ENZYME INSTIGATOR: A PORTABLE SUITCASE EXHIBIT FOR

NINTH GRADE BIOLOGY

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DEDICATION

I would first like to thank the members of my thesis committee. Lew Calver, thank you for hours spent looking at every piece of this project and for your constant inspiration to strive for perfection. Kim Krumwiede, thank you for always lending a listening ear and for keeping me on track during this long and often stressful process. Dr. Goodman, thank you for taking a chance on an unknown medical illustrator and giving me free rein to create my dreams.

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ENZYME INSTIGATOR: A PORTABLE SUITCASE EXHIBIT FOR NINTH GRADE BIOLOGY

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The goal of this project was to create a portable science suitcase exhibit that ninth grade biology teachers can utilize when teaching students the complex concepts of enzymes. I created a homework handout, animation, game, hands-on models, laboratory experiments and an easy to use instruction manual. This suitcase was created to bridge the gaps between required information for standardized testing and the details presented to them in current text books. The entire suitcase was evaluated by current ninth grade biology teachers for its ease and usefulness inside their classes. The suitcase's influence on students' interest, performance and retention will be tested by DISD, STARS, and APS once the suitcase has been incorporated into the curriculum.

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LIST OF DEFINITIONS

Biological reactant - a substance or compound consumed during a chemical reaction within the body.

Induced fit - describes a slight change in the active site of an enzyme once the substrate binds

Activation Energy - the amount of energy to activate the start of a reaction

Active Site - the specifically shaped spot on an enzyme where the substrates dock

Enzyme - a catalyst that helps a reaction between molecules/substrates begin

Optimal pH - the pH at which an enzyme will react the best

Optimal temperature - the temperature at which an enzyme will react the best

Product - the new molecules formed after a reaction

Reaction – the change in chemical bonds that occurs when molecules collide in space and form products

Specificity - referring to an enzyme’s active site; the site is shape specific

Substrates - a molecule that an enzyme reacts upon

CHAPTER ONE
Introduction

Goal

The goal of this project was to create a portable science module which included games, animations, hands-on models and laboratory experiments that ninth grade biology teachers can utilize in teaching students the complex concepts of enzymes. The components of this module are self contained within a single, large case. This is the first of seven science suitcases to be produced for the Science Teacher Access to Resources at Southwestern (STARS) Science Triathlon, a program developed in collaboration with the University of Texas Southwestern Medical Center Graduate School and Department of Biomedical Communications, the Dallas Interdependent School District (DISD), the Dallas Museum of Nature and Science and Advanced Placement Strategies (APS), and funded by a grant from the Howard Hughes Medical Institute. Additional support was given by the O'Donnell Foundation and the University of Texas Southwestern Graduate School.

Objectives

The first objective was to create quality visual aids that conveyed the dynamic structure of enzymes. The second objective was to create a 3-D animation along with 2-D characters that showed the dynamic process of enzymes and gave analogies to students' everyday lives. The third objective was to create a game that challenged students' knowledge and sparked a healthy competition between teams of students. The next objective was to create hands-on models of an enzyme and substrates to be used during a teacher demonstration that students could later touch and piece together. The final objective was to combine the concepts of enzymes that the students learned from the animation, game and models and implement them into experiments where the students could see enzymes at work.

Overall, I intended to create a portable science suitcase that biology teachers could easily utilize in order to enrich their science program for ninth grade biology students. This suitcase focuses on the areas of enzymes that students continue to misunderstand based on teacher interviews and tests scores. With this project, I intended not only to create teaching materials that DISD teachers can easily understand and follow, but also to create a very flexible suitcase with components that can effortlessly be incorporated into different teachers' curriculum, lesson plans and class time. This enzyme-based suitcase has the potential to aid in students' retention, excitement and general understanding of this information

