
Aide? Yes____ No____
Student Teacher? Yes____ No____

Do you teach or practice within DISD? Yes____ No_x___ Don't know_____

Do you teach Science as your primary lessons? Yes__x__ No____
If "No", what do you teach?

Do you have access to a TV and DVD player in class? Yes_x___ No____

Do your students have access to computers and internet in class?
Yes__x__ No____ Don't know_____

Do they have access to computers and/or internet outside of class?
Yes__x__ No____ Don't know_____

Do you have access to a centrifuge in your classroom/lab? Yes____ No__x__

What concepts about Genetic Mutations do you teach?
-I teach chemistry (Forensic)
If any concepts, which seem to be difficult for the students to understand?

What concepts about Cell Membranes do you teach? Circle or list additional concepts:
-Just the basic.
Compartmentalization of the Cell \ Fluid Mosiac Model \ Lipid Rafts \ Membrane Fluidity \ Membrane Transport \ Cell to Cell Communication

If any concepts, which seem to be difficult for the students to understand?

-None

Do you have time to teach material about Genetics, Genetic Mutations or Cell Membranes that may go beyond the established guidelines found within the TEKS requirements?
Yes____ No____ Don't know_x____

Do you currently use any kind of visual aids, models, animations or games to teach Genetics, Genetic Mutations or Cell Membranes? Yes____ No____ Don't know_x____

Please list:

Do you think that visual aids, models, animations or games are useful in teaching Genetics, Genetic Mutations or Cell Membranes? Yes____ No____ Don't know_x____

If "Yes", in what order, from most useful to least, would you place each item?
Please list the following: Visual Aids, Models, Animations and Games
Most Important:
Second Most Important:
Third Least Important:
Least Important:

From these items of Visual Aids, Models, Animations and Games, are there any you have never used before? Yes____ No____ Don't know_x____

If "Yes", please list which:

Have you ever used interactive media animations, such as a comprehensive 3D animation, to teach a class? Yes_x___ No____

Have you ever used such animations to teach Genetic Mutations or Cell Membranes?
Yes____ No_x___

Would you use, or be willing to use, an animation to teach Genetic Mutations or Cell Membranes?
Yes_x___ No____ Don't know_____

Would you find a hands-on model demonstrating the Hydrophobic Effect useful?
Yes_x___ No____ Don't know____

Have you ever used a game to teach Genetic Mutations or Cell Membranes?
Yes____ No_x___

Would you be willing to use such to teach Genetic Mutations or Cell Membranes?
Yes____ No____ Don't know__x___

Do you feel you have time to use games to teach Genetics in class?
Yes_x___ No____ Don't know_____

If you would use games, would you feel you have the time to read the instructions on how to use the games properly? Yes_x___ No____ Don't know_____

What level of complexity would you accept in a game for classroom use?
Simple: Yes____ No____
Moderate: Yes_x___ No____
Complex: Yes____ No____

What type of game would you prefer for teaching Genetic Mutations or Cell Membranes?
Interactive games: Yes_x___ No____
Board games: Yes____ No____
Card games: Yes__x__ No____
Communication games: Yes____ No____
(Shout-out games)
Word games: Yes_x___ No____
Memory games: Yes____ No____
Matching games:
Physical models: Yes__x__ No____
Combination:
A game that is integrated into a usable model: Yes_x___ No____
Others: Yes____ No____
List them please:

Would you prefer a game that can be played quickly in one day, or that can be played across several days? One day_x_____ Two or more days_____

That has few pieces but simple, or more pieces but a more complex game?
Few pieces__x___ More pieces_____

That follows a standard well known game, like Chutes and Ladders, or is different from what most students have played? Standard___x_____ Different_____

Please list any idea or concept you think we could utilize to help you in teaching Genetics, Genetic Mutations or Cell Membranes more effectively?

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Survey

Are you a teacher? Yes__x__ No____
Substitute? Yes____ No____
Aide? Yes____ No____
Student Teacher? Yes____ No____

Do you teach or practice within DISD? Yes____ No__x__ Don't know_____

Do you teach Science as your primary lessons? Yes__x__ No____
If "No", what do you teach?

Do you have access to a TV and DVD player in class? Yes__x__ No____

Do your students have access to computers and internet in class?
Yes__x__ No____ Don't know_____

Do they have access to computers and/or internet outside of class?
Yes__x__ No__x__ Don't know_____

Do you have access to a centrifuge in your classroom/lab? Yes____ No__x__

What concepts about Genetic Mutations do you teach? 4 kinds of mutations (deletion, duplications, transpositions and translocations, etc.), genetic diseases (CF, Sickle Cell, etc.)

If any concepts, which seem to be difficult for the students to understand? They seem to understand the concept of mutations and how/why they happen: "copying errors during mitosis." The only thing they usually have a problem with is accurately recalling/distinguishing the 4 kinds of mutations

What concepts about Cell Membranes do you teach? Circle or list additional concepts:

Compartmentalization of the Cell \ Fluid Mosiac Model \ Lipid Rafts \ Membrane Fluidity \

Membrane Transport \ Cell to Cell Communication

If any concepts, which seem to be difficult for the students to understand?

Do you have time to teach material about Genetics, Genetic Mutations or Cell Membranes that may go beyond the established guidelines found within the TEKS requirements?
Yes__x__ No____ Don't know_____

Do you currently use any kind of visual aids, models, animations or games to teach Genetics, Genetic Mutations or Cell Membranes? Yes__x__ No____ Don't know_____

Please list: BrainPop, some iDNA website animations, simple DNA model building lab (with colored paperclips and rubber bands), Nova Science Now video clip about CF

Do you think that visual aids, models, animations or games are useful in teaching Genetics, Genetic Mutations or Cell Membranes? Yes__x__ No____ Don't know_____

If "Yes", in what order, from most useful to least, would you place each item?
Please list the following: Visual Aids, Models, Animations and Games
Most Important: Visual Aids (including videos)
Second Most Important: Models
Third Least Important: Animations
Least Important: Games

From these items of Visual Aids, Models, Animations and Games, are there any you have never used before? Yes____ No____ Don't know_____

If "Yes", please list which:

Have you ever used interactive media animations, such as a comprehensive 3D animation, to teach a class? Yes__x__ No____

Have you ever used such animations to teach Genetic Mutations or Cell Membranes?
Yes__x__ No____

Would you use, or be willing to use, an animation to teach Genetic Mutations or Cell Membranes?
Yes__x__ No____ Don't know_____

Would you find a hands-on model demonstrating the Hydrophobic Effect useful?
Yes__x__ No____ Don't know____

Have you ever used a game to teach Genetic Mutations or Cell Membranes?
Yes____ No__x__ (I'm not aware of one!)

Would you be willing to use such to teach Genetic Mutations or Cell Membranes?
Yes__x__ No____ Don't know_____

Do you feel you have time to use games to teach Genetics in class?
Yes__x__ No____ Don't know_____

If you would use games, would you feel you have the time to read the instructions on how to use the games properly? Yes__x__ No____ Don't know_____

What level of complexity would you accept in a game for classroom use?
Simple: Yes__x__ No____
Moderate: Yes__x__ No____
Complex: Yes__x__ No____

What type of game would you prefer for teaching Genetic Mutations or Cell Membranes?
Interactive games: Yes__x__ No____
Board games: Yes__x__ No____
Card games: Yes__x__ No____
Communication games: Yes____ No__x__
(Shout-out games)
Word games: Yes____ No__x__
Memory games: Yes____ No__x__
Matching games:
Physical models: Yes__x__ No____
Combination:
A game that is integrated into a usable model: Yes__xxx__ No____
Others: Yes____ No____
List them please:

Would you prefer a game that can be played quickly in one day, or that can be played across several days? One day___x___ Two or more days_____

That has few pieces but simple, or more pieces but a more complex game?
Few pieces___x__ More pieces_____

That follows a standard well known game, like Chutes and Ladders, or is different from what most students have played? Standard_____x_____ Different_____

Please list any idea or concept you think we could utilize to help you in teaching Genetics, Genetic Mutations or Cell Membranes more effectively?

Something I haven't touched on is the concept of probability. Kids often miss the fact that for each birth, the probability of having a given mutation remains constant. It would be a bonus if you could include a probability factor in your game activity to help reinforce this concept.

Collaborative Survey for Roshni Nelson and Richard Thomas Lankes for the *STARS* science suit project.

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Beforehand, thank you for taking this survey. Your answers will help sculpt the types of animations, games, physical models and interactive material, if any, that will be used in a STARS science suitcase. We fully understand that your time is precious, so any answered questions will be greatly appreciated!

Survey

Are you a teacher? Yes_x___ No____
Substitute? Yes____ No____
Aide? Yes____ No____
Student Teacher? Yes____ No____

Do you teach or practice within DISD? Yes____ No__x__ Don't know_____

Do you teach Science as your primary lessons? Yes_x___ No____
If "No", what do you teach?

Do you have access to a TV and DVD player in class? Yes_x___ No____

Do your students have access to computers and internet in class?
Yes_x___ No____ Don't know_____

Do they have access to computers and/or internet outside of class?
Yes____ No____ Don't know__x___

Do you have access to a centrifuge in your classroom/lab? Yes____ No_x___

What concepts about Genetic Mutations do you teach? Substitution –deletion& insertion

If any concepts, which seem to be difficult for the students to understand?

What concepts about Cell Membranes do you teach? Circle or list additional concepts:

Compartmentalization of the Cell \ Fluid Mosiac Model \ Lipid Rafts \ Membrane Fluidity \ Membrane Transport \ Cell to Cell Communication

If any concepts, which seem to be difficult for the students to understand?

Do you have time to teach material about Genetics, Genetic Mutations or Cell Membranes that may go beyond the established guidelines found within the TEKS requirements?
Yes__x__ No____ Don't know_____

Do you currently use any kind of visual aids, models, animations or games to teach Genetics, Genetic Mutations or Cell Membranes? Yes_x___ No____ Don't know_____

Please list: Models, Animations ,visual aids.

Do you think that visual aids, models, animations or games are useful in teaching Genetics, Genetic Mutations or Cell Membranes? Yes_x___ No____ Don't know_____

If "Yes", in what order, from most useful to least, would you place each item?
Please list the following: Visual Aids, Models, Animations and Games
Most Important: model
Second Most Important: animation
Third Least Important: visual aid
Least Important:

From these items of Visual Aids, Models, Animations and Games, are there any you have never used before? Yes____ No_x___ Don't know_____

If "Yes", please list which:

Have you ever used interactive media animations, such as a comprehensive 3D animation, to teach a class? Yes__x__ No____

Have you ever used such animations to teach Genetic Mutations or Cell Membranes?
Yes_x___ No____

Would you use, or be willing to use, an animation to teach Genetic Mutations or Cell Membranes?
Yes__x__ No____ Don't know_____

Would you find a hands-on model demonstrating the Hydrophobic Effect useful?
Yes____ No____ Don't know__x__

Have you ever used a game to teach Genetic Mutations or Cell Membranes?
Yes____ No__x__

Would you be willing to use such to teach Genetic Mutations or Cell Membranes?
Yes__x__ No____ Don't know_____

Do you feel you have time to use games to teach Genetics in class?
Yes____ No____ Don't know__x___

If you would use games, would you feel you have the time to read the instructions on how to use the games properly? Yes____ No_x___ Don't know_____

What level of complexity would you accept in a game for classroom use?
Simple: Yes_x___ No____
Moderate: Yes____ No____
Complex: Yes____ No____

What type of game would you prefer for teaching Genetic Mutations or Cell Membranes?
Interactive games: Yes__x__ No____
Board games: Yes_x___ No____
Card games: Yes__x__ No____
Communication games: Yes____ No____
(Shout-out games)
Word games: Yes_x___ No____
Memory games: Yes__x__ No____
Matching games:
Physical models: Yes__x__ No____
Combination:
A game that is integrated into a usable model: Yes_x__ No____
Others: Yes____ No____
List them please:

Would you prefer a game that can be played quickly in one day, or that can be played across several days? One day__x____ Two or more days_____

That has few pieces but simple, or more pieces but a more complex game?
Few pieces__x___ More pieces_____

That follows a standard well known game, like Chutes and Ladders, or is different from what most students have played? Standard___x_____ Different_____

Please list any idea or concept you think we could utilize to help you in teaching Genetics, Genetic Mutations or Cell Membranes more effectively?

Collaborative Survey for Roshni Nelson and Richard Thomas Lankes for the STARS science suit project.

If you wish, you may answer this document in Microsoft Word or another document editor and e-mail the survey document back to us, or you may print it, fill out by hand and return to the STARS program.
You may return to the following e-mails:
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Beforehand, thank you for taking this survey. Your answers will help sculpt the types of animations, games, physical models and interactive material, if any, that will be used in a STARS science suitcase. We fully understand that your time is precious, so any answered questions will be greatly appreciated!

Survey

Are you a teacher? Yes__x__ No____
Substitute? Yes____ No__x__
Aide? Yes____ No_x___
Student Teacher? Y
es____ No___x_

Do you teach or practice within DISD?Yes____ No__x__
Don't know_____

Do you teach Science as your primary lessons? Yes__x__ No____
If "No", what do you teach?

Do you have access to a TV and DVD player in class? Yes_x___
No____

Do your students have access to computers and internet in class?
Yes__x__ No____ Don't know_____

Do they have access to computers and/or internet outside of class?

Yes_x__ No____ Don't know_____

Do you have access to a centrifuge in your classroom/lab?
Yes__x__ No____

What concepts about Genetic Mutations do you teach? Names of types of mutations, monosomy, trisomy, examples of these (Down's, Turners, Kleinfelter)

If any concepts, which seem to be difficult for the students to understand?

What concepts about Cell Membranes do you teach? Circle or list additional concepts:
Compartmentalization of the Cell \ Fluid Mosiac Model \ Lipid Rafts \ Membrane Fluidity \
Membrane Transport \ Cell to Cell Communication

If any concepts, which seem to be difficult for the students to understand?
Figuring out which way water moves in osmosis

Do you have time to teach material about Genetics, Genetic Mutations or Cell Membranes that may go beyond the established guidelines found within the TEKS requirements?
Yes____ No____ Don't know__x___

Do you currently use any kind of visual aids, models, animations or games to teach Genetics, Genetic Mutations or Cell Membranes?
Yes___x_ No____ Don't know_____

Please list: DNA helix model, animation of protein synthesis, paper cell membrane model

Do you think that visual aids, models, animations or games are useful in teaching Genetics, Genetic Mutations or Cell Membranes?
Yes_x___ No____ Don't know_____

If "Yes", in what order, from most useful to least, would you place each item?
Please list the following: Visual Aids, Models, Animations and Games

Most Important: Animations
Second Most Important: Visual aids
Third Least Important: models
Least Important: games

From these items of Visual Aids, Models, Animations and Games, are there any you have never used before? Yes___x_

No____ Don't know_____

If "Yes", please list which:

Have you ever used interactive media animations, such as a comprehensive 3D animation, to teach a class?
Yes_x___ No____

Have you ever used such animations to teach Genetic Mutations or Cell Membranes?
Yes____ No___x_

Would you use, or be willing to use, an animation to teach Genetic Mutations or Cell Membranes?
Yes__x__ No____ Don't know_____

Would you find a hands-on model demonstrating the Hydrophobic Effect useful?
Yes_x___ No____ Don't know____

Have you ever used a game to teach Genetic Mutations or Cell Membranes?

Yes____ No__x__

Would you be willing to use such to teach Genetic Mutations or Cell Membranes?
Yes__x__ No____
Don't know_____

Do you feel you have time to use games to teach Genetics in class?
Yes____ No____
Don't know_x____

If you would use games, would you feel you have the time to read the instructions on how to use the games properly? Yes____
No____ Don't know__x___

What level of complexity would you accept in a game for classroom use?
Simple: Yes__x__ No____

Moderate: Yes_x___ No____

Complex: Yes____ No_x__

What type of game would you prefer for teaching Genetic Mutations or Cell Membranes?

Interactive games: Yes_x___ No____

Board games: Yes_x__ No____

Card games: Yes___x_ No____

Communication games: Yes__x__ No____

(Shout-out games)

Word games: Yes__x__ No____

Memory games: Yes__x__ No____

Matching games:

Physical models: Yes____ No____

Combination:

A game that is integrated into a usable model: Yes____ No____

Others: Yes____ No____

List them please:

Would you prefer a game that can be played quickly in one day, or that can be played across several days? One day____x__ Two or more days_____

That has few pieces but simple, or more pieces but a more complex game?

Few pieces__x___ More pieces_____

That follows a standard well known game, like Chutes and Ladders, or is different from what most students have played?

Standard___x_____Different_____

Please list any idea or concept you think we could utilize to help you in teaching Genetics, Genetic Mutations or Cell Membranes more effectively?

Collaborative Survey for Roshni Nelson and Richard Thomas Lankes for the *STARS* science suit project.

If you wish, you may answer this document in Microsoft Word or another document editor and e-mail the survey document back to us, or you may print it, fill out by hand and return to the STARS program. You may return to the following e-mails:

richard.lankes@utsouthwestern.edu
roshni.nelson@utsouthwestern.edu

Beforehand, thank you for taking this survey. Your answers will help sculpt the types of animations, games, physical models and interactive material, if any, that will be used in a STARS science suitcase. We fully understand that your time is precious, so any answered questions will be greatly appreciated!

Survey

Are you a teacher? Yes__X__ No____
Substitute? Yes____ No____
Aide? Yes____ No____
Student Teacher? Yes____ No____

Do you teach or practice within DISD? Yes____ No___X_ Don't know_____

Do you teach Science as your primary lessons? Yes__X__ No____
If "No", what do you teach?

Do you have access to a TV and DVD player in class? Yes__X__ No____

Do your students have access to computers and internet in class?
Yes__X__ No____ Don't know_____

Do they have access to computers and/or internet outside of class?
Yes__X__ No____ Don't know_____

Do you have access to a centrifuge in your classroom/lab? Yes___X_ No____

What concepts about Genetic Mutations do you teach? Insertion, deletion, monosomy, trisomy, non-disjunction, Inversion,

If any concepts, which seem to be difficult for the students to understand? Homologous Pairs, Mitosis/Meiosis and the Haploid/Diploid part of it.

What concepts about Cell Membranes do you teach? Circle or list additional concepts:

Compartmentalization of the Cell \ **Fluid Mosiac Model** \ Lipid Rafts \ Membrane Fluidity \ **Membrane Transport** \ **Cell to Cell Communication**

If any concepts, which seem to be difficult for the students to understand? That the membrane crates absolutely no energy. Stores no DNA

Do you have time to teach material about Genetics, Genetic Mutations or Cell Membranes that may go beyond the established guidelines found within the TEKS requirements?
Yes___X_ No____ Don't know_____

Do you currently use any kind of visual aids, models, animations or games to teach Genetics, Genetic Mutations or Cell Membranes? Yes__X__ No____ Don't know_____

Please list: I have magnets from speakeasies.biz, we do a Cell Play

Do you think that visual aids, models, animations or games are useful in teaching Genetics, Genetic Mutations or Cell Membranes? Yes_X___ No____ Don't know_____

If "Yes", in what order, from most useful to least, would you place each item?
Please list the following: Visual Aids, Models, Animations and Games
Most Important: Visual
Second Most Important: Models
Third Least Important: Games
Least Important: Animations

From these items of Visual Aids, Models, Animations and Games, are there any you have never used before? Yes____ No___X_ Don't know_____

If "Yes", please list which:

Have you ever used interactive media animations, such as a comprehensive 3D animation, to teach a class? Yes__X__ No____

Have you ever used such animations to teach Genetic Mutations or Cell Membranes?
Yes__X__ No____

Would you use, or be willing to use, an animation to teach Genetic Mutations or Cell Membranes?
Yes_X___ No____ Don't know_____

Would you find a hands-on model demonstrating the Hydrophobic Effect useful?
Yes__X__ No____ Don't know____

Have you ever used a game to teach Genetic Mutations or Cell Membranes?
Yes__X__ No____

Would you be willing to use such to teach Genetic Mutations or Cell Membranes?

Yes__X__ No____ Don't know_____

Do you feel you have time to use games to teach Genetics in class?
Yes___X_ No____ Don't know_____

If you would use games, would you feel you have the time to read the instructions on how to use the games properly? Yes__X__ No____ Don't know_____

What level of complexity would you accept in a game for classroom use?
Simple: Yes____ No____
Moderate: Yes___X_ No____
Complex: Yes___X_ No____

What type of game would you prefer for teaching Genetic Mutations or Cell Membranes?
Interactive games: Yes___X_ No____
Board games: Yes____ No____
Card games: Yes____ No____
Communication games: Yes__X__ No____
(Shout-out games)
Word games: Yes____ No____
Memory games: Yes____ No____
Matching games:
Physical models: Yes___X_ No____
Combination:
A game that is integrated into a usable model: Yes___X_ No____
Others: Yes____ No____
List them please:

Would you prefer a game that can be played quickly in one day, or that can be played across several days? One day____X__ Two or more days_____

That has few pieces but simple, or more pieces but a more complex game?
Few pieces___X__ More pieces_____

That follows a standard well known game, like Chutes and Ladders, or is different from what most students have played? Standard____X_____ Different_____

Please list any idea or concept you think we could utilize to help you in teaching Genetics, Genetic Mutations or Cell Membranes more effectively?

APPENDIX B
Card Game Instruction Guide

card game

Mutations!

Instruction Manual

An Educational Card Game Created With the Generous Support of

STARS
UT SOUTHWESTERN MEDICAL CENTER

Mutations!

Game Components List

Nucleotide Cards
Twenty Five (25) Each of *Adenine, Guanine, Cytosine*, and *Thymine*

Mutation Cards
Ten (10) Each of *Deletion, Duplication, Insertion, Inversion, Silent,* and *Translocation*

Movement Cards
Ten (10) Each of *1 Forward, 2 Forward* and *3 Forward*

Movement Cards
Twenty (20) Each of *1 Back*

Gene Therapy Cards
Five (5) *Gene Therapy*

Game Boards
Two (2) Game Boards - *Team A* and *Team B*

Game Card Deck
One (1) Game Card Deck for Shuffled Cards

Team Tokens
Two (2) Team Tokens - One Per Team

Quick Reference Sheets
Two (2) *Student Quick Reference Sheets*
One (1) *Educator Quick Reference Sheets*

One (1) Instruction Manual

Mutations!

An Educational Card Game on Genetic Mutations

For 2 teams of up to 6 players each / Suggested Age 10th grade

Game Introduction

The card game "**Mutations!**" is an educational gaming tool designed to assist high school science educators in the teaching of genetic mutations in a 10th grade classroom setting.

Objective

By forming two opposing teams, students will utilize game cards to build a stable DNA helix for their own team while producing mutations in the opposing team's DNA Strand. These card-created DNA Strands serve both as part of the game board and the game itself, since tokens representing each team will travel up and down the DNA card helices in an attempt to be the first to reach the end of the game board.

Components

The card game "**Mutations!**" utilizes the following components:

Cards

- Series of four distinct cards, each representing one of four 'Nucleotides'.
- Series of six distinct cards, each representing a basic 'Mutation'.
- Series of four distinct cards, each representing 'Movement' that allow Team Tokens to move a fixed number of spaces on the DNA.
- A unique card representing 'Gene Therapy', a manner for correcting inflicted mutations.

Game Board

Two game boards, one designated for each participating team. A game board has three primary functions.

- The game board functions as a docking site for the game cards that form the DNA helix in the primary phase (Building Phase) of the game.
- The game board functions as a traveling route for team tokens that travel up and down the helix in the secondary phase (Movement Phase) of the game.
- To play all game cards upon.

Team Token

Round plastic chip that represents an enzyme that travels upon the DNA card helices. Team tokens are identical and interchangeable. Each team has one token.

Game Deck Board

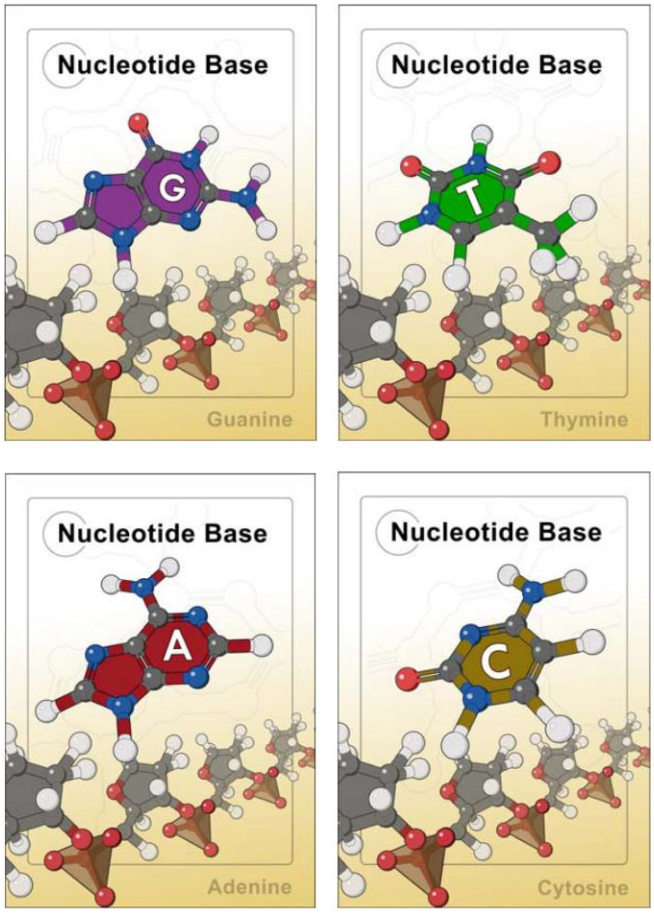
A standard size board for holding game card decks after being shuffled.

Reference Sheet

A reference guide given to each team and an educator.

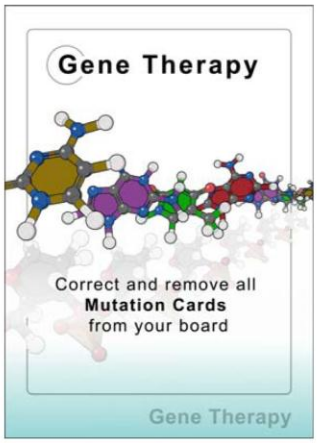
Components Detailed Description

Nucleotide cards are four specific cards that represent the known nucleotides of *Guanine*, *Thymine*, *Adenine* and *Cytosine*. These are the primary building cards of the game, utilized in the construction of a stable DNA helix Template Strand and its Complementary Strand.