Background

Triathlon

STARS designed a three part enrichment program called the *STARS Science Triathlon*. This project is composed of three parts which include workshops, symposia and research projects that DISD teachers can participate in during the regular school semesters and over the summer months. These outreach activities will include three events that will take place over 15 months; a 12-day summer workshop, a series of symposia and an 8-week research program during the following year. The Triathlon will be offered to 10 participating teachers each year and will cover core science topics that are mandated by the Texas Education Agency. These topics are listed in the Texas Essential Knowledge and Skills (TEKS) and include chemistry, biochemistry, enzymes, membranes, organelles, cell respiration and photosynthesis. The first Triathlon event will consist of workshops that will instruct the teachers about the core science topics and give them lessons on using laboratory activities that will be constructed based on the TEKS core science topics. During the school semester, the teachers will attend the second event, which consist of six symposia that will cover more detailed aspects of the core topics. The third event will include research conducted by the teachers based on their experiences with the laboratories. Each of the triathlon's events will give the teachers tools to enrich their current teaching materials for ninth grade biology students.

The laboratory activities that will be taught during the Triathlon will consist of fully functioning portable science modules that are called science suitcases. Two Biomedical Communications students were selected to design and develop the first two suitcases. These suitcases will be designed as portable exhibits covering one of the TEKS core science topics. They will contain animations, which have been proven to raise tests scores, along with games, models and experiments (Cradler 4). Teachers will have the ability to reserve the suitcases free of charge throughout the school year.

What the students are required to know

The Texas Education Agency has developed a list of science topics and concepts that students should understand. These concepts are published in the Texas Essential Knowledge and Skills (TEKS), and the Texas Education System requires students to take a standardized test called the Texas Assessment of Knowledge and Skills (TAKS) which covers the same concepts. Students are given the TAKS test during their tenth grade school year and the questions are based on the knowledge that they have acquired during the previous years. The TEKS requirement regarding enzymes for this age level is an understanding of “the effects of enzymes on food molecules.” Students should also understand the “ways in which matter interacts to create new substances” and how temperature can influence this interaction.

Student learning styles

Attention to student learning style is a strong factor in the development of successful learning materials. There are three main learning styles; visual, auditory, and kinesthetic. Regarding visual aids, visual learners focus on pictures and movement in videos; aditory learners like the narration from the video; and kinesthetic learners gain knowledge from role playing games and hands-on tools (Hassard, sec. 2.14:3).

Many studies support open-ended collaborative learning among students. In a study reported by the *High School Survey of Student Engagement* (HSSSE), 55% of students in an honors course said they learned a great deal from discussing questions with no clear answer (What We Can Learn 12). Students may also remember concepts better when engaged in the topics rather than passively receiving information from a lecture or text book (Using Multimedia, par. 2). When students construct science understanding from a combination of experience, interpretation and structured interactions with peers, they gain a higher comprehension (Using Multimedia, par. 2).

Significance

The learning materials available to ninth graders learning biology are often inadequate and ineffective. Most of the animated visual aids on enzymes that accompany current textbooks are flat 2-D animations. These flat animations lose many of the dynamic qualities of these three dimensional proteins (Biology, chap. 2). Hands-on models can be engaging and help students physically understand the dynamic structure of enzymes, yet most DISD teachers have little to no access to them (Ward's). Many of the experiments that students conduct in a typical biology course rarely relate to their daily lives, but research shows if they did, students would be more prepared to tackle these concepts in the real world (Using Multimedia, par. 1).

The intention of this science suitcase to provide teachers with a resource that could aide in students' retention, excitement, and understanding of biological processes presented to them in a typical ninth grade biology course. The case will be maintained and distributed by STARS. Teachers from around the district have the ability to utilize these suitcases in order to illustrate dynamic science concepts in a more effective manner than their current teaching materials allow them. This suitcase has the potential to give teachers resources that could not only help increase students' understanding of enzymes, but also possibly raise their test scores on core science topics, stimulate their interest in science, and motivate them to attain a higher level of knowledge.