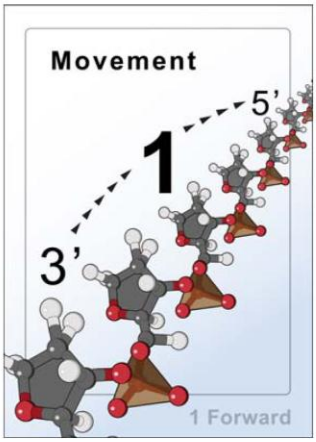


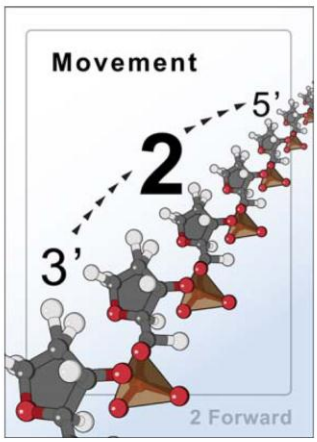
Mutation cards describe six basic mutations. They are *Deletion*, *Duplication*, *Insertion*, *Inversion*, *Silent* and *Translocation*. All Mutation cards, except *Silent*, produce negative changes to an opposing team's Complementary Strand. The Mutation card *Silent* allows one chosen Mutation already on the DNA helix to be ignored during game play. Because of this, *Silent* is the only Mutation card that a team can play on themselves to override or ignore an inflicted Mutation.

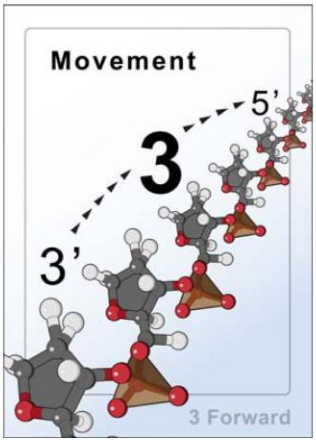
Gene Therapy cards are unique cards that allow teams to successfully change all mutated portions of their Complementary Strand back to its original form. This will repair and remove all mutations, including *Silent*.



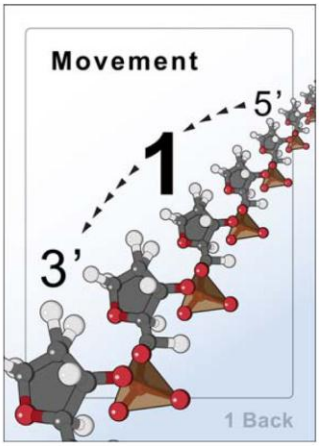
Movement cards allow teams to move their Team Tokens up and down the DNA helix during the Movement Phase of the game. The cards have a set number upon them with an arrow indication the direction of movement. Team Tokens will move either forward or back depending on the indicated number of spaces. These are the three cards that indicate forward movement.







This is the singular Movement card that forces Team Tokens to travel backward on the DNA helix.

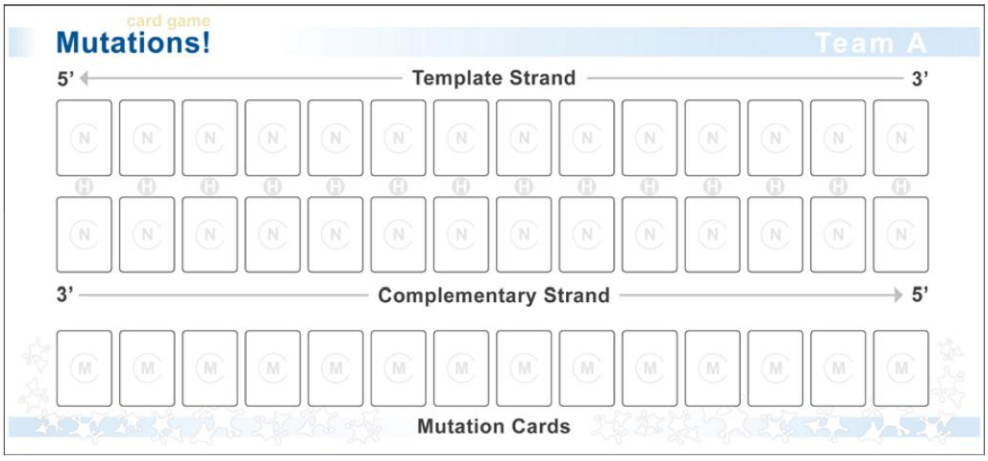


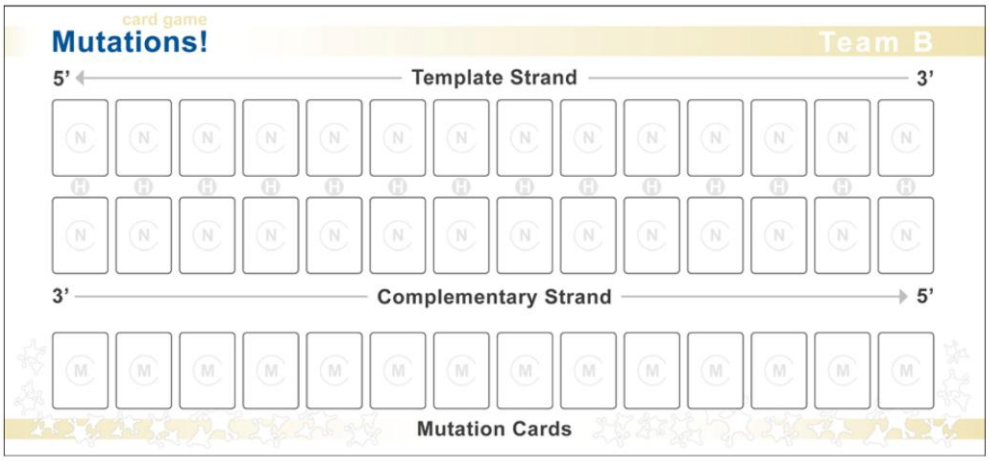
All cards have the same backing so identification by an opposing team is not possible.

The ‘Game Board’ is a four foot wide, twenty-two inch high flexible playing board that teams utilize for multiple functions.

- To build their team’s DNA double helix with the use of Nucleotide cards.
- To play Nucleotide, Mutation and Movement Point cards upon.
- To move their Team Token upon.

Game Boards are identified as either belonging to Team A or Team B. Each individual Game Board has three separate card Strands. One each for the Template Strand, the Complimentary Strand and the Mutation Card play area. The board will have opposing 3’-5’ orientations, just like that found in true DNA.





A Team Token is a round plastic piece that represents a team’s progress on the game board. It is a small playing device that teams move up and down

the card-built DNA helix itself in an attempt to reach the end point, the last card, of the 5' edge on the Complementary Strand. Each token is identical.

Standard Game Mechanics

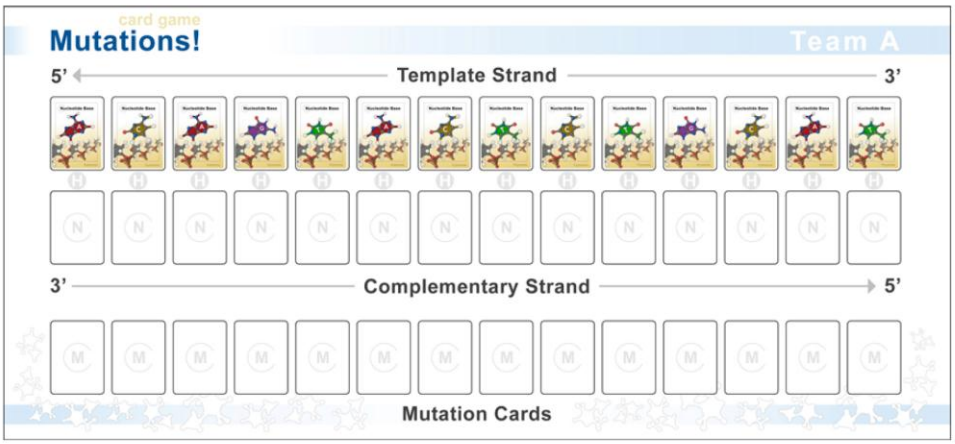
Students form into two teams, Team A and Team B, with their own respective game boards. Recommended play is that each team should have up to six players.

Cards are separated out and grouped by type. Each team receives one free Gene Therapy card, and the rest are mixed in with the Mutation cards. All cards will be shuffled and placed into three separate decks. The decks are the Nucleotide deck, Movement deck, and Mutation deck. The Nucleotide and Movement decks are placed face down after shuffling and shared between Teams A and B.

After shuffling, five Mutation cards are dealt out to each team, insuring a random load of mutation types to each side. The Mutation deck is then set aside.

Starting with team A and then alternating, each team draws a Nucleotide card from the Nucleotide Deck and places the same drawn card face up on the game board upon their Template Strand, beginning at the 3' site and going to the 5' end. This continues until all the card slots on each game board are filled. The game officially begins when the last card is laid down for both teams.

Below is a sample of a filled Template Strand on a game board.



Each team will then draw five Nucleotide cards. During game play, each team must always have five nucleotide cards in hand. If one is ever used, it is immediately replenished from the Nucleotide deck.

A free Gene Therapy card, five Mutation cards and five Nucleotide cards constitute each team's hand. Nucleotides are replenished immediately after being used, while Mutation cards are never replenished except in one case. Should a team wish it, they may give up a Gene Therapy card and receive five more Mutation Cards. This can be done either with their free Gene Therapy card or any other Gene Therapy card dealt to them. This is the only way a team can

receive more than the initial five Mutation cards. This can be done on any team's turn.

Build Phase (Simple Play)

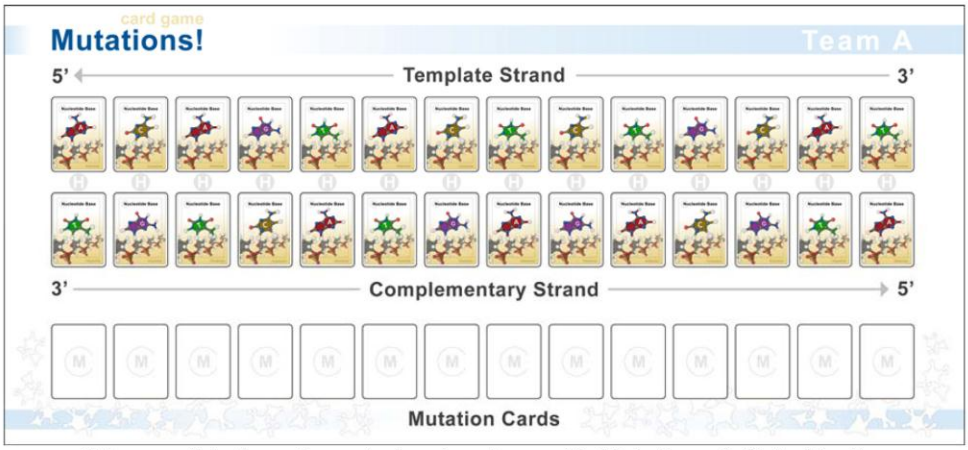
In the Build Phase, during their turn a team may chose to build up their Complementary Strand, or play a Mutation card on their opponents' Complementary Strand and/or correct Mutations to their own DNA. No matter what action the team takes, they may also turn in a Gene Therapy card at any time to receive five more Mutation cards. They may not both build up their Complementary Strand and inflict/repair Mutations.

Beginning with Team A and then alternating, each team may build up their Complementary Strand. The team may play up to all five Nucleotide cards from their hand, trying to correctly pair them with the Template Strand cards in order of appearance while following the 3'-5' orientation of the Complementary Strand. **Cards put down must be in order and must complement the opposing card on the Template Strand**. After a team has put down as many cards as they can from their hand, the team replenishes all the cards used till they have five Nucleotides cards once more.

If a team has no Nucleotide card they can put down at all, the team may discard one card of their choice from their hand and pick up a new one.

After Team A has finished their turn, Team B may take steps to build up their Complementary Strand.

This continues until a team has managed to fill all the card slots with the correct pairing, leaving no empty card spaces. Below is an example of a filled Complementary Strand.



It is possible for a team to begin a turn with Mutations inflicted to its game board. A team is not required to automatically repair any Mutations inflicted upon it. Instead, the team may decide to build up their Complementary Strand and leave the mutation to be repaired till a later turn. If this the choice, the team moves over to the next empty space that is not affected by a Mutation and continues to build from that point. In this way, a team may decide to repair a

Mutation immediately, wait to repair a Mutation till a later turn, or continue building their Complementary Strand and make all repairs till after the Complementary Strand has been completely built.

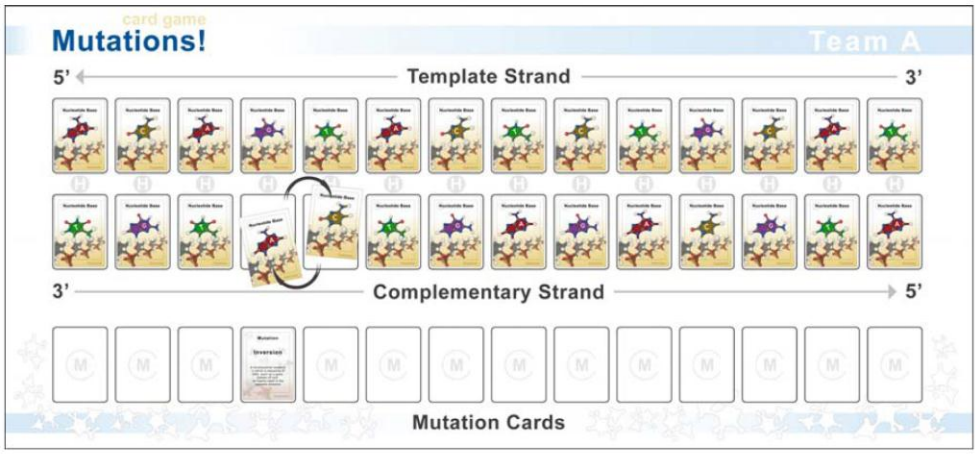
A Complementary Strand will be considered built when all available card slots not affected by Mutations have been filled with the proper Nucleotide cards.

In the Building Phase, a team may decide to instead play a Mutation card on an opposing team's Complementary Strand to slow down or prevent helix formation. They may also decide to repair any Mutations inflicted to their own game board.

To inflict a Mutation, a team selects a specific Mutation card from their hand and places it on the slot of their choice on the Mutation Cards track of the opposing team's game board. The slot chosen for the Mutation card must be underneath a played Nucleotide card that has not already suffered a Mutation. A Mutation card cannot be played underneath an empty space nor can double Mutations be played upon the same spot. A team may only play one mutation per turn.

After a team has played a Mutation, they are allowed to switch the cards on the opposing team's Complementary Strand to reflect the inflicted Mutation.

For example, Team B decides to play a Mutation to halt Team A's formation of its helix by causing the *Inversion* of two cards already put down. Team B has picked the fourth spot to play their Mutation *Inversion*. After putting down the Mutation card, they may take the Nucleotide card above their Mutation and the next Nucleotide card and switch their positions. Below is an example.



Along with inflicting a Mutation, a team may repair one mutation on their side. This can be done in one of two ways.

The first involves using the *Silent* Mutation card. By picking a specific Mutation on their own game board, a team may play a *Silent* Mutation directly on top of it. Nucleotide cards are not set back to their original positions, nor is the Mutation removed from the game board. Instead, *Silent* Mutation permits the

team to ignore the effects of the Mutation as if it did not exist. For the purpose of the game, any Mutation that has *Silent* Mutation played on top of it can be considered to be nonexistent, and thus, affected Nucleotide cards are considered to be paired normally even though they may be in a wrong position, or missing entirely.

The second way to repair a Mutation involves using a Gene Therapy card. Once played anywhere on the board, Gene Therapy removes all Mutations. All Nucleotide cards are set back to their original position, and all Mutation cards are removed. Gene Therapy cards played to repair damage may only be played in rounds when a team is inflicting/repairing any Mutations.

A team may play a Gene Therapy card for the exclusive purpose to get five more Mutation cards at any time during any of their turns.

To win this turn, a team must be the first to completely build their Complementary Strand with all Mutations repaired with either Gene Therapy or *Silent* Mutation cards. Even if a team does build its Complementary Strand first, it must repair the Mutations within. Until then, the other team still has a chance to finish building its own Complementary Strand and/or repair all Mutations.

In case one or both teams have run out of cards to repair any present Mutations, they can only finish building their Complementary Strand and/or continue inflicting Mutations onto the other team. In the case both teams cannot repair all Mutations, the team with the least amount of unrepaired Mutations wins the turn. The game may end here, or continue onward to the Movement Phase.

To enter the Movement Phase, a team must finish building its Complementary Strand, despite having Mutations present. Teams are not required to move into the Movement Phase together. One can continue in the Building Phase while the other continues into the Movement Phase.

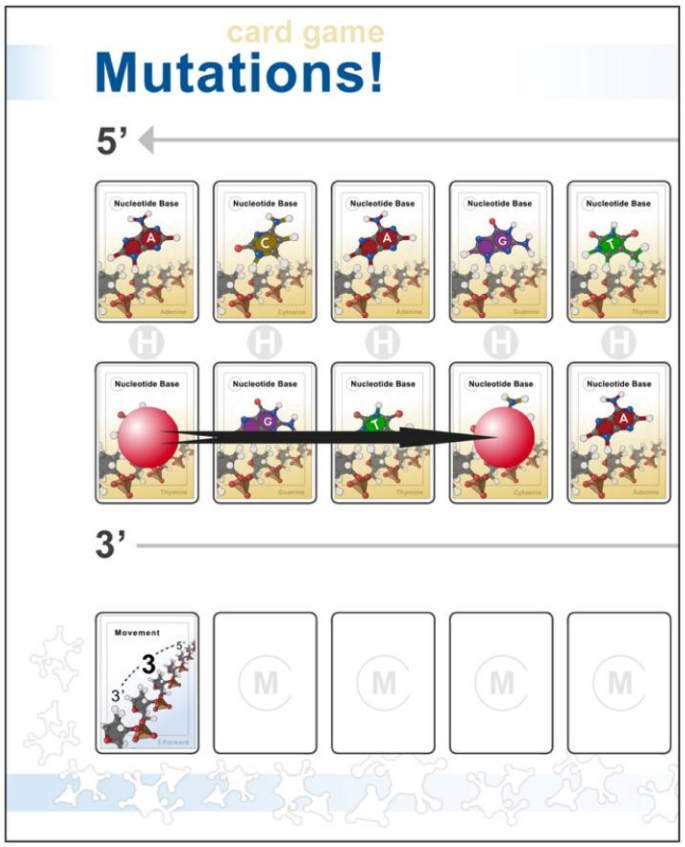
Movement Phase (Advanced Play)

The objective during the Movement Phase will involve teams moving their Team Token over the Complementary Strand cards, starting at the 3' zone and moving rightward to reach the 5' zone. The first team to successfully navigate to the last card at the 5' end, while repairing any Mutations that appear **ahead** of their token, wins the turn and game. Mutations that are inflicted to the Complementary Strand behind the Team Token may be ignored and do not need to be repaired unless the Mutation changes the Nucleotides in front of the Team Token.

In the Movement Phase, teams on their turn can either elect to move their Team Token forward, or inflict Mutations on the opposing team and/or repair Mutations on their own game board.

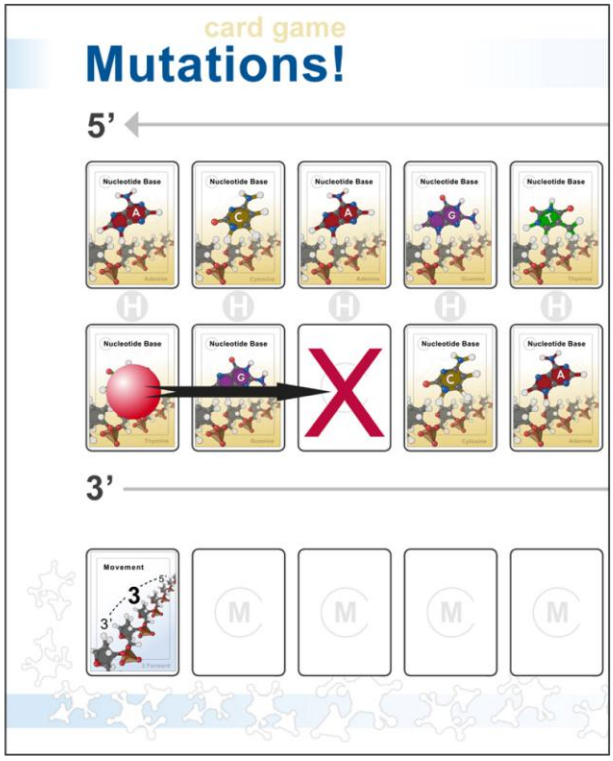
Each team that enters the Movement Phase must discard all cards in hand. They will receive one free Gene Therapy card, five Mutation cards and five Nucleotide cards taken from their respective decks. Since teams may move into this phase with unrepaired Mutations left over from the Building Phase, the Gene Therapy card may be necessary to repair and restore the game board.

Each team in this turn is given a Team Token that is placed on the first Nucleotide card of the Complementary Strand by the 3' edge. Starting with the first team to enter the Movement Phase, a single card is drawn from the Movement deck. A team may only draw on Movement card per turn. Each card will either allow Team Tokens to move forward one, two or three spaces toward the 5' edge of the game board, or move one space back toward the 3' edge of the game board. Movement cards can be placed in the Mutation Cards track below the Team Token, or played off to the side. Below is an example where a Movement card has allowed the Team Token to move forward three spots to the 5' edge.



All the spaces involved in a movement indicated by the Movement card must have a complimentary Nucleotide card already laid down. There may be no empty spaces, and the Nucleotide cards present must be the correct ones for the Team Token to travel over the card. For example, if a card calls for a movement of three forward, but only two spaces have the proper Nucleotide cards, the second space being empty because of a *Deletion* Mutation, then the Team

Token cannot move forward at all. In this case, the Team Token stays in place, does not move and the team loses its turn. Below is an example of this.



As you can see, the empty space has invalidated movement of the Team Token. Teams may draw only one Movement card per turn.

The *Silent* Mutation card, if played on a specific Mutation, may allow a Team Token to ignore that Mutation and its changed Nucleotides and continue onward as if the Nucleotide cards were the proper ones.

When a team draws a Movement card that requires backward movement, the Team Token must go back one space towards the 3' edge of the board. If this card is drawn when the Team Token is already at the 3' edge, or forces the Team Token unto an unrepaired Mutation **behind** the Team Token, then the movement is ignored and the Team Token does not move. The team loses its turn.

In the Movement Phase, teams may also inflict a single Mutation on the opposing team and/or repair a single Mutation on their own game board, utilizing the same rules found in the Building Phase section.

Should a Mutation behind a Team Token cause a change in the Nucleotides in front of the Team Token, the Mutation must be repaired in some manner before the Team Token may move forward. An example of this would be

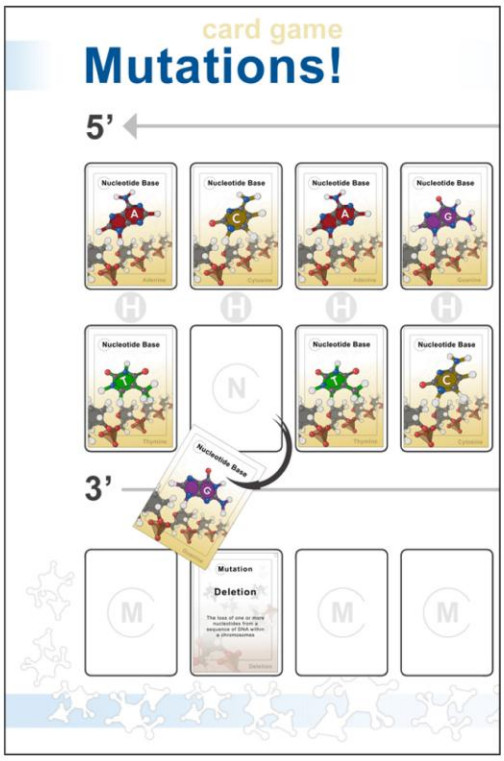
an *Insertion* Mutation played on the very first Nucleotide since it would affect the entire Complementary Strand.

To win this turn, a team must successfully navigate their Team Token to the last card on the 5' edge of the game board, while correcting all Mutations that appear before the Team Token or that alter the Complementary Strand.

Should a team be unable to repair Mutations before the Team Token, then they may not move forward and will lose if the other team reaches the end or gets closer to the 5' edge of the game board.

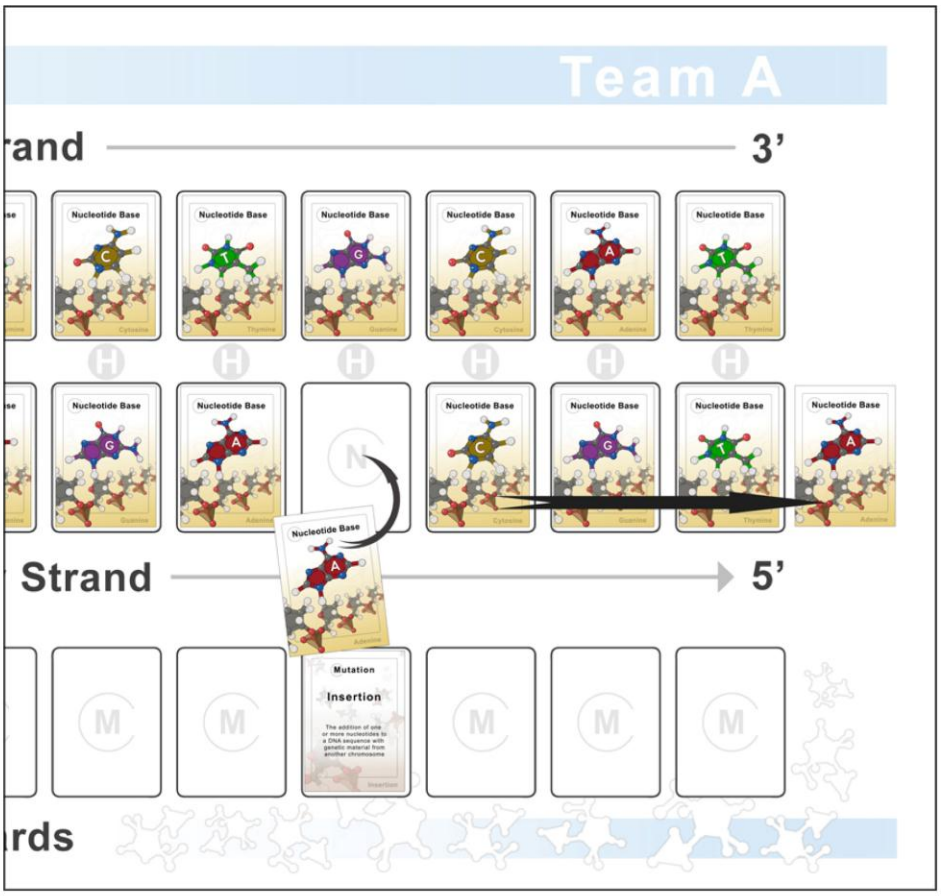
Mutation Card Descriptions

Deletion Mutation. The team that plays this card may take a Nucleotide card from the other team's Complementary Strand. The Nucleotide is discarded, and it creates an empty space that must be filled first before the affected team's Token can travel over it. Sample below of a *Deletion* removing a Nucleotide.