Scope of the Project

The scope of this thesis was limited to level-appropriate learning materials for ninth graders. The materials incorporated into the suitcase could not exceed $3500 in cost. The materials also had to be easily replenished and the cost to maintain them for ten uses per year could not exceed $1000. The written material intended for students such as the homework handout and laboratory experiments had to be easily reproducible on a plain black and white copy machine. The animation had to be formatted to run on a PC or Macintosh computer along with any DVD player. The game had to be flexible enough to fit within the suitcase and sturdy enough to last the wear and tear of three years of usage. The hands-on models had to be light enough not to heavily weigh down the suitcase but tough enough to withstand rough handling by students. The experiments had to have easily maintainable materials that were accessible to all teachers. They also had to contain procedures that only used sinks, electrical outlets and a minimal amount of other materials. This would allow the labs to be readily used in all DISD schools. Lastly, all materials within the suitcase had to resist breaking even if the suitcase were dropped or shaken, dowsed with water or other liquids or exposed to extreme hot or cold temperature during transport and storage.

Evaluations

The entire suitcase was demonstrated to seven ninth grade biology teachers from the Dallas community. These teachers were attending the first summer workshop of the STARS Triathlon at the University of Texas Southwestern Medical Center where they were learning laboratory experiments and activities to enrich their classroom. They then participated in an informal evaluation of this suitcase which included twenty-eight questions.

The suitcase's influence on students' interest, performance and retention will be tested by DISD, STARS, and APS once the suitcase has been incorporated into the curriculum.

CHAPTER TWO
Review of the Literature

Diverse areas were investigated before I could develop the materials for this suitcase. Some of these areas included the required concepts from TEKS, written material currently available on enzymes, current media on this topic, literature on designing media for this topic, designing games and developing lab experiments. Each of these areas was then further researched to determine the most successful approach to these topics.

Research has shown that the Dallas Independent School District needs help teaching its students about the complex concepts of enzymes. Dallas students' 2006 tests scores showed that only 30% to 56% of students met minimum state standards of knowledge (Goodman 20). The current material suffers many problems and is not a sufficient learning tool for ninth grade biology students. The literature review showed that material was needed to aid students' knowledge on this difficult biology topic.

Relevant Literature

Some of the reasons for students' low understanding and therefore low test scores regarding enzymes may stem from the current learning materials for this dynamic topic. The animations, models, handouts, and experiments aiding the students understanding of enzymes often contain numerous deficiencies.

Most of the animated visual aids that accompany material on enzymes in textbooks are flat 2-D animations. These flat animations lose many of the dynamic qualities of these three dimensional proteins (Biology, chap. 2). "Because they are flat, important spatial relationships of the process are not captured" (McClean 170). Also, since these animations are often created by teachers who have not had professional art training and are not reviewed or edited by experts in the proper field, they may contain factual errors. The animations are also rendered in a low quality which can be viewed on small computer monitors but when enlarged to view on a projector screen for the entire class, they are often blurry and jumpy (McCromick).

Many teachers have also reported that hands-on enzyme models are very difficult to find. In a search of available catalogs, few to no enzyme models were found (Ward's). Models can be engaging and help students fully understand the dynamic structure of enzymes.

The use of color is much more helpful for understanding than plain black and white (Savrock). Even though this is true, most teachers only have access to black and white copy machines for mass reproduction. These copy machines lose the help of vivid color images and often distort fine detail when translated to black and white.

The experiments that many students are required to conduct in a typical biology course rarely relate to their daily lives. Students that experience applying real world inquiry and reasoning will have a better grasp when faced with these questions as adults (Using Multimedia, par. 1). The *Journal of Research in Science Teaching* has also supported student associated experiments stating that active learning based laboratories teach students better than traditional book learning (Klahr 183).

Similar Materials

In the previous section it has been shown that ninth grade biology students of DISD struggle with the complex concepts of enzymes because of the low quality and quantity of visual aids regarding this topic. The next section will discuss research found on different teaching materials.

1. Homework/pamphlet for students to take home the night before.

New concepts are very difficult for students to grasp the first time the material is presented. The more terms and concepts that a student is presented with prior to in class visual aids, the better retention and understanding with which the student will depart (Savrock).

2. <u>3-D Animation showing the five aspects of enzymes that are difficult for students to understand.</u>

Numerous studies have shown that animations help raise students test scores. In a study that used animations to teach cell biology to students at the University of Colorado at Denver, one class was split in half. Half the class was shown a two minute animation while the other half stayed in the hall. The students who viewed the animation scored 10% higher on the quiz that followed the course (Stith 186). Students that view instructional video, have higher interest, understanding and will to learn than students that only view text and static pictures in a text book (Cradler 3).

The way students learn scientific concepts is also affected by the way an animation is produced. In another study about animations in cell biology, junior level students at the University of Toronto learned more when text was next to the action on the screen (O'Day, 2007 sec. "Introduction"). Students that viewed animations that consisted of short 8-10 second segments followed by a question were more engaged in the process than students that viewed long animations with no stops (Cradler 4). Animations with a conversational style of narration are the best way for students to learn scientific material (O'Day "Animated", 255). Studies have shown that animations with text and narration cover both the auditory learner and the visual learner (Hassard, sec. 2.14). Two dimensional animations lose some of the spatial relationships of three dimensional dynamic processes (Using Multimedia, par. 10).

Many artists decide to use a very simple style to animate enzymes. This style often resembles puzzle pieces and basic shapes. The 3-D shape of the enzyme and substrate are lost by this type of illustration.

Scientific objects that are animated with too much realism are more difficult for students to understand than simplified versions of the same object (Savrock). In figure 2-2, one can see the abundant amount of information projected onto the student. Again, this type of illustration can be confusing and without sufficient explanation.

Fig 2-2. Scan from the textbook Biology 7th Ed, pg 81, by Neil Campbell and Jane Reese, Copyright 2005. Reprinted by permission of Pearson Education, Inc.

Also, animations that have very fast movement and narration can overwhelm a student and deter them from learning the material (O'Day "Animated" 256). Overall, animations containing 3-D images and text on the screen to accompany the narration seem to be most effective.

3. Competitive game that will split the class into their lab groups.

Games are a proven motivator. One teacher surveyed her class about their opinions of games. Of the students, 90% mentioned games as a motivator to learn, 80% wrote the word "fun" when describing games as a way of learning and 30-50% mentioned that games made them feel more comfortable with their peers. The same teacher also noticed a significant improvement in students' self esteem during tests and social skills with other students when games were utilized in the classroom (Nemerow 362-364). It has also been found that stimulating games are better for students' retention of knowledge than traditional book work (Spraggins 220).

4. Hands-on models for the teachers to use as a demonstration and for the students to handle for extra visual understanding.

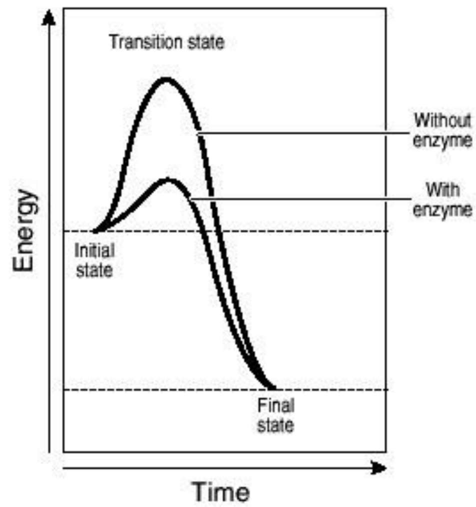
While looking through a *Ward's* science catalogue, I found few to no hands-on models for students to play with and view (Ward's). Models not only further drive home the three dimensional concept of enzymes but they are an integral part of the kinesthetic learning style. Any student can benefit from models, especially the kinesthetic learners.