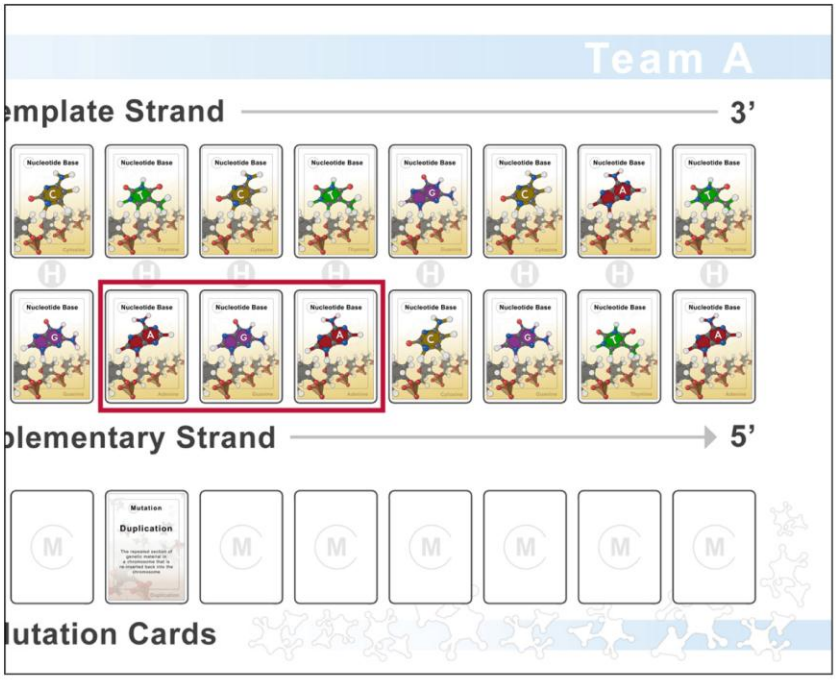
Insertion Mutation. The team that plays this card may take a nucleotide card from their hand and insert it anywhere on the other team's Complementary Strand, sliding all cards to the right toward the 5' edge. Until corrected, this makes their Complementary Strand longer, thus taking the token longer to reach the last card and the end of the game. If this card is played before an empty

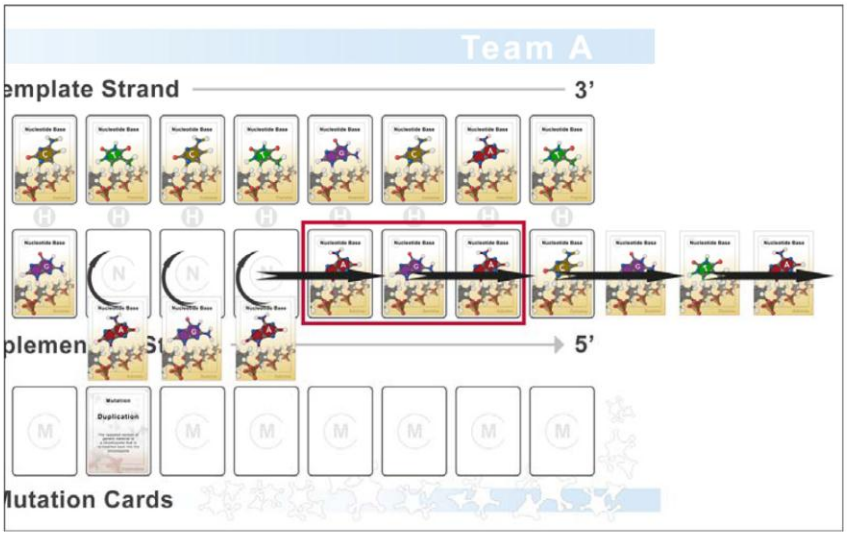
space, like that created by a deletion in a track, it could push the cards forward closing the space. The cards moved by an *Insertion* will most likely not be complementary to those in the Template Strand, creating a series of wrong base pairs that cannot be traveled on. Placed at the beginning of a Complementary Strand, this card could change all the pairings.



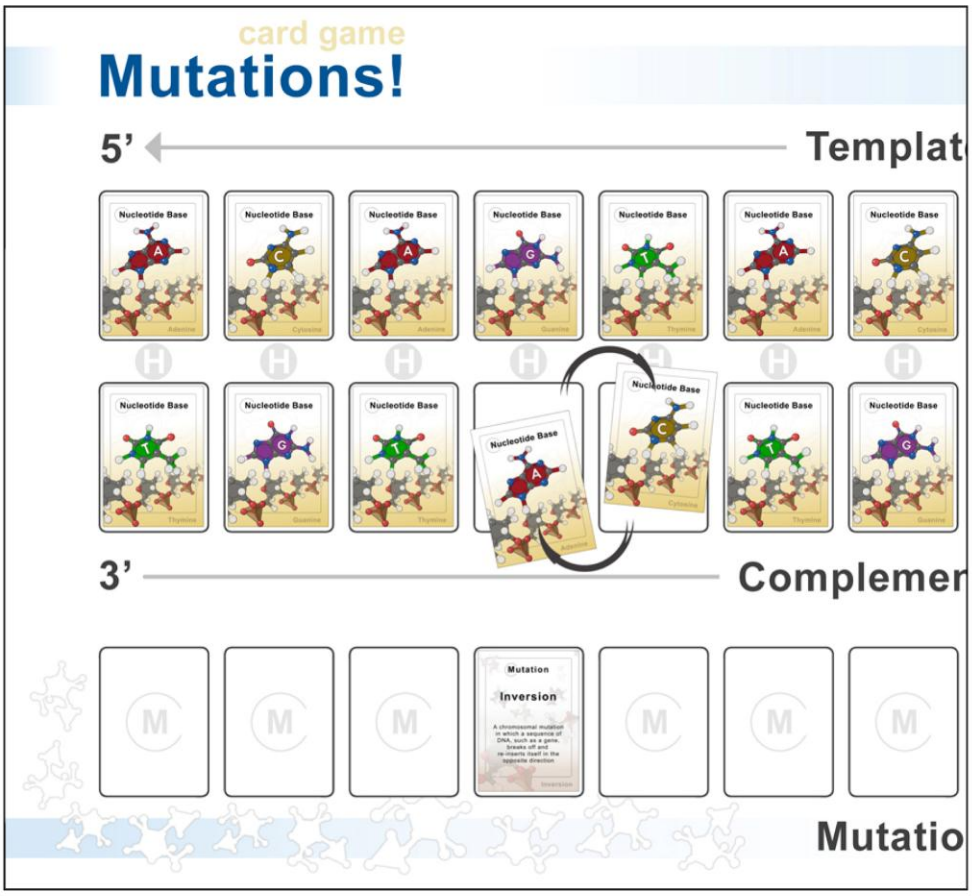
Duplication Mutation. This mutation allows the team playing it to copy any sequence of up to three cards from their opponents' Complementary Strand and insert those same cards right before or after the original Nucleotides. It works much like the insertion card, only that it uses up to three cards instead of one. This card cannot be used on empty spaces, nor can it copy empty spaces. The copy Nucleotide cards must come from the cards held by the team playing *Duplication*. Any Nucleotide cards utilized may be replenished immediately from the Nucleotide deck. The copy Nucleotides are inserted into the opposing team's Complementary Strand, pushing all cards towards the 5' edge of the game board and making the Complementary Strand longer. Below is an example of the chosen cards being copied, with copies being inserted before the originals. The

cards moved by an *Duplication* will most likely not be complementary to those in the Template Strand, creating a series of wrong base pairs that cannot be traveled on. Placed at the beginning of a Complementary Strand, this card could change all the pairings.



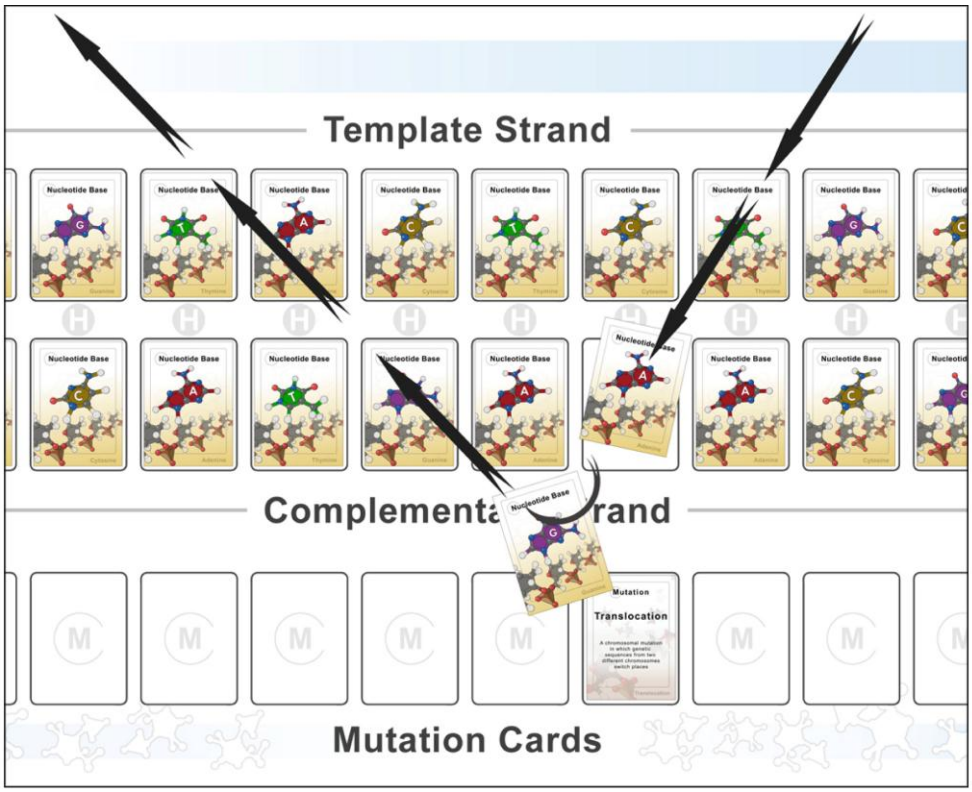


Inversion Mutation. This mutation allows the team to take two cards from the opposing players' Complementary Strand and invert their location. The inverted cards must be next to each other, and the second Nucleotide card may be in front or behind the affected Nucleotide. This card cannot be used on empty spaces. Below is an example.



Translocation Mutation. This mutation allows the team playing the Mutation to take any card from their opponent's Complementary Strand, any card from their own Complementary Strand, and switch them. This move could correct an improperly paired card on a team's game board by replacing it with the correct card from their opponent. This card cannot be used on empty spaces, nor can it be used to move a Nucleotide to an empty space. Two Nucleotide cards must be moved by this Mutation.

Below is an example.



Silent Mutation. This card, when played, will immediately ignore any single Mutation on a team's Complementary Strand. This is this only Mutation a team may play on themselves. The other Mutations must be played on the opposing team.

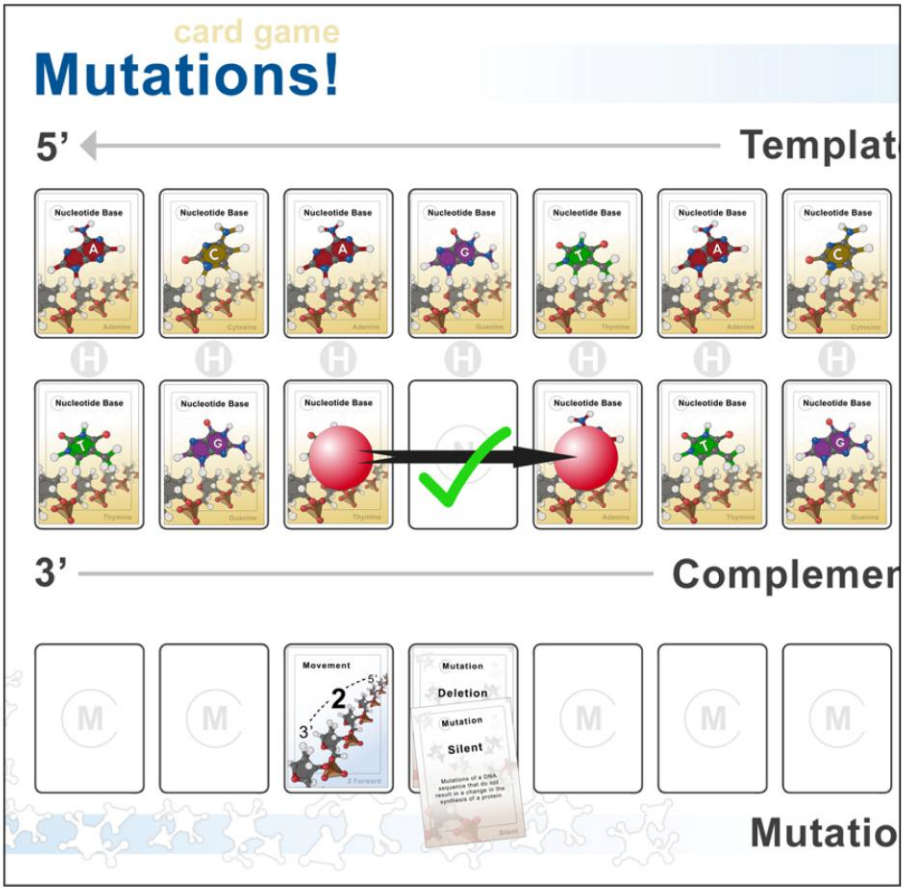
A *Silent* Mutation Card will only defend against one Mutation, so a team with two Mutations on their Complementary Strand will need a *Silent* Mutation for each.

In the Building Phase, a *Silent* mutation allows a team to ignore an unrepaired Mutation when counting how many Mutations have been inflicted on their game board.

In the Movement Phase, a *Silent* Mutation will allow a Team Token to pass over one specific Mutation as if it did not exist.

Silent Mutations do not remove Mutations from the board physically, nor do they repair the incorrect pairings of Nucleotides caused by Mutations. They only allow teams to ignore Mutations as they travel over the affected Nucleotides, even going over empty spaces as if normal. Remember, Mutations like *Insertion* and *Duplication* make the Complementary Strand longer, so even if the team may ignore the altered nucleotides and travel over them as if they were normal, the Team Token must still travel a longer distance to reach the last card of the 5' edge.

When a *Silent* Mutation is played, it is put directly on top of a single Mutation to signal that it has been neutralize and should be regarded as normal. Below is an example of a *Silent* Mutation permitting a Team Token to go over a *Deletion* Mutation as if it did not exist.



Gene therapy card

The Gene Therapy card may be played for various reasons. The primary purpose of the Gene Therapy card is to physically remove any and all Mutations on a game board, including *Silent* Mutations, while putting all original nucleotides back to their original positions.

The secondary purpose of the Gene Therapy card is to provide a reserve of Mutation cards. No matter what action they take their turn, a team may turn in their Gene Therapy card to receive five new Mutation cards drawn randomly from the Mutation deck.

At the beginning of the Build Phase, all teams receive a free Gene Therapy card. When entering the Movement Phase, a team also receives a free Gene Therapy card, as well.

Optional Rules with Predetermined Mutations

Instead of drawing five random cards from the Mutation deck at the beginning of each game stage, the teams may instead receive one free copy of each Mutation –*Deletion, Duplication, Insertion, Inversion and Translocation*- plus three *Silent* Mutation cards. This assures of having at least one of each mutation. If a Gene Therapy card is played for the purpose of replenishing their Mutation cards, the teams draw randomly from the Mutation deck to replenish their cards.

APPENDIX C
Final Scientific Script

Richard Thomas Lankes
May 2010

Scene 1	Opening Scene: Introduction • Proteins are called polypeptides. • Proteins are formed into a linear chain then folded into regular patterns. • Amino acid sequences of proteins are determined by the DNA nucleotides. (Are you going to mention codons at all? It might make explaining single nucleotide changes easier later on. Protein expression is the process of protein creation. • Proteins can be enzymes that catalyze biochemical reactions; proteins participate in cell signaling, immune responses, cell adhesion and cellular life cycle. They can also serve structural functions to maintain cell shape, for example.
Scene 2	• Changes in a protein's amino acid sequence can alter its structure and function. • Gain of function alteration gives proteins the ability to realize a function it normally does not (or become especially good at its native function. Answer: As in advantageous mutation? Good point). • Loss of protein function often leads to dead proteins that are removed in the cell.
Scene 3	• Very high or very low amounts of otherwise normal proteins can lead to serious problems and even cell death. • The correct amount of proteins created is just as important as having properly created/functioning proteins
Scene 4	• • Proteins are created from specific sequences of DNA, or deoxyribonucleic acid. • Physical traits, as well as intelligence and other mental traits, are influenced by DNA. • DNA is made by nucleotides • Nucleotides are formed from one of four bases, a sugar, and a phosphate. • **N**ucleotides hook together to generate DNA. • The bases contain the actual genetic information of the DNA helix, while the phosphates and pentose sugars are structure components that hold the structure together.
Scene 5	• The bases that comprise the genetic material can be purines or pyrimidines. These are ring structures composed to carbon, and nitrogen, with oxygen and hydrogen attached at the outside of the rings. Purines contain two fused rings, a pentagon and a hexagon. Pyrimidines contain only a hexagon ring. • Adenine and guanine are the purines. • Cytosine and thymine are pyrimidines. • In DNA, the bases pair through special bonds called hydrogen bonds. Adenine normally pairs with thymine, while guanine pairs with cytosine. • Connected to the bases are sugars and phosphates, that link together to form the DNA backbone. • Millions of base pairs form the base DNA helix.

Scene 6	• One strand of DNA, if stretched out, would measure six feet long. • Super-coiling is what allows DNA to fit inside of a cell's nucleus. • There are several levels to DNA supercoiling, but the most important one might be the wrapping of DNA around histones to generate nucleosomes. • Four types **o**f histones comprise the core of the nucleosome: H2A, H2B, H3, H4. • Two copies of each of these generate a histone octamer, which is like a sphere. • DNA coils around the octamer 1.6 times. • DNA coiled around the octamer is stabilized by a fifth type of histone, called H1. [Richard: H5 is only found in birds.] http://www.springerlink.com/content/q01550758ul2456l/ • **http://books.google.com/books?id=bwIOesgXyIsC&pg=PA42&lpg=PA42&dq=Is+histone+H5+present+in+mammals%3F&source=bl&ots=XtCZ05p998&sig=MHcNR07aPj6TkBeU9wDH8nnxTvQ&hl=en&ei=UBFjTNfwKsH_Igei0ogf&sa=X&oi=book_result&ct=result&resnum=5&ved=0CCYQ6AEwBA#v=onepage&q=Is%20histone%20H5%20present%20in%20mammals%3F&f=false** • SO nucleosomes are histone octamers with DNA wrapped around, and histone H1 capping the structure.
Scene 7	• Nucleosomes are essential for super coiling. • DNA wraps around millions of nucleosomes. • DNA wrapped around nucleosomes can be seen in a stage called 'beads on a string'. • Stages of supercoiling involve bring nucleosomes together, tightly packing them next to each other. • Nucleosomes allow DNA to be compressed into chromatin. • Chromatin is difficult to see without powerful microscopes or instruments. • Euchromatin, or expanded chromatin, is a loosely compacted form that allows for protein expression to occur. During prophase is when chromatin compresses more to form visible chromatin forming chromosomes. This chromatin is known as heterochromatin or condensed chromatin. • Condensed chromatin during prophase is not used for protein expression. • Chromosomes in cell division will divide, giving one half to a daughter cell and the other half to another daughter cell. • After cellular division, chromatin will become euchromatin once again so proteins can be expressed.
Scene 8	• Nucleosomes are essential for the process of epigenetics. Epigenetics is the study of heritable traits that are not based on the DNA sequence itself but on levels of gene expression that are controlled by histones or even chemical modification of the DNA bases. • Human pluripotent cells are capable of becoming different types of cells. • The 8 histones in a nucleosomes act upon DNA, allowing or disallowing access to certain sequences of DNA. Histones do not actively modify the DNA code itself. They make the expression of a certain portion of DNA possible by making the DNA accessible to a large number of other proteins that promote gene expression. • Each histone only affects the DNA sequence it is in physical contact with though it is believed that a histone from a particular nucleosome could affect a nearby nucleosome. • A histone is modified by enzymes which act upon the tails of individual histones. These modified histones make a given portion of DNA accessible or not to gene expression. • The histone-modifying enzymes are capable of affecting just a specific nucleosome at any given time. Not all the nucleosomes/histones are affected by the same type of enzyme in the same way, at the same time. Histones affect given DNA sequences by making them accessible for gene expression, inducing the necessary changes that allow pluripotent cells to become different types of mature cells.

Scene 9	• Genetic mutations are changes in DNA sequence. • They can be caused by radiation, viruses, chemicals, errors during DNA synthesis • Improper protein expression, or the protein expression of the wrong sequence of can lead complications. • Location of mutation, length of affected DNA sequence, or how the protein is used are factors to determine whether mutations are undetected or fatal.
Scene 10	• Genetic mutations are either large scale or small scale. • Large scale mutations affect multiple genes, whole chromosomes or several chromosomes. • Small mutation affects a few nucleotides, or just one. Even the modification of one DNA base can produce a completely abnormal protein.

Scene 11	• Deletion mutations are accidental removal of bases. It can be on a large scale or small scale. • It generally affects the sequence in one chromosome. • Deletion generally leads to loss of function, and is the cause of a large number of genetic illnesses.

Scene 12	• Insertion is usually small scale mutation that may involve the addition of a single base, several bases, or even a segment from another chromome. • Chromosome A loses genetic material while chromos**o**me B gains that genetic material. • Chromosomes do not need to be next to each other. DNA fragments can float from one chromosome to another. • Insertion is a strong example of a mutation that leads to gain and loss [Richard, what do you mean??] of function of a protein.

Scene 13	• Point mutation is a small scale mutation. • Point mutation affects one nucleotide only, on one chromosome. • A nucleoside is replaced with a different nucleoside. A nucleoside can also be deleted, or another nucleoside could be inserted. • A purine can be replaced with a pyrimidine, or a pyrimidine can be replaced with a purine, in a process known as transversion. [Richard: if you express this, it needs more information, since the paired base also must be changed.]Also, a purine can be replace with a purine, or a pyrimidine with a pyrimidine. This type of point mutation is called a transition. • A point mutation may be "silent" if the new codon still codes for the original amino acid; the resulting protein is not changed. Within point mutations, are several specific forms. Missense and nonsense mutations are two known forms. A missense mutation results in an altered amino acid, often leading to the creation of a protein that does not function properly. A nonsense mutation will cause protein synthesis to stop, generating a smaller unfinished protein that may not work at all.

Scene 14	• Duplication is often a large scale mutation. Affects one chromosome. • Genetic material is duplicated and reinserted immediately after the copied material. • Duplication may create just one or many copies. • Duplication may have a large negative impact on the genetic material. [YES IT DOES! Huntingon's, Schizophrenia…. Cf: http://neuromuscular.wustl.edu/mother/dnarep.htm) • Duplication is known to impact cancer, allowing multiple copies of oncogenes. • But DNA repeats may not always lead to a negative outcome. Theory holds duplication may have led to evolutionary survival. •
Scene 15	• Inversion is a large scale mutation. Involves one chromosome. • Genetic material is turned around and reinserted, with no loss or duplication. • Inversion many times goes undetected. • Inversion can lead to loss of function for proteins.
Scene 16	• Translocation is a large scale mutation involving two chromosomes. • Genetic material from two chromosomes switch places. • The chromosomes do not need to be next to each other. • Exchanged material can be a balanced exchange, or unbalanced. [You must explain this.] • Translocation can create an undetected mutation in a host organism that manifests in the host's offspring. • Translocation can create loss or gain of function in cases it does express itself.
Scene 17	• Small scale or large mutations can go undetected, produce a varied state of alterations, or be fatal.
Scene 18	Cancer • Cancer is an illness that is provoked by the out of control growth of abnormal cells. • Normal human cells can present abnormal growth through mutation of the cell's genetic code. • Onocogenes are genes that, when they are expressed in high amounts or suffer mutations, can induce abnormal changes in a cell. Many times the permanent activation of an oncogene is enough to begin a cancer. • Oncogenes produce proteins that can alter the regulation of cells. These proteins can allow an affected cell to keep dividing without limit, or to avoid cell death, known as apoptosis. • KRAS an essential gene that stimulates normal cell growth and division. But if permanently activated, it becomes an oncogene that allows unregulated and uncontrolled division and growth of cells. • Tumor suppressor genes protect cells from becoming cancer cells. Through mutations these genes can be turned off. • P53 is an important tumor suppressor gene in the human genetic code. • Most cancers require both an oncogene to become active and a tumor suppressor gene to become inactive. This allows for a cell to divide uncontrollably without being suppressed or to have little control exerted upon it. • All types of mutations are capable of producing one type or another of cancer. • Chromosomal translocation, duplication, and point mutation are very well known and strong factors for cancer. • Missense mutation, a form of point mutation, of p53 happens in 75 percent of mutations of this gene. Mutation of this gene is believed to cause 30-50% of cancers.

APPENDIX D
Final Narrative Script

Narrative Script
Richard Thomas Lankes
August 2010

Opening	*Isabella:* "STARS and the UT Southwestern Medical Center present **Genetic Mutations Made Easy**!"
Opening	*Isabella:* "Funding by the **Howard Hughs Medical Institute**"
Scene 1	*Isabella:* "Hello there everyone! Welcome to the STARS science video animation made for your classroom. My name is Isabella. Today, I will talk to you about unexpected changes that occur in genetics. You may wonder, what 'genetics' means. (Pause) Genetics is the science that studies how traits are inherited from one organism to another, like from parents to children. In this video, we will discuss the sudden changes that can sometimes occur within those inherited traits. These changes are called 'mutations', and sometimes they can even occur within a person without being inherited from their parents."(Pause) "Whoa!" (Pause) "But to understand what a mutation is, we first need to talk about the small, important structures found in cells called 'proteins.' It is important to discuss what they do." (Pause) After that, we will discuss other important things, like how mutations affect living creatures by causing unexpected changes in proteins."
Scene 2	*Isabella:* "Proteins are complex structures that are made up of many tiny units called 'amino acids.' You can think of amino acids as bricks. They are essential when used to make proteins in a process called 'protein synthesis.' First the amino acids, or bricks, are placed in a specific sequence, forming long chains. These chains are the original form of proteins. (Pause) But after the chain is formed, it is folded in different directions and angles. The amino acids, like bricks, help hold and maintain the protein in its new, twisted form. (Pause) A protein's function depends not just on what amino acids were used to make it, but also in what way the chain of amino acids is folded!"

Scene 3	*Isabella:* "You might wonder what function or jobs proteins do in a human? Proteins assist our cells in many ways!" "They let cells talk to one another." "They allow cells to fight infection." "Proteins help cells grow and divide." "They allow our body to digest food." "Proteins can help the body create energy." "They even assist cells in holding their shape." (Pause) "All in all, these are just a few of the things that proteins can do in the human body!"
Scene 4	*Isabella:* "Despite their many functions, proteins are fragile. Any change, even just one amino acid out of the many that make up a protein, can alter the entire protein. It's like changing one brick in a wall. Change the wrong one and the whole wall might even fall! In proteins, the change of one amino acid could change its entire form!" (Pause) "This change could mean the protein stops working like it was intended."
Scene 5	*Isabella:* "Amino acids can be changed, added or removed from proteins in different ways." (Pause) "The most common change is called 'loss-of-function.' The protein loses a part, or all, of its functions. All in all, this means the protein stops working correctly. Cells will often remove these useless or disabled proteins."
Scene 6	*Isabella:* "A rare type of change can make proteins too good at what they normally do! They can become super-efficient. Or they can do jobs they couldn't do before." (Pause) "By becoming super-efficient or acquiring a 'gain-of-function', these proteins can become an advantage to the cell."
Scene 7	*Isabella:* "But changes to proteins do not just occur to their sequence of amino acids." (Pause) "A protein can be normal, but too much or too little of a protein could lead to severe complications for the cell. Maybe even death of the cell. Because of this, it is important to have the right amount of protein, not just a well-made one."
Scene 8	*Isabella:* "Protein synthesis is tied directly into our genetic material, to our DNA. DNA, also known as Deoxyribonucleic Acid, is essential in the formation of proteins. (Pause) Think of DNA as the plans for building a house. With these plans, cells know what amino acids, the bricks, are needed to create a specific protein, the house. Without the instructions given by DNA, a cell would not know how and which amino acids to use to make a specific protein."
Scene 9	*Isabella:* "Looking closely at our DNA, we can see it is made up of several different units. DNA is physically formed by two separate strands that twist around on another. This is known as a double helix. Yet, the most important units found in DNA are the millions of nucleotides that form each strand." (Pause) "A nucleotide has three parts: One of four 'bases', a molecule of sugar called 'deoxyribose,' and the mineral known as phosphate."

Scene 10	*Isabella:* "The sugar deoxyribose and phosphate in nucleotides do not have any genetic information in them. Instead, they work together like a strong backbone that allows nucleotides to connect with other nucleotides in series. This forms two extremely long chains made up of millions of connected nucleotides. These two chains form the well-known double helix of DNA." (Pause) "Just as important, deoxyribose and phosphate hold securely in place the most important component of each nucleotide: the base. The bases actually store our genetic material."
Scene 11	*Isabella:* "Each base is a ring-like structure, made up by carbon and nitrogen. Attached to the rings we can find hydrogen, nitrogen and oxygen atoms. Bases appear in two general forms known as either Purines or Pyrimidines. " (Pause) "But purines are slightly different from pyrimidines. Purines actually are two rings fused together, instead of just one. The bigger ring has six atoms while the other ring is made up of just five atoms. Pyrimidines, though, have only one central ring with six atoms."
Scene 12	*Isabella:* "Within the DNA sequence, there are two types of purines. They are called Adenine and Guanine. Pyrimidines also have two forms in DNA, labeled as Cytosine and Thymine." (Pause) "Under normal circumstances, Adenine will only form a strong union with the pyrimidine Thymine. The pyrimidine Cytosine will only bond with the purine Guanine. This is an important fact."
Scene 13	*Isabella:* "Also important is the fact that these bonds are formed between the strands of DNA. Bases will not form bonds with other bases found in the same strand of DNA." (Pause) "These bonds, called hydrogen bonds, help the deoxyribose-phosphate backbone create a very strong but flexible DNA helix. They are extremely difficult to open."
Scene 14	*Isabella:* "Some proteins, called enzymes, have very specialized jobs. For example, there are enzymes that can break the hydrogen bonds between bases. This allows for the DNA strands to separate from one another, exposing the bases found in the nucleotides." (Pause) "This is very important, because the amino acids that make up proteins are coded by the bases found within DNA nucleotides."
Scene 15	*Isabella:* "During the synthesis of proteins, a specialized enzyme called 'RNA polymerase' will read the base in a sequence and build a complimentary strand. For example, providing a thymine for each adenine in the DNA, and a guanine for cytosine. RNA polymerase travels only in one direction."
Scene 16	*Isabella:* "Every three bases in a segment of DNA that will lead to protein formation is called a codon. These codons will specify a specific amino acid in the protein. Several codons may code for the same amino acid! "(Pause) "The RNA polymerase will form a separate sequence of nucleotides called 'mRNA' from the original DNA strand. Once mRNA is formed and taken outside of the nucleus, it is 'read' by a little factory in the cytoplasm called a ribosome, which will create a new protein from the code read on the mRNA."
Scene 17	*Isabella:* "Think of a ribosome as a two part factory. Within this ribosomal factory, mRNA is laid out bare. Molecules known as transfer RNA carry amino acids and bind to each codon on the mRNA. We can think of tRNA as factory workers." (Pause) "The ribosome factory allows the tRNA worker to join with a specific sequence in the mRNA."

Scene 18	*Isabella:* "When the tRNA finds its particular codon, it releases its amino acid to the growing sequence of amino acids forming on the ribosome. As more tRNA molecules read the mRNA, more amino acids are released. Once the sequence of amino acids reaches its programmed size, it is released from the ribosomal factory. But to become an active protein it must go through a series of folding reactions and perhaps be modified further by other enzymes. (Pause) As you can see, one changed nucleotide in a strand of DNA can lead to one changed codon. This codon can lead to the wrong amino acid, which can lead to a malformed protein!"
Scene 19	*Isabella:* "So thanks to the bases found in the nucleotides that make up DNA, cells can determine which sequence of amino acids should be used in protein synthesis."
Slide	*Isabella:* "**Super-Coiling, Epigenetics and Those Amazing Histones**!"
Scene 20	*Isabella:* "How big is a strand of DNA? Since it fits in the nucleus of a cell, and you would normally need a microscope see a cell, it must be very small." (Pause) "But if you were to take a strand of DNA and stretch it out fully, it would reach about six feet in length! Taller than many people!"
Scene 21	*Isabella:* "The reason DNA fits so well into such a small area, like a cell's nucleus, is because of a process called 'super-coiling.'" (Pause) "Super-coiling involves wrapping DNA around itself and structures called histones. This twisting is incredibly tight, and reduces the overall length of DNA millions of times. (Pause) There are multiple levels of wrapping, but the primary wrapping involves 'histones.'"
Scene 22	*Isabella:* "Histones are small molecules. There are four main types of histones, and they are known as H2A, H2B, H3 and H4. Normally, histones will pair up with one another, two of each kind, to form a tight ball-like core of eight individual histones. We call this core an 'Octamer'. (Pause) "It is around the octamer that DNA itself will wrap around 1.6 times. Whenever DNA is wrapped around an octamer, the octamer plus DNA is known as a 'nucleosome.'" (Pause) "As an interesting point, the histones that make up the octamer have tails that can wrap and move around. These tails allow each individual histone to interact with a strand of DNA within reach!"
Scene 23	*Isabella:* "To hold DNA in place around an octamer, a special histone called 'H1" locks it down. This histone makes certain that there is DNA in physical contact with the octamer."
Scene 24	*Isabella:* "Super-coiling leads to the creation of millions of nucleosomes on each double strand of DNA." (Pause) "If we utilize a special microscope called an electron microscope, we can see the DNA wrapped and locked around the octamers. Visually, this is called 'beads on a string' because the DNA does look like a string with millions of beads!" (Pause)"By further compacting, the nucleosomes are brought closer together, into a tight grid. Like stacking baseballs next and on top of each other."
Scene 25	*Isabella:* "As more nucleosomes are brought together into a tighter package, the strand of DNA is twisted and wrapped around itself, like twisting yarn or twine. This creates a folded, wavy strand of DNA." (Pause) In a method that is still not well known, DNA can then be folded into segments called genes. Genes are sequences of DNA that code for specific proteins. And finally, DNA is folded into a final form known as 'chromatin'. Chromatin is

	very tightly compacted DNA that may be stored in a small area, like a nucleus." (Pause) "Chromatin is so tightly packed it cannot normally be seen with regular microscopes!"
Scene 26	*Isabella:* "When a cell is not dividing, its chromatin can be active in the formation of proteins. During this activity, it is loosely compacted. It is not as tightly wrapped around the octamers as it normally would be when a cell divides." (Pause) "This type of loose chromatin is known as euchromatin."
Scene 27	*Isabella:* "During the stage of cellular division known as 'prophase,' chromatin becomes extremely wrapped. At that time, it is not used for protein synthesis." (Pause) "This chromatin, called heterochromatin, can be seen easily with powerful microscopes in the shape we recognize as a chromosome."
Scene 28	*Isabella:* "Nucleosomes are not just important in super-coiling. They also participate in epigenetics." (Pause) "Epigenetics is the study of traits you can inherit that are not based directly from a DNA sequence. Think of this. Skin cells and muscle cells have different functions. They act differently, look very distinct, but they both have the exact same genetic material inside each nucleus. So why don't all cells look and act the same? The answer is epigenetics."
Scene 26	*Isabella:* "Many living animals have 'pluripotent' cells. These special cells are capable of becoming different types of related cells, depending on what the body needs. For example, one type of pluripotent cell can turn into blood cells, cells that fight infections or cells that help blood clot. But how does the pluripotent cell know what type of cell to turn into? Histones help the pluripotent cells decide." (Pause) "Histones do not actively modify or alter the sequence of DNA wrapped around them. Instead, specific enzymes modify the histone tails. The tails will change position upon the DNA, making DNA accessible to RNA polymerase. This means that the DNA could be used in protein synthesis. Or, the change in position could make it impossible for RNA polymerase to reach a portion of DNA, so it cannot be used for the formation of mRNA. And this means that no protein would be made!"
Scene 30	*Isabella:* "It is believed that histones only affect the portion of DNA that makes direct physical contact with them. Evidence does exist that maybe histones can affect DNA that is much further away. But this is still theory." (Pause) "We know that enzymes affect histones and their tails in a specific order. Not all enzymes affect all histones in the same way, at the same time! What we don't know is how an enzyme decides which histone to interact with."
Scene 31	*Isabella:* "Through changes in the position of the histone tails, histones determine if cells create a specific protein or not. This can lead a pluripotent cell into becoming one type of cell if a certain protein is formed or into another type if a different protein is synthesized."
Slide	*Isabella:* "Questions and Answers"
Slide	*Isabella:* "**Genetic Mutations and How They Work!**"
Scene	*Isabella:* "DNA sequence mutations happen often in cells. Mutations can be caused by many things, such as radiation, chemicals or even errors in the synthesis of DNA. But, the cells can repair many of these mistakes. Enzymes dedicated to this function repair many of these mistakes when they find them." (Pause) "Yet, errors do manage to slip by."

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Scene 33	*Isabella:* "Since DNA holds the 'building plan' for the making of proteins, any change in DNA can lead to the creation of the wrong sequence of amino acids." (Pause) "Many times, these changes lead to the formation of an incorrectly-made protein."
Scene 34	*Isabella:* "A mutation that occurs within a segment of DNA does not mean it automatically produces proteins that do not function correctly." (Pause) "Other factors determine whether a mutation provokes a noticeable change or not. The location of the mutation, the length of DNA that is changed, and how the changed protein is normally used are all important factors. All these things determine if the mutation is undetected, if it provokes minor illness or if it is fatal to the organism."
Scene 35	*Isabella:* "Genetic mutations can be either very large or extremely small. A large scale mutation could affect several genes, whole chromosomes or sets of chromosomes at the same time." (Pause) "By contrast, a mutation could affect something as tiny as just one nucleotide base out of the millions that make up a DNA strand!"
Scene 36	*Isabella:* "Even with a change as small as one nucleotide base, it is possible to produce a protein that is completely abnormal. By contrast, several changes do not always produce a protein that fails to work properly." "Hmmm. That's unusual!"
Scene 37	*Isabella:* "There are several basic types of mutations. The first mutation we will talk about is called 'Deletion'." (Pause) "A deletion is the accidental removal of bases. This can happen on a small scale, such as the deletion of just one base. Or, it can occur on a large scale, removing an entire gene or genes. Sometimes, even whole chromosomes."
Scene 38	*Isabella:* "A deletion generally causes the loss of a sequence within just one chromosome. With deletions, proteins are usually synthesized with a loss of function." (Pause) "Deletions are known to be the cause of many genetic illnesses."
Scene 39	*Isabella:* "Another type of well known mutation is 'Insertion'. A small scale mutation, insertion involves the addition of genetic material. It can involve a single base, several bases, or even a small portion of another chromosome." (Pause) "In the last case, genetic material is separated from one chromosome then inserted into the sequence of another chromosome."
Scene 40	*Isabella:* "This exchange of genetic material from one chromosome to another can happen at a large distance within the nucleus. Because of this, chromosomes do not need to be next to each other." (Pause) "As strange as it may sound, the genetic material floats from one chromosome to another!"
Scene	*Isabella:* "Insertion can lead to the creation of proteins that suffer both 'loss of function' and

41	'gain of function'. 'Loss of function' is the more common consequence of the two."
Scene 42	*Isabella:* "Both deletion and insertion can produce what is known as 'frame-shift'. Think of a sequence of marbles, numbered 1 to 21. Each marble represents a nucleotide. Every three marbles in the order represents a codon. So in this sequence of marbles we have seven codons, where the first codon has numbers 1 to 3, codon 2 has numbers 4 to 6, etc. (Pause) In a frame shift, a deletion or insertion produces a change in the number of nucleotides in a sequence and leaves the wrong nucleotides in the codon."
Scene 43	*Isabella:* "Let us say that marble number 5 is removed from the sequence. That means that codon 1 has the correct marbles in it, numbers 1 to 3. But codon number 2 has the marbles numbered 4, 6 and 7. This means that is has marble 7, a different nucleotide, in it. And all the following codons will have their numbers shifted over one, with the last codon having only two marbles in it instead of the normal three. (Pause) This is important, because a deletion can leave a codon missing a nucleotide, and the nucleotides it does have may not be the ones it should possess. Insertion causes the same complication. But unlike deletion, it adds nucleotides, instead of removing them."
Scene 44	*Isabella:* "Point mutation is a small scale change that affects just one base on one chromosome." (Pause) "The affected base can be switched out with another, or it can be deleted completely. A new extra base could be inserted into the sequence!"
Scene 45	*Isabella:* "When a point mutation causes a base to be replaced with another, there are several things that can happen. In a change known as transversion, a purine, like adenine, can be changed for a pyrimidine, like cytosine." (Pause) "In a change called transition, a purine is changed for a purine, like adenine for guanine. Or, it could just be a pyrimidine for another pyrimidine."
Scene 46	*Isabella:* "In either transversion or transition, when a base pair is change the paired base on the opposite DNA strand must also be changed. Otherwise, the new base will not be able to form hydrogen bonds with the opposing base." (Pause) "For example, if we have an adenine and put a guanine in its place, the thymine on the opposite strand that bonded with the adenine must be changed for a cytosine, so it may bond with the new base of guanine."
Scene 47	*Isabella:* "A point mutation can be called 'silent' if the changed base leads to a codon that still codes for the original amino acid. This will lead to a protein that has an amino acid sequence that is not changed, even if the original base is altered. So naturally, this protein should function as expected."
Scene 48	*Isabella:* "A missense mutation is a form of point mutation in which a different amino acid replaces the original one. This may lead to the creation of a protein that does not function the way it should." (Pause) "A nonsense mutation is another form of point mutation that will cause protein expression to suddenly stop. This can create a smaller, unfinished protein that may not work at all."

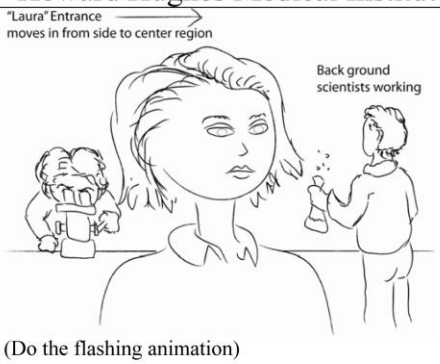
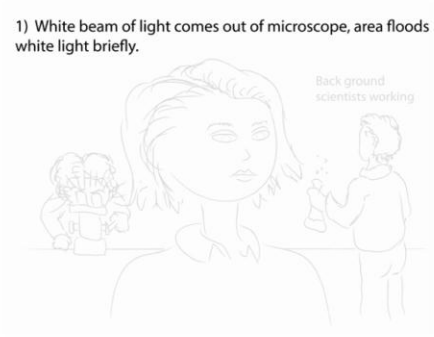
Scene 49	*Isabella:* "Duplication is often a large scale mutation that normally affects one chromosome. A large sequence of DNA is duplicated and then reinserted immediately after the portion that has been copied." (Pause) "Duplication may create one copy, or it may create many copies of the same segment. All copies can be re-inserted together one after another."
Scene 50	*Isabella:* "Duplication is known to be a large factor in the development of cancer." (Pause) "As an interesting theory, researchers believe duplication may have been instrumental in evolutionary survival. In this process, a species develops or improves inherited traits. This can allow a species to survive in its environment with greater success."
Scene 51	*Isabella:* "Inversion is a large scale mutation. Normally, it involves one chromosome." (Pause) "Inversion is when genetic material is turned around. The affected material, like a gene, is taken out, flipped in the opposite direction, and then reinserted from the same location it was taken."
Scene 52	*Isabella:* "With inversion, there is no loss of genetic material, and there is no duplication. The genetic material is simply turned around." (Pause) "Many times, inversion is undetected. But when it does affect protein formation inversion can lead to a 'loss of function'."
Scene 53	*Isabella:* "Translocation is a type of large scale mutation that involves two chromosomes. In this mutation, genetic material from the two affected chromosomes trade places." (Pause) "Just like in insertion, the affected chromosomes do not need to be next to each other."
Scene 54	*Isabella:* "Translocation can cause a balanced or unbalanced exchange of material. In a balanced exchange, the two chromosomes trade equal amounts of genetic material." (Pause) "In an unbalanced exchange, unequal amounts of material are exchanged. This means one chromosome gains extra genetic material while the other chromosome loses genetic material."
Scene 55	*Isabella:* "Translocation can lead to the expression of proteins that have a 'loss of function' or 'gain of function'."
Scene 56	*Isabella:* "Duplication, deletion, insertion, inversion, point mutation and translocation are basic forms of mutation that can alter DNA sequences. As you have seen, these changes can be on a very small scale, affecting just one base out of millions. Or they can be so large as to affect two chromosomes at the same time!" (Pause) "But remember, both large scale and small scale mutations can go undetected. It will depend on what part of the DNA sequence they affect, and whether this sequence is used for protein synthesis or what the protein normally does. "

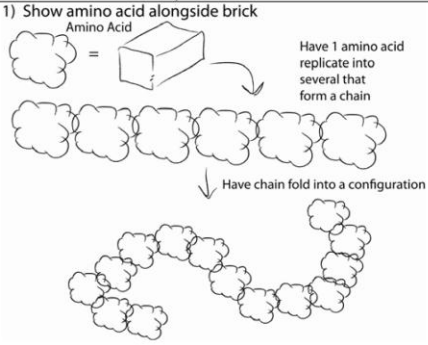
Slide	*Isabella:* **"Genetic Mutations and Illness!"**
Scene 57	*Isabella:* "In this section we will talk about one particular illness that is induced directly by changes in our DNA sequence. Cancer. There are at least 200 hundred different types of cancer, affecting at least 60 different organs in the human body." (Pause) "All of the mutations talked about in the previous sections are known to be a cause of many forms of cancer. Some mutations do cause cancer more often than others."
Scene 58	*Isabella:* "By definition, cancer is an illness provoked by the malignant growth and division of abnormal cells. These abnormal cells grow and divide without any control at all." (Pause) "Human cells can undergo abnormal growth or division as a consequence of mutations to a cell's genetic material."
Scene 59	*Isabella:* "Crucial to the development of cancer are oncogenes." (Pause) "Oncogenes are genes that can cause abnormal changes in a cell when they produce their proteins in high amounts, which is often the result of a mutation. These changes may allow cells to divide out of control. The cell might even avoid a process of programmed cell death called 'apoptosis'."
Scene 60	*Isabella:* "Apoptosis is a process in which cells normally die after they have served their functions. It is pre-programmed in most normal cells. But oncogenes remove the programming of apoptosis from a cell." (Pause) "This creates a cell capable of living indefinitely, never dying and dividing over and over."
Scene 61	*Isabella:* "Oncogenes, if they become permanently activated, could be enough to trigger cancer." (Pause) "An example of this is the KRAS gene. KRAS is essential in normal cell growth and division. If the KRAS gene is permanently activated, it turns into an oncogene that allows a cell to grow and divide uncontrolled."
Scene 62	*Isabella:* "But oncogenes are not the only factors in cancer. Tumor suppressor genes protect cells from becoming cancer cells." (Pause) "A mutation can cause a tumor suppressor gene to become inactive or turned off, increasing the chance that cells will begin dividing uncontrollably."
Scene 63	*Isabella:* "Within human DNA, p53 is a well known and important tumor suppressor gene." (Pause) "What, no accident?" "Niiicceeeee."
Scene 64	*Isabella:* "Generally, for cancer to develop an oncogene must become active at the same time a tumor suppressor gene becomes inactive." (Pause) "This allows a cell to divide and grow without being suppressed by a tumor suppressor gene."

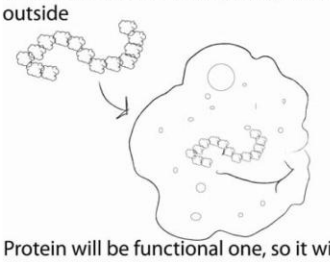
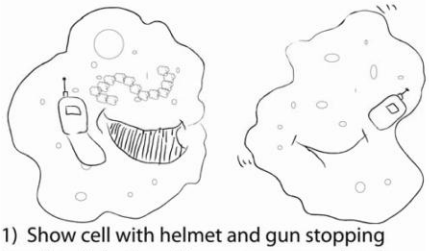
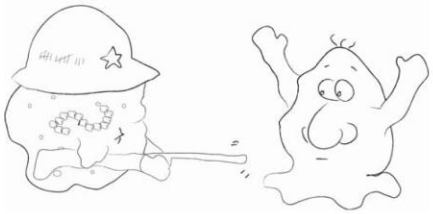
Scene 65	*Isabella:* "Though all mutations can cause cancer, translocation, duplication and point mutations have an especially strong influence in the formation of cancer." (Pause) "A missense mutation can be very significant." (Pause) "A missense mutation of the p53 tumor suppressor gene is the most common form of mutation of this gene, occurring in 75 percent of cases of p53 mutations."
Scene 66	*Isabella:* "Considering that p53 mutations are believed to be involved in 30-50% of known cases of cancer, you can see how a missense mutation is significant in the development of this illness!" (Pause) "And now, we have reached the end of our video lesson. I would like to thank all of you for being part of today's animation. It's been a great pleasure being part of your classroom, and hopefully we can do this again in the near future. Before I forget, the guys behind me have a little something to say to all of you…"
Slide	*Credits for the animation, voice and funding*

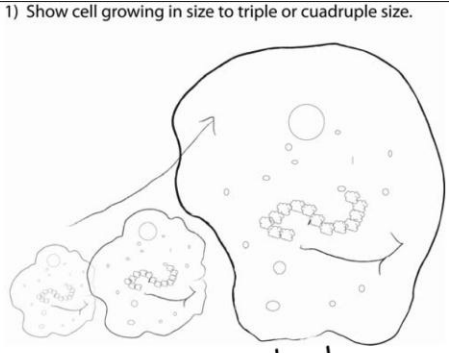
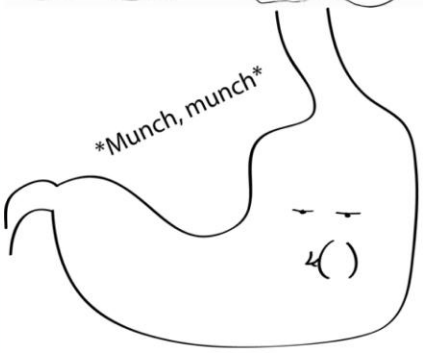
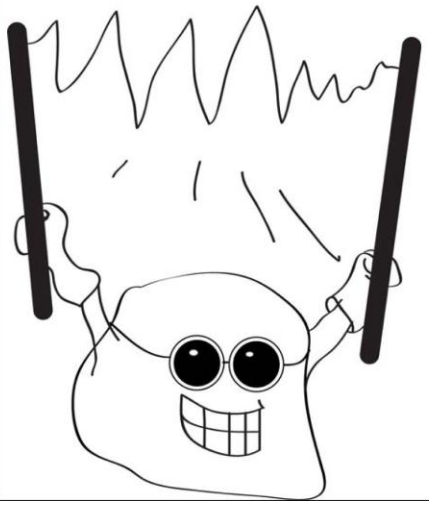
APPENDIX E
Final Narrative Script With Storyboard

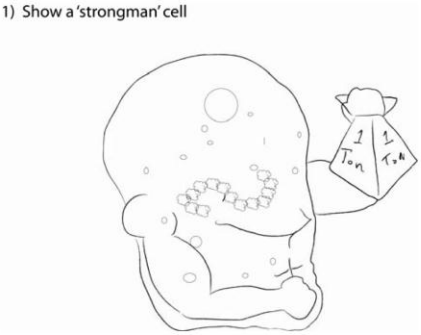
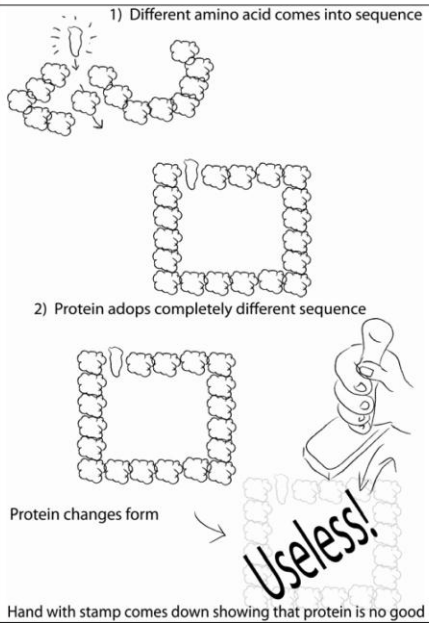
Narrative Script
Richard Thomas Lankes
August 2010

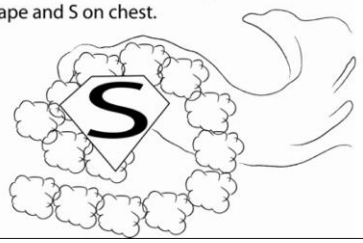
Opening	STARS and the UT Southwestern Medical Center present **Genetic Mutations Made Easy!**	*Isabella:* "STARS and the UT Southwestern Medical Center present **Genetic Mutations Made Easy**!"
Opening	Funding by the Howard Hughes Medical Institute	*Isabella:* "Funding by the **Howard Hughes Medical Institute**"
Scene 1	 (Do the flashing animation) 	*Isabella:* "Hello there everyone! Welcome to the STARS science video animation made for your classroom. My name is Isabella. Today, I will talk to you about unexpected changes that occur in genetics. You may wonder, what 'genetics' means. (Pause) Genetics is the science that studies how traits are inherited from one organism to another, like from parents to children. In this video, we will discuss the sudden changes that can sometimes occur within those inherited traits. These changes are called 'mutations', and sometimes they can even occur within a person without being inherited from their parents."(Pause) "Whoa!" (Pause)

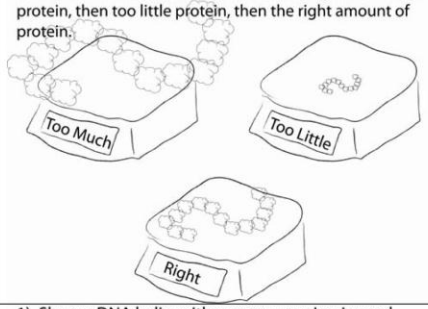
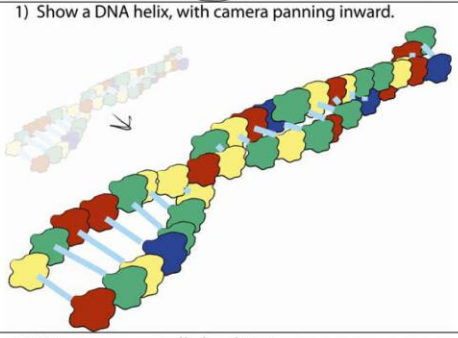
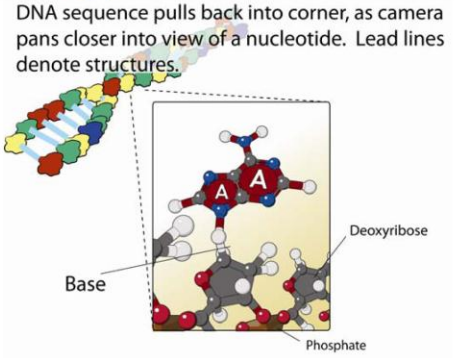
	1) White fades and dazed scientist is looking up, with blank stare and dizzy spins around eyes and head.  (Have scientist in background write on board instead of with flask)	"But to understand what a mutation is, we first need to talk about the small, important structures found in cells called 'proteins.' It is important to discuss what they do." (Pause) After that, we will discuss other important things, like how mutations affect living creatures by causing unexpected changes in proteins."
Scene 2	1) Show amino acid alongside brick  	*Isabella:* "Proteins are complex structures that are made up of many tiny units called 'amino acids.' You can think of amino acids as bricks. They are essential when used to make proteins in a process called 'protein synthesis.' First the amino acids, or bricks, are placed in a specific sequence, forming long chains. These chains are the original form of proteins. (Pause) But after the chain is formed, it is folded in different directions and angles. The amino acids, like bricks, help hold and maintain the protein in its new, twisted form. (Pause) A protein's function depends not just on what amino acids were used to make it, but also in what way the chain of amino acids is folded!"

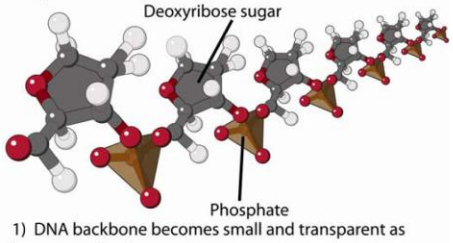
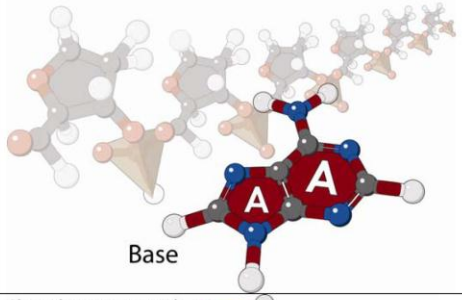
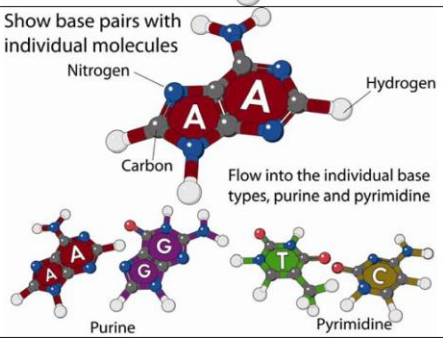
Scene 3	1) Protein enters cell, migrating inward from the outside  Protein will be functional one, so it will have "S" shape to it. 1) Phase to two cells communicating with one another via cell phones. Second cell nods agreement!  1) Show cell with helmet and gun stopping invading infection. Moves gun upward and infection raises hands into air. 	*Isabella:* "You might wonder what function or jobs proteins do in a human? Proteins assist our cells in many ways!" "They let cells talk to one another." "They allow cells to fight infection."

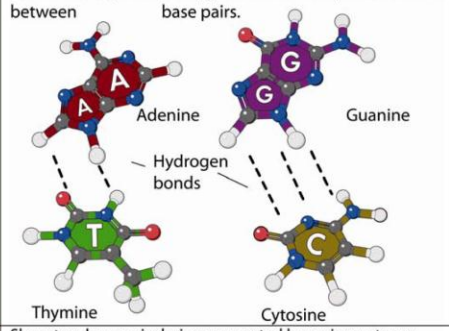
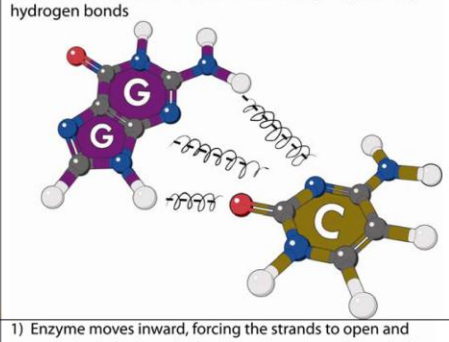
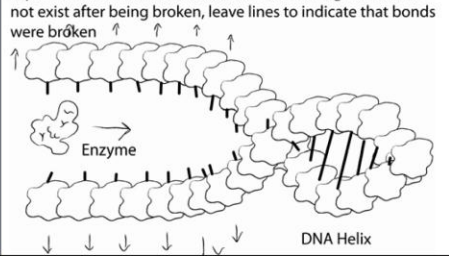
	1) Show cell growing in size to triple or cuadruple size. 	"Proteins help cells grow and divide."
		"They allow our body to digest food."
		"Proteins can help the body create energy."

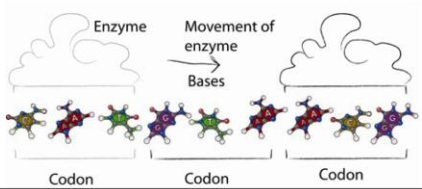
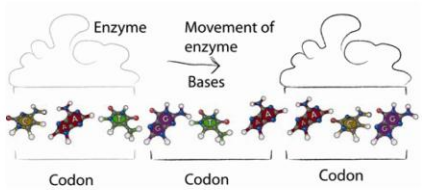
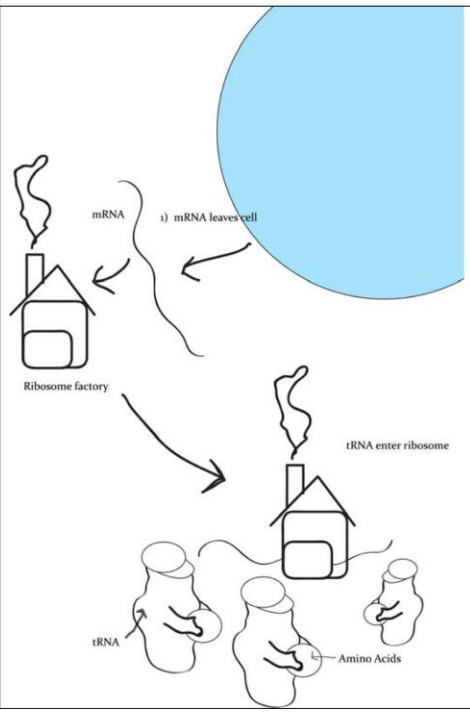
	1) Show a 'strongman' cell  	"They even assist cells in holding their shape." (Pause) "All in all, these are just a few of the things that proteins can do in the human body!"
Scene 4	1) Different amino acid comes into sequence  	*Isabella:* "Despite their many functions, proteins are fragile. Any change, even just one amino acid out of the many that make up a protein, can alter the entire protein. It's like changing one brick in a wall. Change the wrong one and the whole wall might even fall! In proteins, the change of one amino acid could change its entire form!" (Pause) "This change could mean the protein stops working like it was intended."

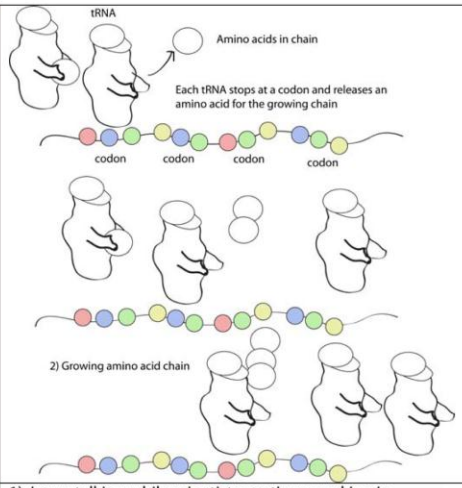
Scene 5	1) Cell plows the useless protein off screen 	*Isabella:* "Amino acids can be changed, added or removed from proteins in different ways." (Pause) "The most common change is called 'loss-of-function.' The protein loses a part, or all, of its functions. All in all, this means the protein stops working correctly. Cells will often remove these useless or disabled proteins."
Scene 6	1) Pan camera into view where protein is dressed with cape and S on chest. 	*Isabella:* "A rare type of change can make proteins too good at what they normally do! They can become super-efficient. Or they can do jobs they couldn't do before." (Pause) "By becoming super-efficient or acquiring a 'gain-of-function', these proteins can become an advantage to the cell."

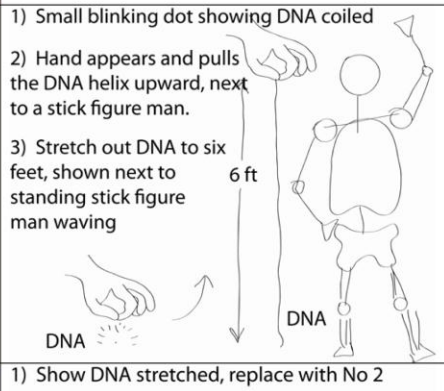
Scene 7	1) Show three scales, one at a time, showing first too much protein, then too little protein, then the right amount of protein. 	*Isabella:* "But changes to proteins do not just occur to their sequence of amino acids." (Pause) "A protein can be normal, but too much or too little of a protein could lead to severe complications for the cell. Maybe even death of the cell. Because of this, it is important to have the right amount of protein, not just a well-made one."
Scene 8	1) Show a DNA helix, with camera panning inward. 	*Isabella:* "Protein synthesis is tied directly into our genetic material, to our DNA. DNA, also known as Deoxyribonucleic Acid, is essential in the formation of proteins. (Pause) Think of DNA as the plans for building a house. With these plans, cells know what amino acids, the bricks, are needed to create a specific protein, the house. Without the instructions given by DNA, a cell would not know how and which amino acids to use to make a specific protein."
Scene 9	DNA sequence pulls back into corner, as camera pans closer into view of a nucleotide. Lead lines denote structures. 	*Isabella:* "Looking closely at our DNA, we can see it is made up of several different units. DNA is physically formed by two separate strands that twist around on another. This is known as a double helix. Yet, the most important units found in DNA are the millions of nucleotides that form each strand." (Pause) "A nucleotide has three parts: One of four 'bases', a molecule of sugar called 'deoxyribose,' and the mineral known as phosphate."

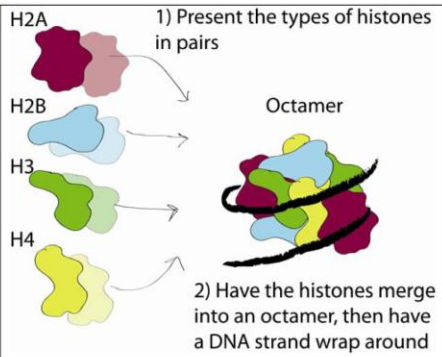
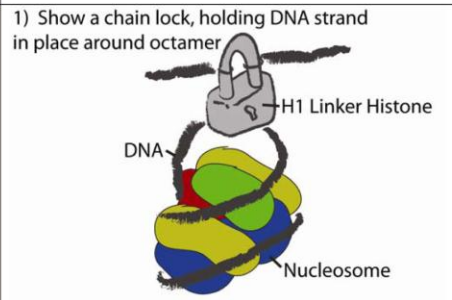
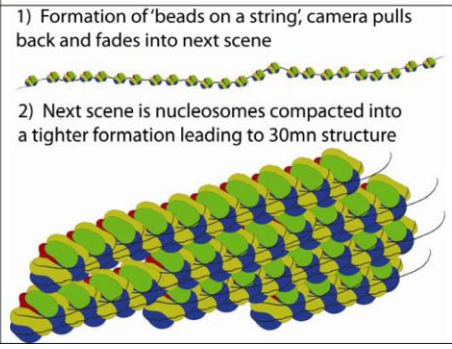
Scene 10	1) DNA backbone is shown first, then fly into image of base as backbone recedes.  1) DNA backbone becomes small and transparent as base grows in size 	*Isabella:* "The sugar deoxyribose and phosphate in nucleotides do not have any genetic information in them. Instead, they work together like a strong backbone that allows nucleotides to connect with other nucleotides in series. This forms two extremely long chains made up of millions of connected nucleotides. These two chains form the well-known double helix of DNA." (Pause) "Just as important, deoxyribose and phosphate hold securely in place the most important component of each nucleotide: the base. The bases actually store our genetic material."
Scene 11	Show base pairs with individual molecules 	*Isabella:* "Each base is a ring-like structure, made up by carbon and nitrogen. Attached to the rings we can find hydrogen, nitrogen and oxygen atoms. Bases appear in two general forms known as either Purines or Pyrimidines. " (Pause) "But purines are slightly different from pyrimidines. Purines actually are two rings fused together, instead of just one. The bigger ring has six atoms while the other ring is made up of just five atoms. Pyrimidines, though, have only one central ring with six atoms."

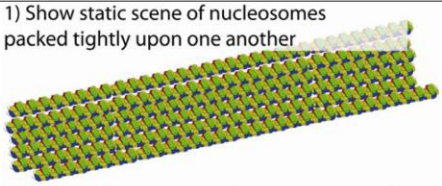
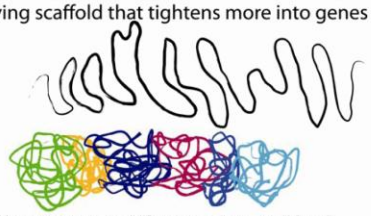
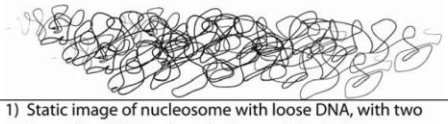
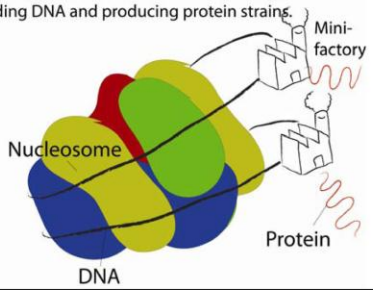
Scene 12	Label Purines, then label pyrimidines. After, create bonds between base pairs. 	*Isabella:* "Within the DNA sequence, there are two types of purines. They are called Adenine and Guanine. Pyrimidines also have two forms in DNA, labeled as Cytosine and Thymine." (Pause) "Under normal circumstances, Adenine will only form a strong union with the pyrimidine Thymine. The pyrimidine Cytosine will only bond with the purine Guanine. This is an important fact."
Scene 13	Show two base pairs being connected by springy, strong hydrogen bonds 	*Isabella:* "Also important is the fact that these bonds are formed between the strands of DNA. Bases will not form bonds with other bases found in the same strand of DNA." (Pause) "These bonds, called hydrogen bonds, help the deoxyribose-phosphate backbone create a very strong but flexible DNA helix. They are extremely difficult to open."
Scene 14	1) Enzyme moves inward, forcing the strands to open and separate in the indicated directions. Even though bonds do not exist after being broken, leave lines to indicate that bonds were broken 	*Isabella:* "Some proteins, called enzymes, have very specialized jobs. For example, there are enzymes that can break the hydrogen bonds between bases. This allows for the DNA strands to separate from one another, exposing the bases found in the nucleotides." (Pause) "This is very important, because the amino acids that make up proteins are coded by the bases found within DNA nucleotides."

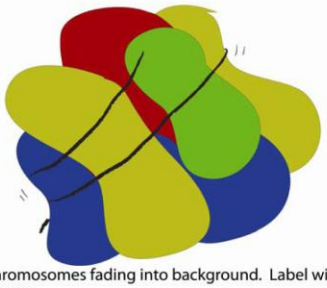
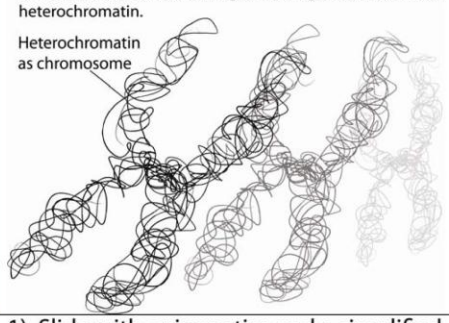
Scene 15	1) Enzyme moves in the indicated direction, scooting three bases at a time. A codon label appears at the bottom of each group of threes. Will use ball and stick form for the bases 	*Isabella:* "During the synthesis of proteins, a specialized enzyme called 'RNA polymerase' will read the base in a sequence and build a complimentary strand. For example, providing a thymine for each adenine in the DNA, and a guanine for cytosine. RNA polymerase travels only in one direction."
Scene 16	1) Enzyme moves in the indicated direction, scooting three bases at a time. A codon label appears at the bottom of each group of threes. Will use ball and stick form for the bases 	*Isabella:* "Every three bases in a segment of DNA that will lead to protein formation is called a codon. These codons will specify a specific amino acid in the protein. Several codons may code for the same amino acid! "(Pause) "The RNA polymerase will form a separate sequence of nucleotides called 'mRNA' from the original DNA strand. Once mRNA is formed and taken outside of the nucleus, it is 'read' by a little factory in the cytoplasm called a ribosome, which will create a new protein from the code read on the mRNA."
Scene 17		*Isabella:* "Think of a ribosome as a two part factory. Within this ribosomal factory, mRNA is laid out bare. Molecules known as transfer RNA carry amino acids and bind to each codon on the mRNA. We can think of tRNA as factory workers." (Pause) "The ribosome factory allows the tRNA worker to join with a specific sequence in the mRNA."

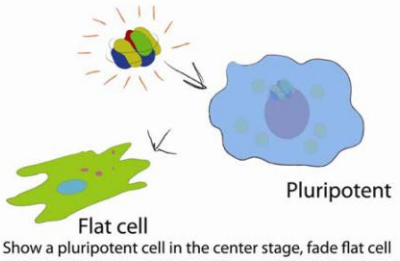
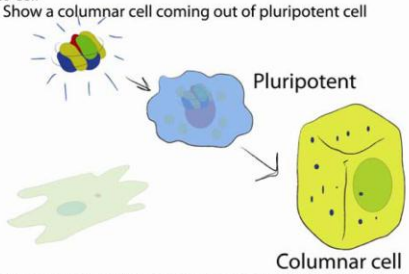
Scene 18		*Isabella:* "When the tRNA finds its particular codon, it releases its amino acid to the growing sequence of amino acids forming on the ribosome. As more tRNA molecules read the mRNA, more amino acids are released. Once the sequence of amino acids reaches its programmed size, it is released from the ribosomal factory. But to become an active protein it must go through a series of folding reactions and perhaps be modified further by other enzymes. (Pause) As you can see, one changed nucleotide in a strand of DNA can lead to one changed codon. This codon can lead to the wrong amino acid, which can lead to a malformed protein!"
Scene 19	1) Laura talking while scientists continue working in background. Side scientist drops flask  1) Laura turns eyes towards scientist who is whistling, looking upward with hands behind back. 	*Isabella:* "So thanks to the bases found in the nucleotides that make up DNA, cells can determine which sequence of amino acids should be used in protein synthesis."

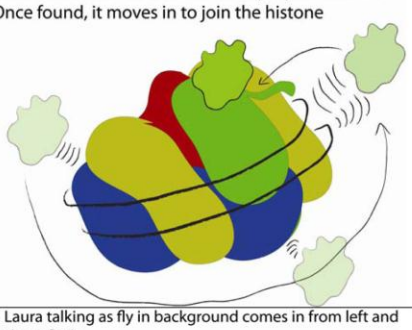
Slide	Questions and Answer for Section 1	
Slide	Section 2 **Super-Coiling, Epigenetics and Those Amazing Histones!**	*Isabella:* "**Super-Coiling, Epigenetics and Those Amazing Histones**!"
Scene 20	1) Small blinking dot showing DNA coiled 2) Hand appears and pulls the DNA helix upward, next to a stick figure man. 3) Stretch out DNA to six feet, shown next to standing stick figure man waving  	*Isabella:* "How big is a strand of DNA? Since it fits in the nucleus of a cell, and you would normally need a microscope see a cell, it must be very small." (Pause) "But if you were to take a strand of DNA and stretch it out fully, it would reach about six feet in length! Taller than many people!"
Scene 21	1) Show DNA stretched, replace with No 2 2) Compress DNA, replace with No 3 3) Do final compression with a vice grip squeezing the DNA 	*Isabella:* "The reason DNA fits so well into such a small area, like a cell's nucleus, is because of a process called 'super-coiling.'" (Pause) "Super-coiling involves wrapping DNA around itself and structures called histones. This twisting is incredibly tight, and reduces the overall length of DNA millions of times. (Pause) There are multiple levels of wrapping, but the primary wrapping involves 'histones.'"

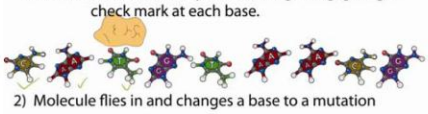
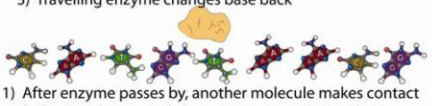
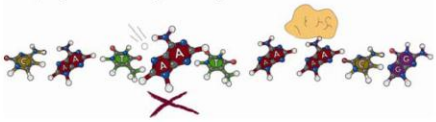
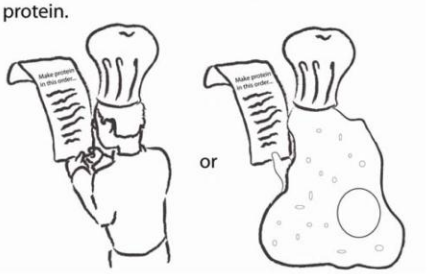
Scene 22		*Isabella:* "Histones are small molecules. There are four main types of histones, and they are known as H2A, H2B, H3 and H4. Normally, histones will pair up with one another, two of each kind, to form a tight ball-like core of eight individual histones. We call this core an 'Octamer'. (Pause) "It is around the octamer that DNA itself will wrap around 1.6 times. Whenever DNA is wrapped around an octamer, the octamer plus DNA is known as a 'nucleosome.'" (Pause) "As an interesting point, the histones that make up the octamer have tails that can wrap and move around. These tails allow each individual histone to interact with a strand of DNA within reach!"
Scene 23		*Isabella:* "To hold DNA in place around an octamer, a special histone called 'H1" locks it down. This histone makes certain that there is DNA in physical contact with the octamer."
Scene 24		*Isabella:* "Super-coiling leads to the creation of millions of nucleosomes on each double strand of DNA." (Pause) "If we utilize a special microscope called an electron microscope, we can see the DNA wrapped and locked around the octamers. Visually, this is called 'beads on a string' because the DNA does look like a string with millions of beads!" (Pause)"By further compacting, the nucleosomes are brought closer together, into a tight grid. Like stacking baseballs next and on top of each other."

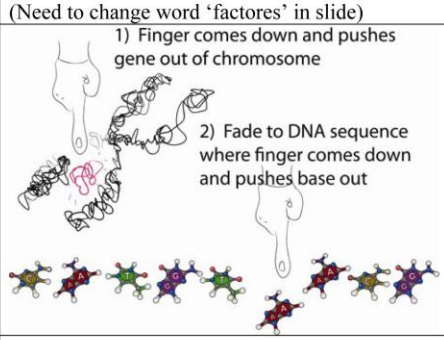
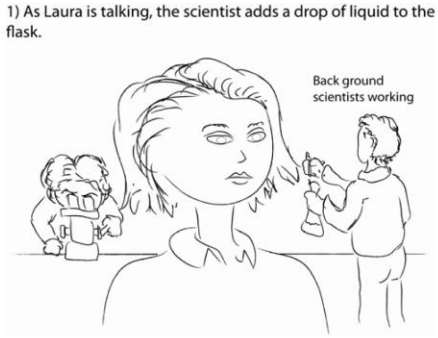
Scene 25	1) Show static scene of nucleosomes packed tightly upon one another  2) Show the structure of nucleosomes in the waving scaffold that tightens more into genes  1) Show genes in different colors, pull back camera to show large expanse of chromatin 2) Phase out to show chromatin 	*Isabella:* "As more nucleosomes are brought together into a tighter package, the strand of DNA is twisted and wrapped around itself, like twisting yarn or twine. This creates a folded, wavy strand of DNA." (Pause) In a method that is still not well known, DNA can then be folded into segments called genes. Genes are sequences of DNA that code for specific proteins. And finally, DNA is folded into a final form known as 'chromatin'. Chromatin is very tightly compacted DNA that may be stored in a small area, like a nucleus." (Pause) "Chromatin is so tightly packed it cannot normally be seen with regular microscopes!"
Scene 26	1) Static image of nucleosome with loose DNA, with two units reading DNA and producing protein strains.  	*Isabella:* "When a cell is not dividing, its chromatin can be active in the formation of proteins. During this activity, it is loosely compacted. It is not as tightly wrapped around the octamers as it normally would be when a cell divides." (Pause) "This type of loose chromatin is known as euchromatin."

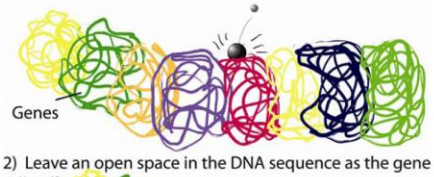
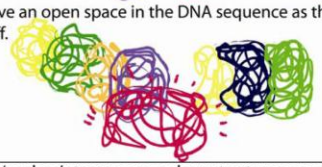
Scene 27	1) Static image where nucleosome is tied down tightly by a DNA strand. Make nucleosome pinched and bloated at the top and bottom, like a balloon.  1) Show chromosomes fading into background. Label with heterochromatin. 	*Isabella:* "During the stage of cellular division known as 'prophase,' chromatin becomes extremely wrapped. At that time, it is not used for protein synthesis." (Pause) "This chromatin, called heterochromatin, can be seen easily with powerful microscopes in the shape we recognize as a chromosome."
Scene 28	1) Slide with epigenetics and a simplified definition of such Epigenetics Epigenetics is the study of traits you can inherit that are not based directly off of DNA sequences	*Isabella:* "Nucleosomes are not just important in super-coiling. They also participate in epigenetics." (Pause) "Epigenetics is the study of traits you can inherit that are not based directly from a DNA sequence. Think of this. Skin cells and muscle cells have different functions. They act differently, look very distinct, but they both have the exact same genetic material inside each nucleus. So why don't all cells look and act the same? The answer is epigenetics."

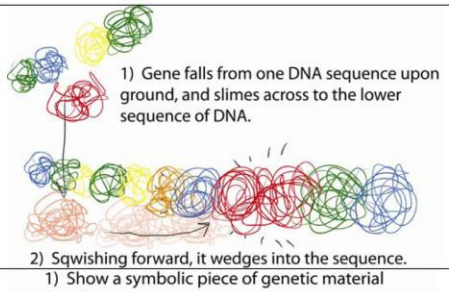
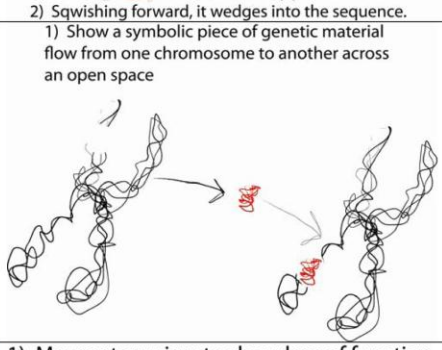
Scene 26	1) Show a pluripotent cell in the center stage 2) Show nucleosome acquire a given color and goes into cell 3) Show a flat cell coming out of pluripotent cell  1) Show a pluripotent cell in the center stage, fade flat cell 2) Show nucleosome acquire a different given color and goes into cell 3) Show a columnar cell coming out of pluripotent cell  1) Show a histone tail coming out and touching the DNA strand nearby  2) Have a glow around DNA and move DNA out to show it changing a bit	*Isabella:* "Many living animals have 'pluripotent' cells. These special cells are capable of becoming different types of related cells, depending on what the body needs. For example, one type of pluripotent cell can turn into blood cells, cells that fight infections or cells that help blood clot. But how does the pluripotent cell know what type of cell to turn into? Histones help the pluripotent cells decide." (Pause) "Histones do not actively modify or alter the sequence of DNA wrapped around them. Instead, specific enzymes modify the histone tails. The tails will change position upon the DNA, making DNA accessible to RNA polymerase. This means that the DNA could be used in protein synthesis. Or, the change in position could make it impossible for RNA polymerase to reach a portion of DNA, so it cannot be used for the formation of mRNA. And this means that no protein would be made!"

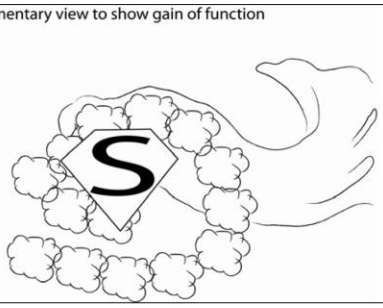
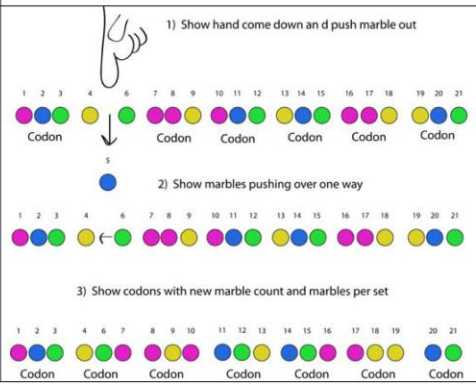
Scene 30	1) Have enzyme circle nucleosome looking for specific histone. Use sonar waves to find the proper histone. 2) Once found, it moves in to join the histone 	*Isabella:* "It is believed that histones only affect the portion of DNA that makes direct physical contact with them. Evidence does exist that maybe histones can affect DNA that is much further away. But this is still theory." (Pause) "We know that enzymes affect histones and their tails in a specific order. Not all enzymes affect all histones in the same way, at the same time! What we don't know is how an enzyme decides which histone to interact with."
Scene 31	1) Laura talking as fly in background comes in from left and lands on flask.  1) Fly grows to incredible size and and flies off with scientist. 	*Isabella:* "Through changes in the position of the histone tails, histones determine if cells create a specific protein or not. This can lead a pluripotent cell into becoming one type of cell if a certain protein is formed or into another type if a different protein is synthesized."
Slide	Questions and Answers	*Isabella:* "Questions and Answers"
Slide		

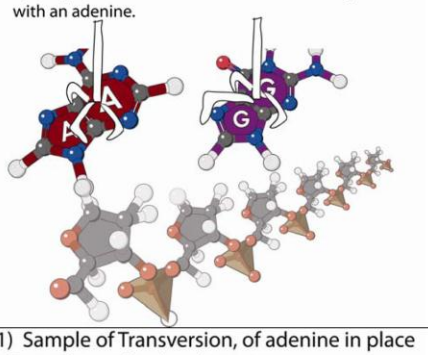
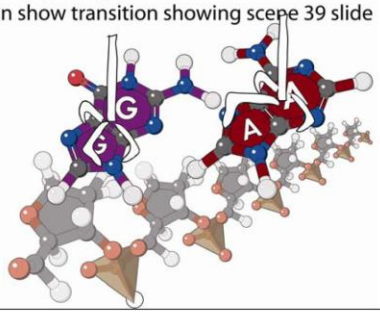
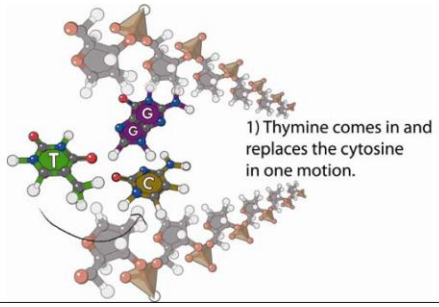
	Section 3 **Genetic Mutations and How They Work!**	*Isabella:* "**Genetic Mutations and How They Work!**"
Scene 32	1) DNA chain with an enzyme travelling along, giving a check mark at each base.  2) Molecule flies in and changes a base to a mutation  3) Travelling enzyme changes base back  1) After enzyme passes by, another molecule makes contact with the DNA bases, and changes one to cytosine, thus escaping correction by the enzyme. 	*Isabella:* "DNA sequence mutations happen often in cells. Mutations can be caused by many things, such as radiation, chemicals or even errors in the synthesis of DNA. But, the cells can repair many of these mistakes. Enzymes dedicated to this function repair many of these mistakes when they find them." (Pause) "Yet, errors do manage to slip by."
Scene 33	1) Show cook or cell with recipe on how to make protein.  (Note: Instead of chef's hats it can be replaced with a construction hat instead.)	*Isabella:* "Since DNA holds the 'building plan' for the making of proteins, any change in DNA can lead to the creation of the wrong sequence of amino acids." (Pause) "Many times, these changes lead to the formation of an incorrectly-made protein."

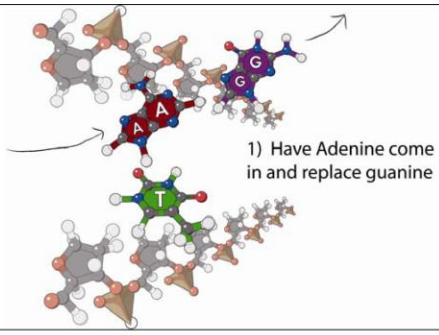
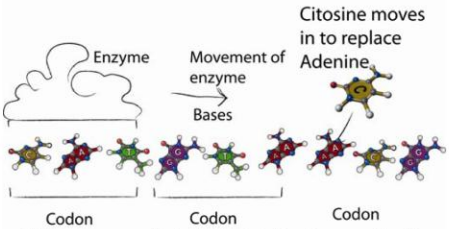
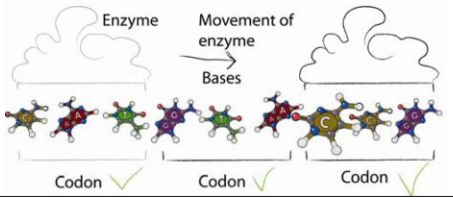
Scene 34	**Mutations** Factores that determine if they cause a noticed change in genetics * Location of mutation * Length of genetic sequence affected * How is the changed sequence used in protein synthesis (Need to change word 'factores' in slide)	*Isabella:* "A mutation that occurs within a segment of DNA does not mean it automatically produces proteins that do not function correctly." (Pause) "Other factors determine whether a mutation provokes a noticeable change or not. The location of the mutation, the length of DNA that is changed, and how the changed protein is normally used are all important factors. All these things determine if the mutation is undetected, if it provokes minor illness or if it is fatal to the organism."
Scene 35		*Isabella:* "Genetic mutations can be either very large or extremely small. A large scale mutation could affect several genes, whole chromosomes or sets of chromosomes at the same time." (Pause) "By contrast, a mutation could affect something as tiny as just one nucleotide base out of the millions that make up a DNA strand!"
Scene 36		*Isabella:* "Even with a change as small as one nucleotide base, it is possible to produce a protein that is completely abnormal. By contrast, several changes do not always produce a protein that fails to work properly."

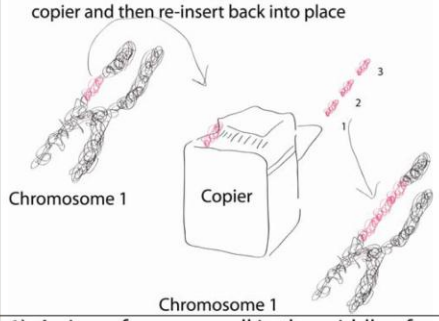
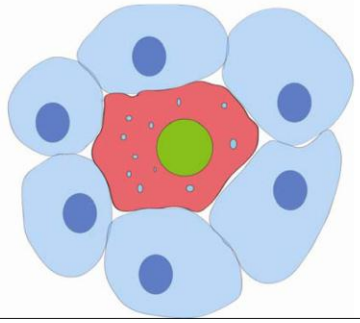
	1) Scientis begins glowing neon gren and grows twice his size. 	"Hmmm. That's unusual!"
Scene 37	1) Have a molecule roll in at high speed and knock out a front gene like a pool ball, forcing it to roll out.  2) Leave an open space in the DNA sequence as the gene rolls off. 	*Isabella:* "There are several basic types of mutations. The first mutation we will talk about is called 'Deletion'." (Pause) "A deletion is the accidental removal of bases. This can happen on a small scale, such as the deletion of just one base. Or, it can occur on a large scale, removing an entire gene or genes. Sometimes, even whole chromosomes."
Scene 38	1) The 'useless' stamp comes down to stamp an abnormal protein  	*Isabella:* "A deletion generally causes the loss of a sequence within just one chromosome. With deletions, proteins are usually synthesized with a loss of function." (Pause) "Deletions are known to be the cause of many genetic illnesses."

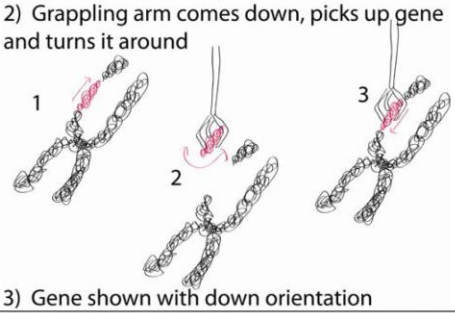
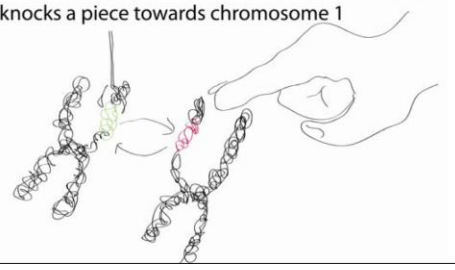
Scene 39		*Isabella:* "Another type of well known mutation is 'Insertion'. A small scale mutation, insertion involves the addition of genetic material. It can involve a single base, several bases, or even a small portion of another chromosome." (Pause) "In the last case, genetic material is separated from one chromosome then inserted into the sequence of another chromosome."
Scene 40		*Isabella:* "This exchange of genetic material from one chromosome to another can happen at a large distance within the nucleus. Because of this, chromosomes do not need to be next to each other." (Pause) "As strange as it may sound, the genetic material floats from one chromosome to another!"
Scene 41		*Isabella:* "Insertion can lead to the creation of proteins that suffer both 'loss of function' and 'gain of function'. 'Loss of function' is the more common consequence of the two."

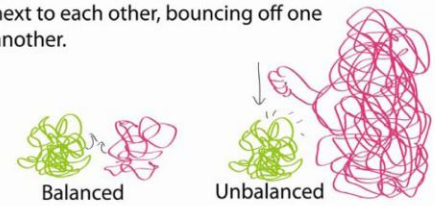
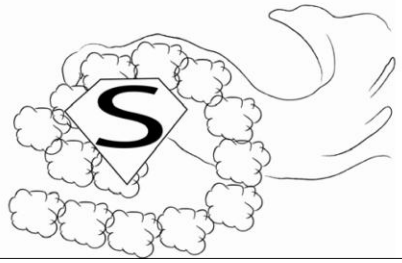
	1) Momentary view to show gain of function 	
Scene 42		*Isabella:* "Both deletion and insertion can produce what is known as 'frame-shift'. Think of a sequence of marbles, numbered 1 to 21. Each marble represents a nucleotide. Every three marbles in the order represents a codon. So in this sequence of marbles we have seven codons, where the first codon has numbers 1 to 3, codon 2 has numbers 4 to 6, etc. (Pause) In a frame shift, a deletion or insertion produces a change in the number of nucleotides in a sequence and leaves the wrong nucleotides in the codon."
Scene 43		*Isabella:* "Let us say that marble number 5 is removed from the sequence. That means that codon 1 has the correct marbles in it, numbers 1 to 3. But codon number 2 has the marbles numbered 4, 6 and 7. This means that is has marble 7, a different nucleotide, in it. And all the following codons will have their numbers shifted over one, with the last codon having only two marbles in it instead of the normal three. (Pause) This is important, because a deletion can leave a codon missing a nucleotide, and the nucleotides it does have may not be the ones it should possess. Insertion causes the same complication. But unlike deletion, it adds nucleotides, instead of removing them."

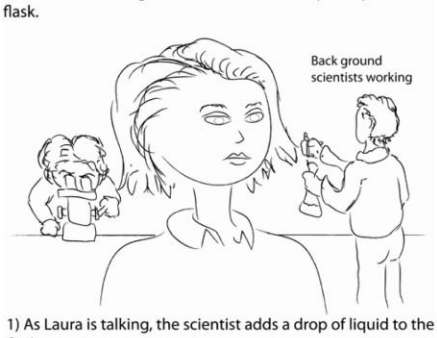
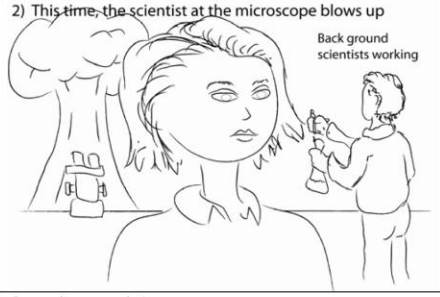
Scene 44	1) Grapple hooks come down and move the guanine with an adenine. 	*Isabella:* "Point mutation is a small scale change that affects just one base on one chromosome." (Pause) "The affected base can be switched out with another, or it can be deleted completely. A new extra base could be inserted into the sequence!"
Scene 45	1) Sample of Transversion, of adenine in place of cytosine, using hooks to move 2) Can show transition showing scene 39 slide 	*Isabella:* "When a point mutation causes a base to be replaced with another, there are several things that can happen. In a change known as transversion, a purine, like adenine, can be changed for a pyrimidine, like cytosine." (Pause) "In a change called transition, a purine is changed for a purine, like adenine for guanine. Or, it could just be a pyrimidine for another pyrimidine."
Scene 46		*Isabella:* "In either transversion or transition, when a base pair is change the paired base on the opposite DNA strand must also be changed. Otherwise, the new base will not be able to form hydrogen bonds with the opposing base." (Pause) "For example, if we have an adenine and put a guanine in its place, the thymine on the opposite strand that bonded with the adenine must be changed for a cytosine, so it may bond with the new base of guanine."

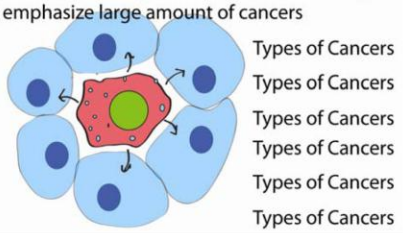
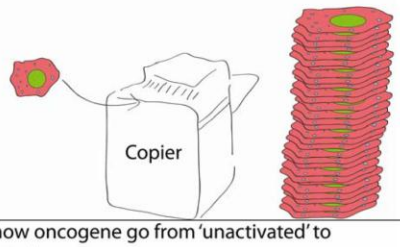
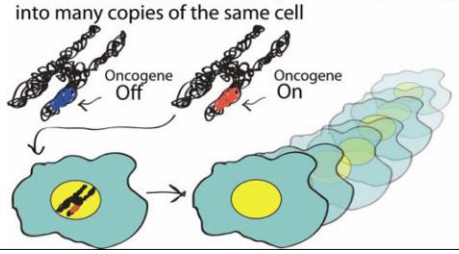
		
Scene 47	1) Enzyme moves in the indicated direction, scooting three bases at a time. A codon label appears at the bottom of each group of threes. Will use ball and stick form for the bases  1) Enzyme moves in the indicated direction, scooting three bases at a time. A codon label appears at the bottom of each group of threes. Will use ball and stick form for the bases, and a check mark notes that the codon is accepted. 	*Isabella:* "A point mutation can be called 'silent' if the changed base leads to a codon that still codes for the original amino acid. This will lead to a protein that has an amino acid sequence that is not changed, even if the original base is altered. So naturally, this protein should function as expected."

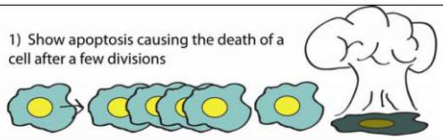
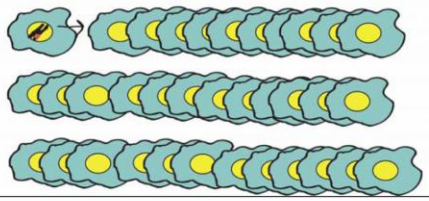
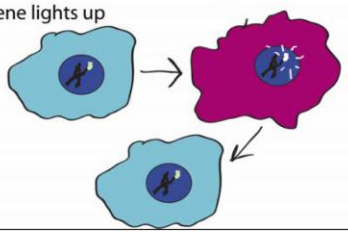
Scene 48	**Point Mutations** Missense mutation: form of point mutation that leads to the creation of a protein that does not function the way it should Nonsense mutation: form of point mutation that will cause protein expression to suddenly stop. This can create a smaller, unfinished protein that may not work at all (Change wording on Missense mutation)	*Isabella:* "A missense mutation is a form of point mutation in which a different amino acid replaces the original one. This may lead to the creation of a protein that does not function the way it should." (Pause) "A nonsense mutation is another form of point mutation that will cause protein expression to suddenly stop. This can create a smaller, unfinished protein that may not work at all."
Scene 49	1) Have a gene come out, copies itself in the copier and then re-insert back into place  	*Isabella:* "Duplication is often a large scale mutation that normally affects one chromosome. A large sequence of DNA is duplicated and then reinserted immediately after the portion that has been copied." (Pause) "Duplication may create one copy, or it may create many copies of the same segment. All copies can be re-inserted together one after another."
Scene 50	1) A view of a cancer cell in the middle of a grouping of normal cells 	*Isabella:* "Duplication is known to be a large factor in the development of cancer." (Pause) "As an interesting theory, researchers believe duplication may have been instrumental in evolutionary survival. In this process, a species develops or improves inherited traits. This can allow a species to survive in its environment with greater success."

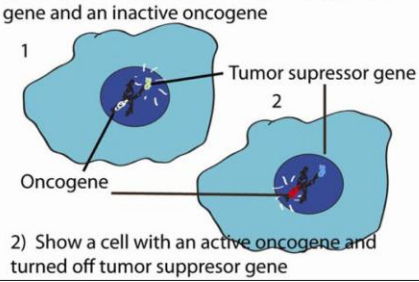
Scene 51	1) Show gene with upper orientation 2) Grappling arm comes down, picks up gene and turns it around  3) Gene shown with down orientation	*Isabella:* "Inversion is a large scale mutation. Normally, it involves one chromosome." (Pause) "Inversion is when genetic material is turned around. The affected material, like a gene, is taken out, flipped in the opposite direction, and then reinserted from the same location it was taken."
Scene 52	1) Hand comes down and stamps the inversion mutation with "ninja stealth". Chromosome will have a mask on. 	*Isabella:* "With inversion, there is no loss of genetic material, and there is no duplication. The genetic material is simply turned around." (Pause) "Many times, inversion is undetected. But when it does affect protein formation inversion can lead to a 'loss of function'."
Scene 53	1) Grappling arm grabs material from chromosome 1, while a hand from chromosome 2 knocks a piece towards chromosome 1 	*Isabella:* "Translocation is a type of large scale mutation that involves two chromosomes. In this mutation, genetic material from the two affected chromosomes trade places." (Pause) "Just like in insertion, the affected chromosomes do not need to be next to each other."

Scene 54	1) Show balanced, where the material line up next to each other, bouncing off one another.  2) Show unbalanced, where the larger genetic material bonks the smaller material over the head with an extended arm.	*Isabella:* "Translocation can cause a balanced or unbalanced exchange of material. In a balanced exchange, the two chromosomes trade equal amounts of genetic material." (Pause) "In an unbalanced exchange, unequal amounts of material are exchanged. This means one chromosome gains extra genetic material while the other chromosome loses genetic material."
Scene 55	1) Momentary view to show loss of function  1) Momentary view to show gain of function  	*Isabella:* "Translocation can lead to the expression of proteins that have a 'loss of function' or 'gain of function'."

Scene 56	1) As Laura is talking, the scientist adds a drop of liquid to the flask.  1) As Laura is talking, the scientist adds a drop of liquid to the flask. 2) This time, the scientist at the microscope blows up  	*Isabella:* "Duplication, deletion, insertion, inversion, point mutation and translocation are basic forms of mutation that can alter DNA sequences. As you have seen, these changes can be on a very small scale, affecting just one base out of millions. Or they can be so large as to affect two chromosomes at the same time!" (Pause) "But remember, both large scale and small scale mutations can go undetected. It will depend on what part of the DNA sequence they affect, and whether this sequence is used for protein synthesis or what the protein normally does. "
Slide	Questions and Answers	
Slide	Section 4 **Genetic Mutations and Illness!**	*Isabella:* **"Genetic Mutations and Illness!"**

Scene 57	1) Show a growing cancer cell in the middle of several cells. 2) Have a scrolling panel of different cancer types to emphasize large amount of cancers  	*Isabella:* "In this section we will talk about one particular illness that is induced directly by changes in our DNA sequence. Cancer. There are at least 200 hundred different types of cancer, affecting at least 60 different organs in the human body." (Pause) "All of the mutations talked about in the previous sections are known to be a cause of many forms of cancer. Some mutations do cause cancer more often than others."
Scene 58	1) Show cancer cell entering copier 2) Numerous copies come out, forming a high stack.  	*Isabella:* "By definition, cancer is an illness provoked by the malignant growth and division of abnormal cells. These abnormal cells grow and divide without any control at all." (Pause) "Human cells can undergo abnormal growth or division as a consequence of mutations to a cell's genetic material."
Scene 59	1) Show oncogene go from 'unactivated' to activated. 2) Show oncogene stimulating cell into replicating into many copies of the same cell  	*Isabella:* "Crucial to the development of cancer are oncogenes." (Pause) "Oncogenes are genes that can cause abnormal changes in a cell when they produce their proteins in high amounts, which is often the result of a mutation. These changes may allow cells to divide out of control. The cell might even avoid a process of programmed cell death called 'apoptosis'."

Scene 60	1) Show apoptosis causing the death of a cell after a few divisions  2) Show lack of apoptosis and constant cell division 	*Isabella:* "Apoptosis is a process in which cells normally die after they have served their functions. It is pre-programmed in most normal cells. But oncogenes remove the programming of apoptosis from a cell." (Pause) "This creates a cell capable of living indefinitely, never dying and dividing over and over."
Scene 61	1) Slide naming the KRAS oncogen and what could happen if it activates KRAS Oncogene that is capable of inducing uncontrolled growth of a cell if activated	*Isabella:* "Oncogenes, if they become permanently activated, could be enough to trigger cancer." (Pause) "An example of this is the KRAS gene. KRAS is essential in normal cell growth and division. If the KRAS gene is permanently activated, it turns into an oncogene that allows a cell to grow and divide uncontrolled."
Scene 62	1) Show cell with an activated tumor suppresor gene 2) Show cell turning, growing into a cancer cell 3) Show the cell revert back to regular cell after oncogene lights up 	*Isabella:* "But oncogenes are not the only factors in cancer. Tumor suppressor genes protect cells from becoming cancer cells." (Pause) "A mutation can cause a tumor suppressor gene to become inactive or turned off, increasing the chance that cells will begin dividing uncontrollably."
Scene 63		*Isabella:* "Within human DNA, p53 is a well known and important tumor suppressor gene." (Pause)

	1) Laura talks, then stops and asks, "What, no event?"  *Music starts and disco ball comes in* 	"What, no accident?" "Niiicceeeee."
Scene 64	1) Show a cell with an active Tumor Suppresor gene and an inactive oncogene  2) Show a cell with an active oncogene and turned off tumor suppresor gene	*Isabella:* "Generally, for cancer to develop an oncogene must become active at the same time a tumor suppressor gene becomes inactive." (Pause) "This allows a cell to divide and grow without being suppressed by a tumor suppressor gene."

Scene 65	1) Slide showing the types of mutations that have major impact in cancer development **Mutations that influence cancer** * Translocation * Duplication * Point Mutation Missense mutation is significant	*Isabella:* "Though all mutations can cause cancer, translocation, duplication and point mutations have an especially strong influence in the formation of cancer." (Pause) "A missense mutation can be very significant." (Pause) "A missense mutation of the p53 tumor suppressor gene is the most common form of mutation of this gene, occurring in 75 percent of cases of p53 mutations."
Scene 66	1) Laura talking while scientists continue working in background.  1) Laura talking while scientists continue working in background. Side scientist drops flask again, but this time both scientist hold up signs that say "good" and " bye"  (*Cue in guys behind Isabella holding signs that say "good" "bye" or "the" "end")	*Isabella:* "Considering that p53 mutations are believed to be involved in 30-50% of known cases of cancer, you can see how a missense mutation is significant in the development of this illness!" (Pause) "And now, we have reached the end of our video lesson. I would like to thank all of you for being part of today's animation. It's been a great pleasure being part of your classroom, and hopefully we can do this again in the near future. Before I forget, the guys behind me have a little something to say to all of you…"
Slide	**Credits**	
	Credits for the animation, voice and funding	

APPENDIX F
Teacher's Instruction Guide

Genetic Mutations Science Suitcase

Teacher's Instruction Manual

An Educational Science Module Created With the Generous Support of

STARS
UT SOUTHWESTERN MEDICAL CENTER

Introduction

Teacher's Instruction Manual

Welcome.

Thank you for selecting the STARS Genetic Mutations Science Suitcase for use within your classroom. This suitcase has been created through the collaboration of the Biomedical Communications Graduate Program and the University of Texas Southwestern Medical Center Graduate School, produced for the Science Teacher Access to Resources Southwestern (STARS) Science Triathlon, with support from the Dallas Musuem of Nature and Science, the Dallas Interdependent School District (DISD) and Advanced Placement Strategies (APS) program. Funding was provided by the Howard Hughes Medical Institute with additional support by the University of Texas Southwestern Graduate School and the O'Donnell Foundation.

This instructional guide has been created with the educator in mind, providing instruction for utilizing the components within the science suitcase.

The Genetic Mutations Science Suitcase should contain the following:

- Genetic Mutations Animation CD/DVD
- Mutations! Card game, with cards, boards and game guides
- Nucleosome model, a flexible physical hands-on model
- Genetic Posters, a series of 3 large wall posters
- Guide DVD, a storage DVD loaded with all guides, manuals and instructions
- Two carrying cases: A central storage case where all small-sized components are found, and a large carrying tube for the storage of the Genetic posters and card game team boards

Index

Genetic Mutations Animation DVD

The Genetic Mutation DVD included in the scientific suitcase contains several components that may be freely utilized in a Biology classroom (Figure 1-1). The primary component of the CD is a short form animation that is over twenty five minutes long. The animation is divided into several primary sections that may be shown together or separately. The principal purpose of the DVD is to serve as a resource tool that shows students basic genetic concepts, such as DNA, nucleotides and codons. It also explains more advanced concepts, such as nucleosomes and their function in both supercoiling and epigenetics. And finally, the DVD covers in detail the concepts of genetic mutations, their causes and the basic forms of genetic mutations found in nature. It is suggested that the DVD be shown first, as an introductory course into genetic mutations. It will provide students with information that they may use subsequently in the other activities presented in the science suitcase.

Figure 1-1. Genetic Mutations Animation DVD.

To utilize the DVD, follow these steps:

- Insert the DVD into your computer drive or DVD player
- Animation DVD should start automatically and lead you to the Main Menu
- Open DVD drive and make certain disk is right-side up. Labeled side should be facing upward.
- If it does not automatically begin and you are on a computer, right click on "My Computer," go to your DVD drive, right click and select "Open with" and choose program to view DVD

The Genetic Mutation DVD should begin automatically and take the educator to the Main Menu. From here, the educator has several choices (Figure 1-2).

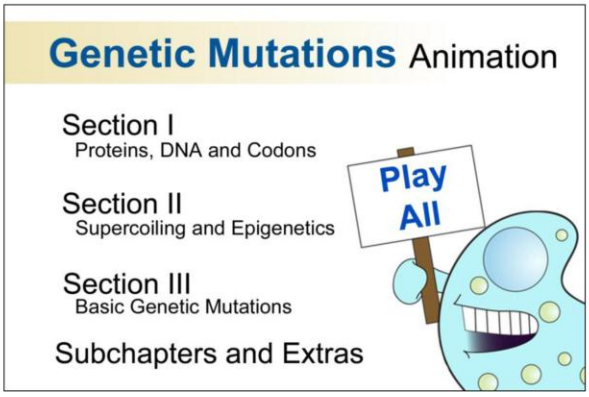


Figure 1-2. Genetic Mutations Animation Main Menu.

Play All

Starts the animation from the very beginning, and will run through the entire animation

Section I: Proteins, DNA and Codons

- Proteins, section that explains their functions and how they are formed
- DNA, section that describes Deoxyribonucleic Acid, the phosphate-deoxyribose sugar backbone and nucleotides
- Codons, section that describes codons and a basic review of formation

Section II: Supercoiling and Epigenetics

- Supercoiling, section that explains histones, nucleosomes and the mechanism by which they allow for compacting of DNA
- Epigenetics, section that explains how nucleosomes help determine what kind of specific cell type a pluripotent cell should turn into

Section III: Basic Genetic Mutations

- Basic traits of genetic mutations, section that describes shared characteristics
- Deletion, section that describes the Deletion mutation
- Insertion, section that describes the Insertion mutation
- Frame-shift, section that describes Frame-shift mutation
- Point mutation, section that describes Point mutation and its different varieties
- Duplication, section that describes the Duplication mutation
- Inversion, section that describes the Inversion mutation
- Translocation, section that describes the Translocation mutation

Subchapters and Extras

This link provides access to the Subchapters and Extras menu (Figure 1-3). This submenu gives access to specific subsections of each primary section found on the Main Menu. This allows an educator to target a specific topic found in the animation. Also, it gives access to extra features, such as:

- Nucleosome Model leads to a video demonstration for the hands-on nucleosome and its use
- Posters leads to a short video animation for the Genetic Posters, showing how they relate with one another
- Credits leads to funding, creator and participants for the animation

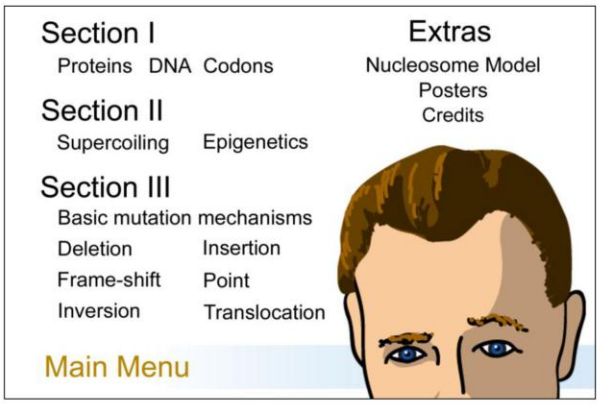


Figure 1-3. Subchapters and Extras Menu.

Mutations! Card Game

The suitcase has a card/board game hybrid titled "Mutations! Card Game". This card game has one primary purpose, which is to teach students the basic types of genetic mutations and how these mechanisms may alter a DNA strand. This educational process is carried out in two stages of the game, where each team of students must first successfully build a DNA strand. And then, navigate their team token to the end of the strand while repairing or surviving mutations inflicted on their game board strand by the opposing team. Teams will both suffer and inflict mutations in all stages of this game. The card game should have the following components:

- Two Team Boards, one for Team A and one for Team B
- Two Student Quick Reference Guides
- One Educator Quick Reference Guide
- One Mutations! Card Game Instruction Manual
- One Deck Board
- Over 200 hundred individual cards
- Two Team Tokens
- Three carrying cases for the cards

This instruction manual will not explain the game mechanics since that portion is covered by the card game's own instruction manual (Figure 1-4).

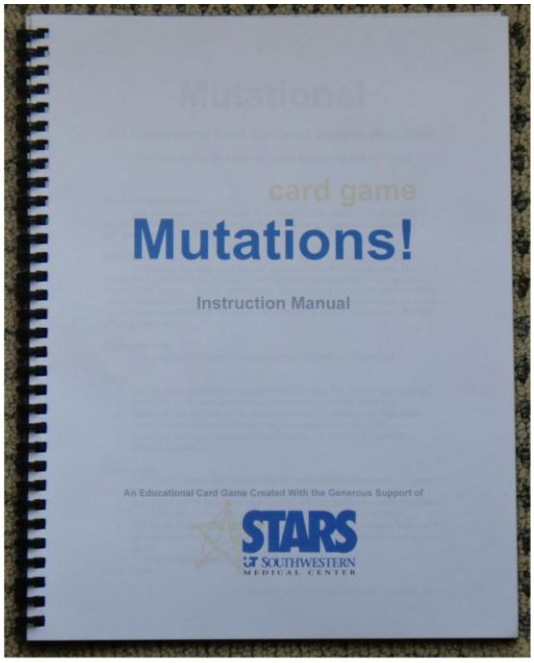


Figure 1-4. Mutations! Card Game Instruction Manual.

The game cards are found in multiple card cases, one case for each card type. Cards fit within each case snuggly, and each is labeled for easy identification. There is one case for Nucleotide cards, one for Mutation cards and one for Movement cards, with support cards being held any of the three cases (Figure 1-5). The Team Tokens are seen here with the cases. They are red plastic blocks that are easy to replace. If the educator wishes it, any item may be substituted for the Team Tokens. Team Tokens have a small Styrofoam strip to hold them in place during packing and transit within the suitcase.

Figure 1-5. Card Cases With Team Tokens in Front.

The Deck Board, game instruction guide, both Student Quick Reference Guides and the Educator Quick Reference Guide may be found with the card cases in the central storage case for the science suitcase. The Team Boards may be found in the carrying tube. It is recommended that the Team Boards be rolled and stored with the face of each board oriented outward.

Set up of the board may look like the following example (Figure 1-6). Team Boards for each side are easy to identify. The name of each team may be found in the upper right, with a blue color band for Team A and an amber color band for Team B. Team boards may be set up next to each other, or facing on another. It is recommended that each Team Board be set on its own table because of their large size.

Figure 1-6. Mutations! Game Card Team Board for Team B.

The Student and Educator Quick Reference Guides are meant to be used for referral material by students and/or teachers at any time. So the guides may be held or set down anywhere for easy access (Figure 1-7).

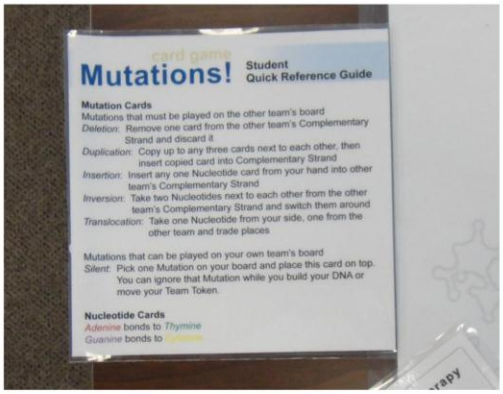


Figure 1-7. Student Quick Reference Guide.

The Deck Board is designed to hold all three kinds of card types for the game. The board is meant to be shared between both teams, so placement of the Deck Board depends on the placement of the Team Boards and the orientation of each team. The Deck Board is roughly the size of a regular sheet of paper with a hard coating. There is a space on the Deck Board reserved for each card type, labeled for easy identification (Figure 1-9). In the image below we see examples of each card type used in the game.

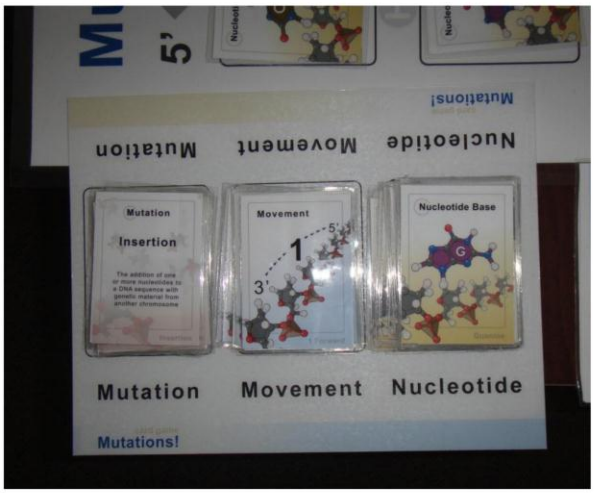


Figure 1-9. Deck Board.

Hands-on Nucleosome Model

The suitcase comes with a hands-on physical model of a nucleosome. This model is based off of the actual molecular structure of a nucleosome, making it an accurate representation. The nucleosome has two purposes.

The first is to show students the theoretical interaction between histone tails and the DNA helix wrapped around the nucleosome. This interaction may cause the DNA wrapped around the nucleosome core to either tighten or loosen. If it tightens, then the DNA cannot be used in protein synthesis. If it loosens, then enzymes may reach the DNA strand and use it to create a new protein. This is essential in epigenetics, where different synthesized proteins can lead to the development of different kinds of cell types from pluripotent cells.

The second purpose of the nucleosome is to show students that DNA wraps around a histone core, a process that allows DNA to become tightly compacted and fit within a cellular nucleus. This is known as supercoiling, and is an essential function of nucleosomes, since without this process a DNA strand would be too big to otherwise fit inside a cell.

A five minute demonstration video on how to use the nucleosome model is found on the Genetic Mutations Animation DVD, under the Subchapters and Extras menu.

The nucleosome model has two components:

- A flexible, bendable physical nucleosome roughly 10 inches in length along its longest axis that is very lightweight (Figure 1-10).
- A three foot cord of derby rope used as representation of a DNA helix. The cord is colored blue-white, very lightweight and resistant to wear (Figure 1-10).

The flexibility of the nucleosome allows for illustrating how histone tails interact directly with DNA, while the derby cord serves not just for this function, but also to illustrate that a DNA strand wrapped around a nucleosome allows for shortening of the same strand. This shortening over a grand scale allows for an important step in supercoiling to occur.

Figure 1-10. Derby Rope and Nucleosome Model.

The nucleosome's construction is light memory foam coated in a rubberized color-coat that helps identify the individual histones that make up the nucleosome model (Figure 1-11). There are a total of 8 histones in the model, so 8 different tones are represented. The foam and rubberized coating allows for extreme rotation and compression of the model (Figure 1-12).

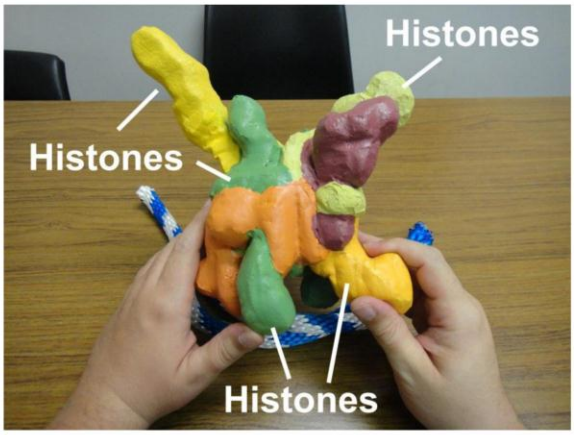


Figure 1-11. The Individual Histones of the Nucleosome Model.

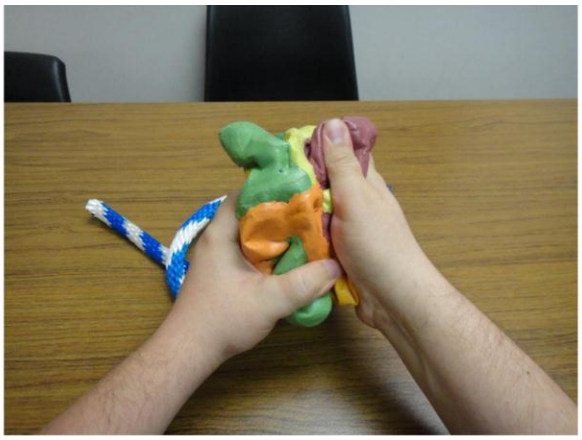


Figure 1-12. Nucleosome Being Compressed.

Theoretical interaction between the histones and DNA occurs through the histone tail. Each histone has its own tail, so a total of 8 tails may be seen in this model. The tails, like the rest of the nucleosome model, may be compressed, twisted or bended. Tails may be identified as the outcroppings that emerge from the central portion of the nucleosome, such as the ones identified in the picture (Figure 1-13).

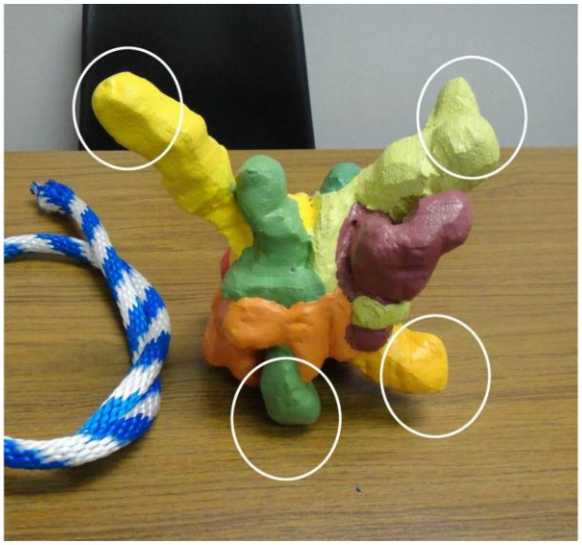


Figure 1-13. Circles Identifying Several Nucleosome Tails.

The purpose of the derby rope is to symbolize a DNA helix. It may be loosened or tightened around the central portion of the nucleosome. Though the nucleosome has no clear up or down orientation, the wrapping of the derby rope around the nucleosome can be done in any direction to facilitate the process. A suggested orientation of the rope may be seen below (Figure 1-14).

Figure 1-14. Derby Rope Around Nucleosome.

Below are two sample images of the derby rope being loosened or tightened around the nucleosome core. The first image represents the effect that a histone tail has on a DNA strand after it directly interacts with it, causing it to loosen its hold on the nucleosome core (Figure 1-15) so it may be used as a template in protein synthesis. The second image shows the effect that a histone may have on DNA, causing it to tighten so much that it no longer can serve as a template for protein synthesis (Figure1-16).

Figure 1-15. DNA Loosened Around a Nucleosome Core.

Figure 1-16. DNA Strand Tightened Around Nucleosome Core.

Genetic Posters

The suitcase provides a series of three posters utilized to show the great size differential that exists between genetic structures. Since a chromosome is roughly 50,000 times larger than a nucleotide, a difference akin to that of a 1 millimeter ink line and the height of a fifteen story building, these posters emphasize the grand difference in scale between them and the structures that lay between. This is done by illustrating the process of supercoiling.

A short demonstration video on how the posters relate to one another can be found in the Subchapters and Extras menu on the Genetic Mutations Animation DVD.

The science suitcase should have the following:

- Three posters of the same size, 6 x 4 feet.

All three posters are stored within the carrying tube that accompanies the case. Posters may be folded length-wise to allow entry into the carrying tube.

Poster 1 represents the formation of DNA from nucleotides, the way DNA begins to wrap around histones to form nucleosomes, and the tightening of these nucleosomes to form a tetramer coil at the bottom of the poster (Figure 1-17).

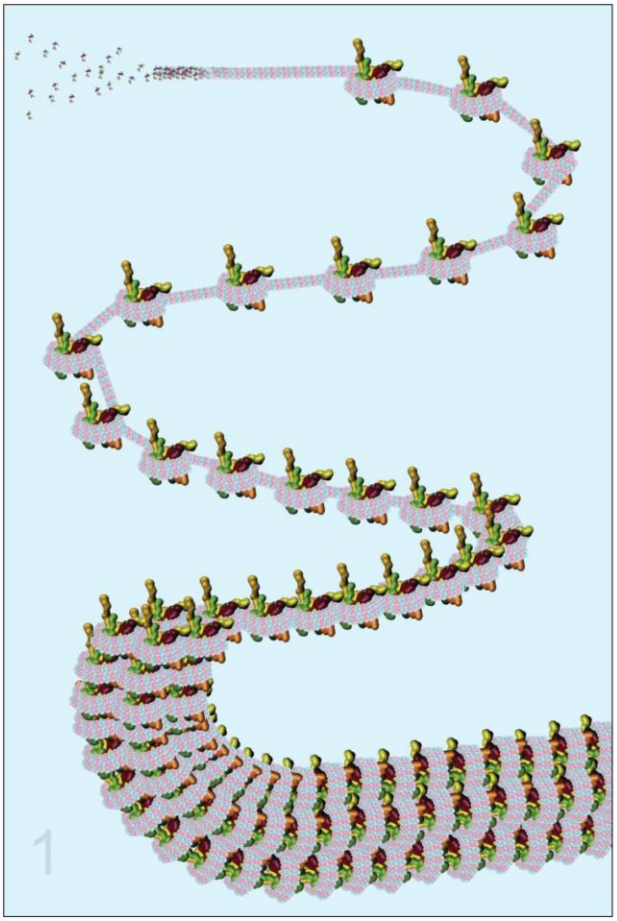


Figure 1-17. Poster 1.

Poster 2 shows the mid-stage of supercoiling, where a DNA helix becomes very kinked, twisted and compacted (Figure 1-18).

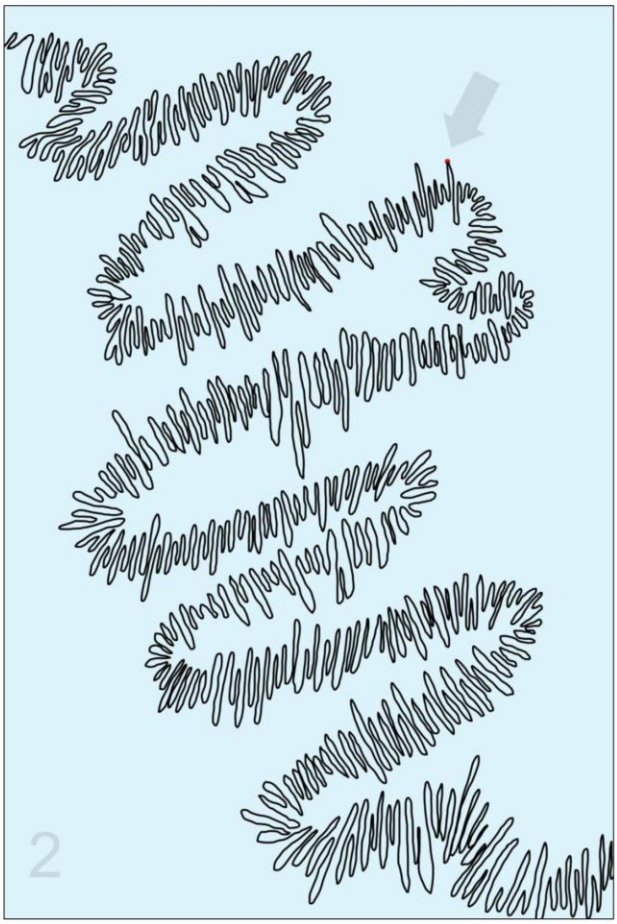


Figure 1-18. Poster 2.

Poster 3 shows the final stage of supercoiling, the chromosome (Figure 1-19).

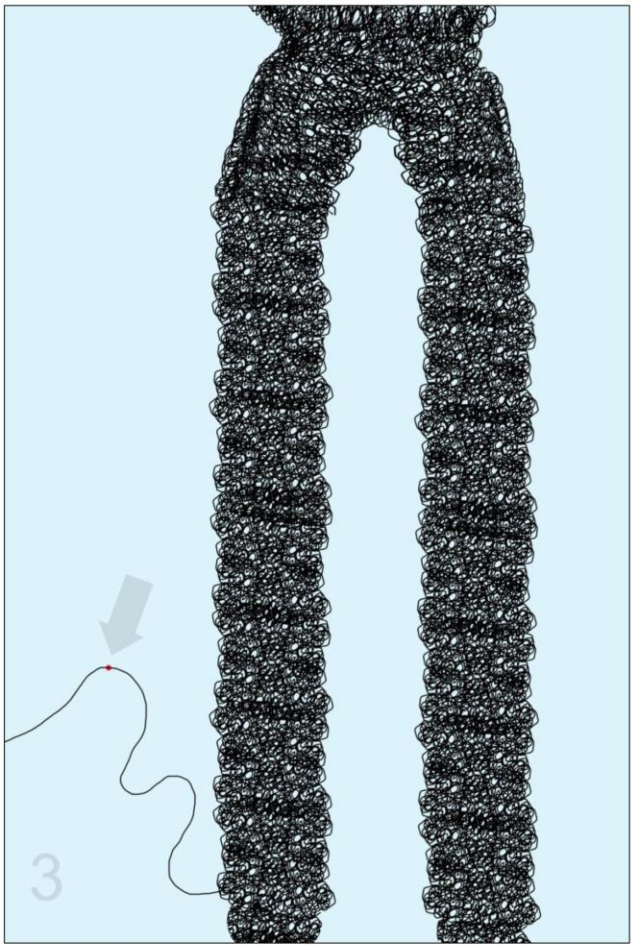


Figure 1-19. Poster 3.

The recommended manner in which to show the posters is to hang them side by side (Figure 1-20). A small, greyed out number may be found on the bottom left corner of each poster. These allow for quick identification of the posters and denote the order they should be put in (Figure 1-21).

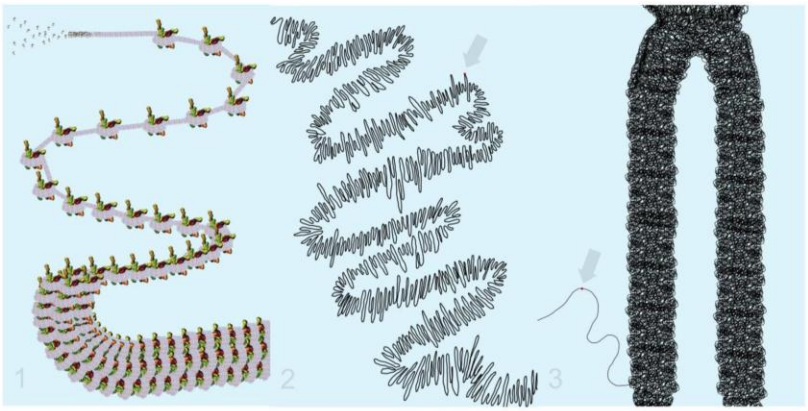


Figure 1-20. Correct Order of Posters.

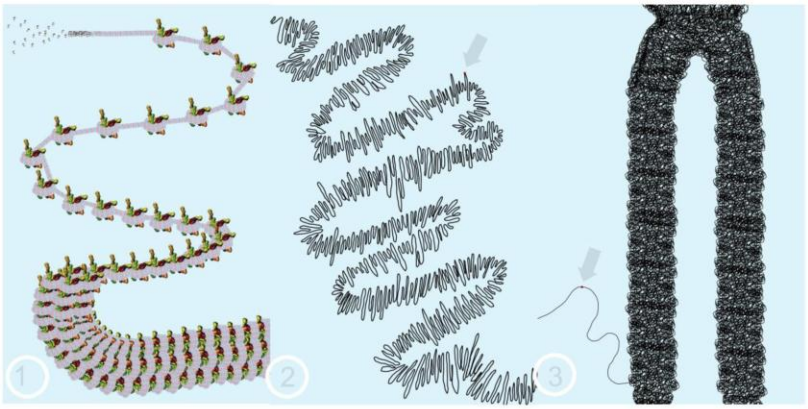


Figure 1-201. Circled Location of Numbers on Posters.

Posters 2 and 3 both have a small red dot with greyed out arrows pointing to their location (Figure 1-22).

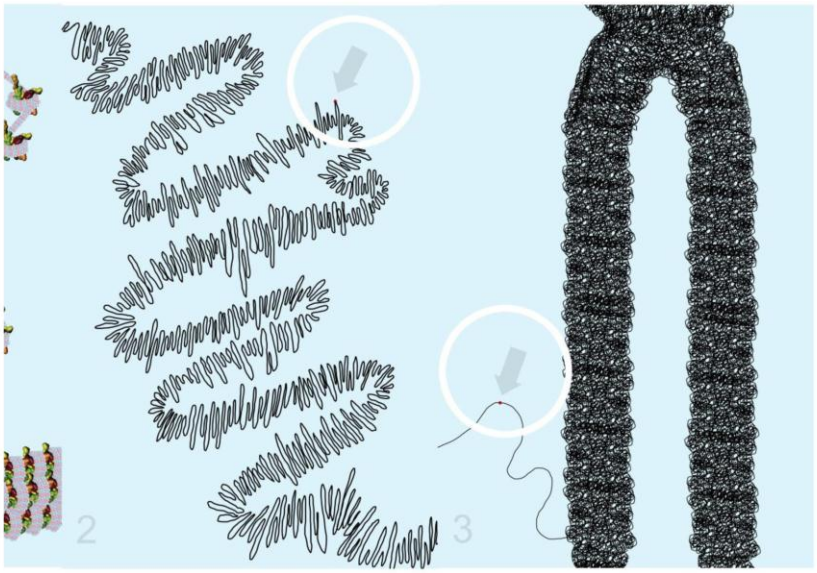


Figure 1-22. Circled Red Dots and Arrows on Posters 2 and 3.

These red dots represent the entirety of the previous posters. The dot on poster 2 represents the area covered by poster 1, while the red dot on poster 3 represents the entire area covered by poster 2. As such, each previous poster theoretically fits into a small space on the following poster. This should assist the student's in understanding that despite seeming to be equal size at first, the events of the first poster are incredibly small when compared to the events depicted in the second poster. And that the events on poster 2 are just a small fragment of what is perceived on poster 3.

Guide DVD

The suitcase comes with a Guide DVD, a data DVD with all the manuals, guides and instructions in a PDF format, as well as animations or demonstrations videos. The files you will find specifically are:

- The Mutations! Card game instruction book
- The Teacher's Instruction Manual
- The Nucleosome demonstration video in Quicktime ® format
- The Genetic posters animation
- Digital copies of the Genetic posters in .jpeg format

The Guide DVD may be found in the central storage case where most other suitcase components are also located. The Guide DVD is labeled for easy identification (Figure 1-23).

Figure 1-23. Guide DVD.

To utilize the DVD, follow these steps:

- Insert the Guide DVD into your computer DVD drive
- If your computer is set to automatically run CDs or DVDs, then the DVD with all files should open in a new window.
- Choose the file you wish to review
- If the Guide DVD does not open automatically, go to the My Computer tab option and double click on it
- Open your DVD drive by double clicking on it. This should take to you an opened window with all the available files on Guide DVD. Choose the file you wish to review.

Carrying Cases

This science suitcase is contained within two separate storage devices.

- A 16 x 12 x 6 inch hard plastic carrying case that is extremely lightweight, durable and resistant to spills, but not including total immersion in a body of water (Figure 1-24). This case functions as the primary storage unit where the majority of the suitcase components are carried. This includes all manuals and instructions, all DVDs and CDs, the game cards and their respective cases, game tokens and the Nucleosome model with derby rope.
- A solid, thick cardboard tube 3 inches in diameter with a length of 24 inches (Figure 1-25). This case carries the Genetic posters, and Team Boards from the card game.

Figure 1-24. Primary Carrying Case.

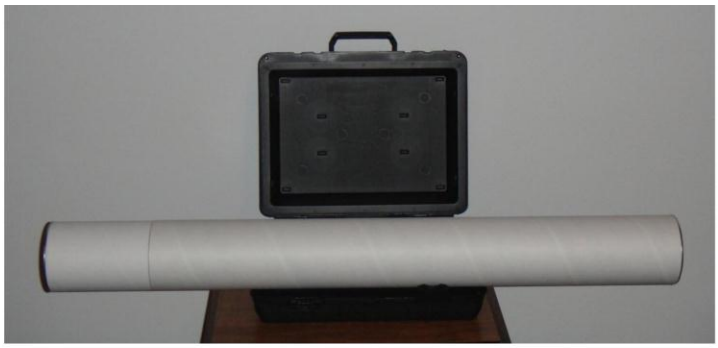


Figure 1-25. Carrying Tube.

Storage in the primary case is simple. First locate the upper lid of the case. The upper lid has both the handle on it and two Styrofoam strips on the inside of the lid on the right side (Figure 1-26).

Figure 1-26. Upper Lid of Carrying Case.

The Deck Board and Quick Reference Guides from the card game are placed at the bottom of the case. (Figure 1-27).

Figure 1-27. Deck Board and Reference Guides at the Bottom of Carrying Case.

Next, the Genetic Mutations Animation DVD and Guide DVD are put down, one next to the other (Figure 1-28).

Figure 1-28. Genetic Animation DVD and Guide DVD Set Within Carrying Case.

The instruction manuals are put in next at the bottom of the case (Figure 1-29).

Figure 1-29. Instruct Manuals are Set Within Carrying Case.

Next the next, the card game Team Tokens are put flush against the upper edge of the case. The Team Tokens are held in place with a cut, rectangular piece of Styrofoam (Figure 1-30).

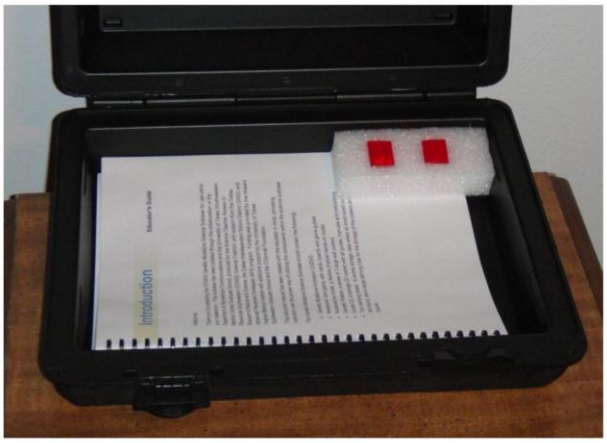


Figure 1-30. Team Token Located in Carrying Case.

Next, the three card carrying cases are set flush up against the lower edge of the Styrofoam holding the Team Tokens, stacked on top of the other (Figure 1-31).

Figure 1-31. Card Cases Set Within Carrying Case.

Finally, the Nucleosome model with derby rope tied around it is set into the case, right next to the card cases (Figure 1-32). The rope may be just tied around itself and set between the model and the card carrying cases, if the educator wishes.

Figure 1-32. Nucleosome Model With Derby Rope Within Carrying Case.

The case is easily carried (Figure 1-33). The lid may present with some resistance when lowering due to the Styrofoam strips on the lid and the flexibility of the Nucleosome model. If the lid presents strong resistance or stops suddenly, reopen the case and organize components once more. All elements should fit comfortably without much resistance to the lid closing if they are stored correctly. Once closed, the case weighs only 6 pounds with all elements in place. There is relatively little shifting of items due to the closeness of the packing, so items are securely in place.

Figure 1-33. Carrying Case Sealed.

In regards to the carrying tube, the card game Team Boards and Genetic posters should fit comfortably within. Due to their size, the Genetic Posters may be folded length-wise and then introduced into the carrying tube. Since the Team Boards may present some rolling with long term storage, it is recommended that they be rolled and inserted facing outward. The total weight of the carrying tube once filled is 4 pounds.

APPENDIX G
Post Production Project Survey

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

Please tell us whether you agree or disagree with the following statements about each session for the event and provide your comments
1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	(3)	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	(5)
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	(4)	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	(5)

8. In what format would you prefer the animation be provided for use in your classroom?
Via DVD or CD / (Via Internet) / Preloaded to a computer / All
Vimeo worked great - I've already downloaded Evo vids.

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	1	2	(3)	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	(5)
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	(5)
13. I would use this card game in my classroom	1	2	3	4	(5)
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	(5)
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	(5)

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	(5)
17. The model would be too complex to be understood by the students of your classroom	1	(2)	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	(5)
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	(4)	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	(2)	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	(5)
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24. The posters would be understood by the students of your classroom	1	2	3	4	(5)
25. The posters would be an effective tool presented in a digital format	1	2	3	(4)	5
26. The posters would be an effective tool presented in a physical format	1	2	3	4	(5)
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	(5)

Name (Optional): JOE KASER

School (Optional): CROCKETT MS, Irving

Grade (Optional): 8TH GRADE GIFTED & TALENTED BIOLOGY

Course(s) taught (Optional):

GT BIOLOGY

Feel free to add your own extra comments:

(*) I AM ALREADY USING VIMEO DOWNLOADS IN MY CLASSROOM

(*) HISTONE MODEL ALSO WORK AS DEMO

- I STILL THINK "HANDS-ON" MANIPULATION OFTEN BEATS DIGITAL "VIRTUAL" EXPLORATIONS B/C KIDS REMEMBER HANDING MANIPULATIVES (KINESTHETIC LEARNING) WHICH AIDS RECALL

- DIGITAL CGI GRAPHIC REPRESENTATIONS ARE GREAT - BETTER THAN A TEXTBOOK LESSON, BUT W/ LIMITED KINESTHETIC LEARNING, I DON'T THINK STUDENT RECALL IS AS GOOD.

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

Please tell us whether you agree or disagree with the following statements about each session for the event and provide your comments
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	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	(5)
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	(5)
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	(5)
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					
Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
10. The card game is too complex to be understood by your students	1	2	3	4	(5)
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	(5)
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	(4)	5
13. I would use this card game in my classroom	1	2	3	(4)	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	(5)
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	(5)
Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24. The posters would be understood by the students of your classroom	1	2	3	4	(5)
25. The posters would be an effective tool presented in a digital format	1	2	3	4	(5)
26. The posters would be an effective tool presented in a physical format	1	2	3	4	(5)
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	(5)

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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
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2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	4	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	5

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	5
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19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
24. The posters would be understood by the students of your classroom	1	2	3	4	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	5
26. The posters would be an effective tool presented in a physical format	1	2	3	4	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

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3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
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13. I would use this card game in my classroom	1	2	3	4	5
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Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
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18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
24. The posters would be understood by the students of your classroom	1	2	3	4	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	5
26. The posters would be an effective tool presented in a physical format	1	2	3	4	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

Name (Optional): Donna Elwell

School (Optional): Community Middle School

Grade (Optional): 8

Course(s) taught (Optional): Science

Feel free to add your own extra comments:

Really enjoyed but I was really hoping to see something more applicable to my middle school classroom – my mistake – not yours. This was my first time here.

Also, thought your poster sequence was very good. My students would understand that – and be amazed.

Model also really good. To be used in middle school, my students would enjoy putting the nucleosome together piece by piece – (lots of excitement in finding out how the parts fit together)

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

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1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	(5)
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	(4)	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	(5)
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	(5)
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	(5)
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / (All)					
Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	(4)	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	5
Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	(5)
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	(5)
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	(5)
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	(5)
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	(5)
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	(5)
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	(5)
26. The posters would be an effective tool presented in a physical format	1	2	3	4	(5)
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	(4)	5

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Genetic Mutations Suitcase

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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	(3)	4	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	(4)	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	(3)	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	(3)	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / (Via Internet) / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	1	(2)	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	(4)	5
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14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	(4)	5
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Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	(3)	4	5
17. The model would be too complex to be understood by the students of your classroom	1	(2)	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	(4)	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	(4)	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	(3)	(4)	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	(3)	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	(4)	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	(4)	5
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
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27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	(4)	5

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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
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3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5

8. ~~In what format~~ would you prefer the animation be provided for use in your classroom?
Via DVD or CD / Via Internet / Preloaded to a computer / All

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
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13. I would use this card game in my classroom	1	2	3	4	5
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15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	5

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
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19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
24. The posters would be understood by the students of your classroom	1	2	3	4	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	5
26. The posters would be an effective tool presented in a physical format	1	2	3	4	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

Name (Optional):

School (Optional): South Hills HS

Grade (Optional): 9th

Course(s) taught (Optional): Physical Science, Biology

Feel free to add your own extra comments:

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	(1)	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	(1)	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	(5)
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	(5)
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	(5)
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / (All)					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
10. The card game is too complex to be understood by your students	(1)	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	(5)
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	(5)
13. I would use this card game in my classroom	1	2	3	4	(5)
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	(5)
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	(5)

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	(5)
17. The model would be too complex to be understood by the students of your classroom	(1)	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	(5)
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	(5)
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	(5)
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	(5)
22. To be effective the model should be designed to be handled by the students	1	2	(3)	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24. The posters would be understood by the students of your classroom	1	2	3	4	(5)
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26. The posters would be an effective tool presented in a physical format	1	2	3	4	(5)
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	(5)

Name (Optional): Krystal Bare

School (Optional): Center for Home Education, Watauga Co.

Grade (Optional): 9-12

Course(s) taught (Optional): Biology, Anatomy + Physiology, Marine Biology

Feel free to add your own extra comments:

I absolutely love this suitcase, and cannot wait until it is available to teachers. Wonderful job!

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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
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2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
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5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
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Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
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2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
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8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	4	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	5

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
24. The posters would be understood by the students of your classroom	1	2	3	4	5
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27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

Name (Optional): Damien Mohammad (Dhania Sulthan)

School (Optional): Rice MS.

Grade (Optional): 8th

Course(s) taught (Optional):

Feel free to add your own extra comments: IM A STUDENT.

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
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4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	(5)
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7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	(3)	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	1	(2)	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	(4)	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	(4)	5
13. I would use this card game in my classroom	1	2	3	(4)	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	(5)
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	(5)

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	(4)	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	(5)
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	(5)
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	(3)	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	(4)	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	(5)
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24. The posters would be understood by the students of your classroom	1	2	3	4	(5)
25. The posters would be an effective tool presented in a digital format	1	2	3	4	(5)
26. The posters would be an effective tool presented in a physical format	1	2	3	(4)	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	(5)

Name (Optional): Dan Boatwright

School (Optional): Canterbury Episcopal School

Grade (Optional): 9-12

Course(s) taught (Optional): Biology I, AP Biology

Feel free to add your own extra comments:

If all the histone octamers are exactly alike, how do they differently coil or uncoil specific sections of chromatin?

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

Please tell us whether you agree or disagree with the following statements about each session for the event and provide your comments
1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	(4)	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	(4)	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	(4)	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / (All)					
Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	1	(2)	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	(4)	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	(4)	5
13. I would use this card game in my classroom	1	2	(3)	4	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	(4)	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	(4)	5
Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	(4)	5
17. The model would be too complex to be understood by the students of your classroom	1	(2)	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	(4)	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	(4)	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	(4)	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	(4)	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	(4)	5
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
25. The posters would be an effective tool presented in a digital format	1	2	3	(4)	5
26. The posters would be an effective tool presented in a physical format	1	2	3	(4)	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	(4)	5

Name (Optional): Bill Martin

School (Optional): FCC NE Campus

Grade (Optional): College

Course(s) taught (Optional): microbiology

Feel free to add your own extra comments:

Excellent idea - Great Game.

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

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1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	(1)	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	(1)	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	(4)	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	(4)	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	(4)	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / (Via Internet) / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	(1)	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	(1)	2	3	(4)	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	(4)	5
13. I would use this card game in my classroom	1	2	3	(4)	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	(4)	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	(4)	5

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	(3)	4	5
17. The model would be too complex to be understood by the students of your classroom	(1)	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	(2)	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	(2)	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	(4)	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	(4)	5
22. To be effective the model should be designed to be handled by the students	1	2	3	(4)	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	(4)	5
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
25. The posters would be an effective tool presented in a digital format	1	2	3	(4)	5
26. The posters would be an effective tool presented in a physical format	1	2	(3)	4	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	(4)	5

Name (Optional):

School (Optional):

Grade (Optional):

Course(s) taught (Optional):

Feel free to add your own extra comments:

Animations and Card Game are fantastic!

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

Please tell us whether you agree or disagree with the following statements about each session for the event and provide your comments
1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	(4)	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	(4)	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	(4)	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	(3)	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	(4)	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / (All)					
Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	1	(2)	3	(4)	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	(3)	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	(2)	3	(4)	5
13. I would use this card game in my classroom	1	2	3	(4)	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	(4)	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	(4)	5
Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	(2)	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	(4)	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	(3)	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	(3)	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	(4)	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	(3)	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	(4)	5
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
25. The posters would be an effective tool presented in a digital format	1	2	3	(4)	5
26. The posters would be an effective tool presented in a physical format	1	2	3	(4)	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	(4)	5

Name (Optional):

School (Optional):

Grade (Optional):

Course(s) taught (Optional):

Feel free to add your own extra comments:

could the cards be made available w/o the suitcase? - for use as a free standing activity.

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

Please tell us whether you agree or disagree with the following statements about each session for the event and provide your comments
1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	(4)	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
10. The card game is too complex to be understood by your students	1	2	3	4	(5)
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	(5)
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	4	(5)
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	(5)
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	(5)

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	(5)
17. The model would be too complex to be understood by the students of your classroom	1	(2)	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	(5)
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	(5)
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24. The posters would be understood by the students of your classroom	1	2	3	4	(5)
25. The posters would be an effective tool presented in a digital format	1	2	3	4	(5)
26. The posters would be an effective tool presented in a physical format	1	2	3	4	(5)
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	(4)	5

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1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	4	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	5

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom Somewhat distracting	1	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
24. The posters would be understood by the students of your classroom	1	2	3	4	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	5
26. The posters would be an effective tool presented in a physical format	1	2	3	4	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

Name (Optional): Gina Roberts

School (Optional): NDHS

Grade (Optional): 9

Course(s) taught (Optional):
Biology

Feel free to add your own extra comments:

The model, while nice, would be too distracting for the majority of my students. Would the "coil" be included?

As far as the animation topics are concerned, we have yet to delve that deeply into the mechanics and structure of nucleosomes and histones in general biology, especially when the in-depth information is NOT included on any of the assessments, district or statewide.

The information is great, but may be too much for general classes. I am not sure, but believe it would be better utilized by the AP class.

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1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	(3)	4	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	(5)
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	(3)	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	(3)	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	(2)	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	(4)	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					
Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	1	2	(3)	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	(4)	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	(3)	4	5
13. I would use this card game in my classroom	1	2	(3)	4	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	(4)	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	(3)	4	5
Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	(3)	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	(3)	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	(4)	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	(4)	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	(3)	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	(4)	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	(5)
26. The posters would be an effective tool presented in a physical format	1	2	3	(4)	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	(5)

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Please tell us whether you agree or disagree with the following statements about each session for the event and provide your comments
1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	4	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	5

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
24. The posters would be understood by the students of your classroom	1	2	3	4	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	5
26. The posters would be an effective tool presented in a physical format	1	2	3	4	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

Name (Optional): Jackie

School (Optional): J. L. Long

Grade (Optional): 8th Grade

Course(s) taught (Optional): Earth Science

Feel free to add your own extra comments:

Great Job!

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

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	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	(4)	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	(3)	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	(3)	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	(4)	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	(4)	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / (Via Internet) / Preloaded to a computer / All					
Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	1	(2)	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	(4)	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	(3)	4	5
13. I would use this card game in my classroom	1	2	3	(4)	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	(4)	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	(4)	5
Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	(4)	5
17. The model would be too complex to be understood by the students of your classroom	1	(2)	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	(4)	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	(5)
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	(4)	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	(4)	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	(4)	5
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
25. The posters would be an effective tool presented in a digital format	1	2	(3)	4	5
26. The posters would be an effective tool presented in a physical format	1	2	3	(4)	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	(4)	5

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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	(5)
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	(4)	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	(5)

8. In what format would you prefer the animation be provided for use in your classroom?
Via DVD or CD / (Via Internet) / Preloaded to a computer / All

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
10. The card game is too complex to be understood by your students	1	(2)	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	(4)	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	(4)	5
13. I would use this card game in my classroom	1	2	3	(4)	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	(4)	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	(4)	5

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	(3)	4	5
17. The model would be too complex to be understood by the students of your classroom	1	(2)	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	(4)	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	(3)	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	(2)	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	(4)	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	(4)	5
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
25. The posters would be an effective tool presented in a digital format	1	2	(3)	4	5
26. The posters would be an effective tool presented in a physical format	1	2	3	(4)	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	(5)

Name (Optional): Kim Mosely

School (Optional): The Colony High School

Grade (Optional): 12

Course(s) taught (Optional): Bio AP

Feel free to add your own extra comments:

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

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	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5

8. In what format would you prefer the animation be provided for use in your classroom?
Via DVD or CD / Via Internet / Preloaded to a computer / All

I am confused!

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	4	5
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Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	5
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19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
24. The posters would be understood by the students of your classroom	1	2	3	4	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	5
26. The posters would be an effective tool presented in a physical format	1	2	3	4	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

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	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	(5)
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	(4)	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	(4)	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / (All)					
Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
10. The card game is too complex to be understood by your students	(1)	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	(5)
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	(5)
13. I would use this card game in my classroom	1	2	3	4	(5)
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	(5)
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	(5)
Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	(4)	5
17. The model would be too complex to be understood by the students of your classroom	1	(2)	3	4	5
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19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	(4)	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	(3)	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	(5)
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	(4)	5
24. The posters would be understood by the students of your classroom	1	2	3	(4)	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	(5)
26. The posters would be an effective tool presented in a physical format	1	2	3	4	(5)
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	(5)

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	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
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2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	5
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
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Section II: Mutations! Card Game (Please circle one answer to each question)					
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10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	4	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	5
Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
24. The posters would be understood by the students of your classroom	1	2	3	4	5
25. The posters would be an effective tool presented in a digital format	1	2	3	4	5
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27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

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	Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)					
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
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4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	4	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
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7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / All					
Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	5
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	5
13. I would use this card game in my classroom	1	2	3	4	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	5
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Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	5
17. The model would be too complex to be understood by the students of your classroom	1	2	3	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	5
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	5
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	5
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	5
22. To be effective the model should be designed to be handled by the students	1	2	3	4	5
Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	(4)	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	(4)	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	(3)	4	5
4. The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	(4)	5
5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6. The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	(5)
7. The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	(5)
8. In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / Via Internet / Preloaded to a computer / (All)					

Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
10. The card game is too complex to be understood by your students	1	2	(3)	4	5
11. The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	3	4	(5)
12. The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	(4)	5
13. I would use this card game in my classroom	1	2	3	(4)	5
14. Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	(4)	5
15. The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	(5)

Section III: Nucleosome Model (Please circle one answer to each question)					
16. The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	(4)	5
17. The model would be too complex to be understood by the students of your classroom	1	2	(3)	4	5
18. The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	(5)
19. The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	3	4	(5)
20. The model would be an effective teaching tool presented in a purely digital manner	1	2	3	4	(5)
21. The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	(5)
22. To be effective the model should be designed to be handled by the students	1	2	3	4	(5)

Section IV: Genetic Posters (Please circle one answer to each question)					
23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24. The posters would be understood by the students of your classroom	1	2	3	4	(5)
25. The posters would be an effective tool presented in a digital format	1	2	3	4	(5)
26. The posters would be an effective tool presented in a physical format	1	2	3	4	(5)
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	(5)

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

Presented by Richard Thomas Lankes / richard.lankes@utsouthwestern.edu

Please tell us whether you agree or disagree with the following statements about each session for the event and provide your comments
1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly Agree If not applicable, do not answer

		Strongly Disagree				Strongly Agree
Section I: Animation (Please circle one answer to each question)						
1.	The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
2.	The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	(3)	4	5
3.	The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	(2)	3	4	5
4.	The animation, with sections that are approximately 10 minutes each, would give you enough time to review, discuss and/or explain the information presented within	1	2	3	(4)	5
5.	The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	(5)
6.	The section dedicated to histones/nucleosomes clearly explains the concept of epigenetics	1	2	3	4	(5)
7.	The introduction section dedicated to genetic mutations clearly explains the basic concept of genetic mutations	1	2	3	4	5
8.	In what format would you prefer the animation be provided for use in your classroom? Via DVD or CD / (Via Internet) / Preloaded to a computer / All					
Section II: Mutations! Card Game (Please circle one answer to each question)						
9.	The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	(5)
10.	The card game is too complex to be understood by your students	1	(2)	3	4	5
11.	The card game section dedicated to building a DNA helix would be an effective tool for teaching and/or re-enforcing the concept of nucleotides, DNA orientation and DNA formation	1	2	(3)	4	5
12.	The card game section dedicated to inflicting mutations would be an effective tool for teaching basic genetic mutations and the changes they may cause	1	2	3	4	(5)
13.	I would use this card game in my classroom	1	2	3	(4)	5
14.	Dividing the card game into different sections of play allows for flexibility in deciding which concepts to teach	1	2	3	4	(5)
15.	The card game mechanics appear to follow the concepts of DNA formation and reflects the expected changes induced by genetic mutations	1	2	3	4	(5)
Section III: Nucleosome Model (Please circle one answer to each question)						
16.	The model would be an effective tool in teaching genetics and genetic mutations	1	2	3	4	(5)
17.	The model would be too complex to be understood by the students of your classroom	1	(2)	3	4	5
18.	The model has been presented in an artistic manner that would be interesting to your students	1	2	3	4	(5)
19.	The model, presented in the same manner in which it was presented to you today, could serve as an effective teaching tool for the subject of super-coiling and epigenetics	1	2	(3)	4	5
20.	The model would be an effective teaching tool presented in a purely digital manner	1	2	(3)	4	5
21.	The model's flexibility effectively allows for the teaching of nucleosome functions	1	2	3	4	(5)
22.	To be effective the model should be designed to be handled by the students	1	2	3	4	(5)
Section IV: Genetic Posters (Please circle one answer to each question)						
23.	The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	(5)
24.	The posters would be understood by the students of your classroom	1	2	3	(4)	5
25.	The posters would be an effective tool presented in a digital format	1	2	3	4	(5)
26.	The posters would be an effective tool presented in a physical format	1	2	3	4	(5)
27.	The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	(4)	5

STARS Teacher In-Service for April 4th, 2011
Genetic Mutations Suitcase

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Please tell us whether you agree or disagree with the following statements about each session for the event and provide your comments
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Section I: Animation (Please circle one answer to each question)	Strongly Disagree				Strongly Agree
1. The animation would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
2. The section of the animation dedicated to the concepts, functions and importance of histones/nucleosomes in genetic mutations would be too complex to be understood by your students	1	2	3	4	5
3. The section of the animation dedicated to genetic mutations would be too complex to be understood by your students	1	2	3	4	5
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5. The section dedicated to histones/nucleosomes clearly explains the concept of super-coiling	1	2	3	4	5
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Section II: Mutations! Card Game (Please circle one answer to each question)					
9. The card game would be an effective tool in the teaching of genetics and genetic mutations	1	2	3	4	5
10. The card game is too complex to be understood by your students	1	2	3	4	5
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23. The posters would be an effective tool in the teaching of size differences in genetics	1	2	3	4	5
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26. The posters would be an effective tool presented in a physical format	1	2	3	4	5
27. The posters have adequately conveyed the sense of the great size differential that exists between a single strand of DNA, the different stages of super-coiling, and the overall form of a chromosome	1	2	3	4	5

Name (Optional): Marcia Cross

School (Optional): L.V. Berkner High School

Grade (Optional): 10-12

Course(s) taught (Optional): Chemistry, Pathophysiology

Feel free to add your own extra comments:

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