5. Laboratories (gelatin and fruit juice; milk and rennin)

Students learn best by hands on experiences, especially in science classes (Using Multimedia, par. 2). One study showed when teachers switched from traditional book work to experimental labs, students test scores rose (Taraban 960). The Biological Sciences Curriculum Study (BSCS) suggests that a successful teaching style for science is letting students explore a concept. Collaboration [from lab teams] allows students to learn from different viewpoints (Using Multimedia, par. 39). Many studies have shown that a collaborative environment is more successful for students than environments with competition of individual approaches (Okebukola 882). This exploration and collaborative atmosphere can be achieved through the use of science labs and experiments.

6. Quiz

A quiz was constructed by formulating questions that tested the areas of enzymes that teachers found lacking. I followed the style of the TAKS tests established by the Texas Education Agency and wrote the quiz with multiple choice questions (2000, question 19). I used sample TAKS questions regarding enzymes to plan my quiz.



19 According to this graph, during a chemical reaction enzymes --

- **A** decrease the required time
- **B** raise the energy produced
- **C** lower the required activation energy
- **D** increase the initial-state energy

Fig 2-3. Screen grab from TAKS sample question website http://www.tea.state.tx.us/student.assessment/resources/online/eoc00/biology.html

Conclusion

Texas requires its ninth grade students to fully understand enzymes, yet currently, there are few quality visual aids constructed to assist ninth graders' understanding. The resources given to students are poorly illustrated or overly complex. They do not cover all of the learning styles that students possess and they do not give ninth graders a complete and easy understanding of the dynamic concepts of enzymes.

CHAPTER THREE
Methodology

Planning the Project

Purpose of the Project

In order to begin the entire project, objectives and limitations had to be established. As mentioned previously, the purpose of this project was to provide ninth grade biology teachers with innovative teaching tools regarding the complex concepts of enzymes, filling the gaps left by current materials on this topic. The suitcase had to be flexible enough to fit into a variety of curriculums and easily transportable. The entire project could not exceed costs of $3500.00 and needed to be replenished yearly for under $1000.00. With these limits and objective established, the project could begin.

Initial Grant Meetings

Before beginning the design of the materials for this science suitcase, many meetings were conducted to understand the background of the grant that funded this project.

The first meeting involved a representative from each component of the grant: O'Donnell Foundation, Dallas Museum of Nature and Science, UTSW Graduate School, UTSW Biomedical Communications Department, AP Strategies, STARS and Texas Instruments. This meeting gave the attendees a brief overview of the entire grant and gave each the opportunity to discuss their intended contribution. From this, meetings were scheduled with all contributing parties to discuss further resources for the development of this suitcase.

Pre-Project Survey

A pre-project survey was produced in order to gain insightful information about the classroom environment and hear teacher's opinions about the instructional materials that they currently utilize. The biology topics chosen for the first two suitcases were combined into one survey in order to keep teachers' time to a minimum. The survey was emailed to over a hundred teachers in the surrounding Dallas area in the hopes that we would hear back from as many as possible. The questions on this survey included:

1. What resources do you have available from the school? (ie. computers for each student? computers that can feed into overhead projectors? lab desks with sinks?)
2. Do you teach either of these topics; enzymes and/or organelles?
3. If so, could you give us a brief description of the lessons for each topic? (ie. we let the students do a science experiment called "x", then they watch a movie called "x", then they can research on www.website, and then they are quizzed on chapter 3-4 from the text "x")
4. Do you notice any specific areas of these topics that students really have a hard time grasping?
5. What ways could you see ninth grade students getting engaged in these topics? (i.e. 3D models, interactive "games", physical activity, etc.)
6. Do you have any wishes or ideas for teaching these topics? (i.e. resources to

teach them that the schools do not offer teachers)

7. Are you willing and/or able to talk further about these topics in the future? Maybe even in person?

Five teachers responded to the survey (see Appendix A). The results from these surveys were very helpful when designing this suitcase. In regards to question number one, many teachers indicated that they had access to computer labs with enough computers for each student, over-head projectors, televisions with DVD players and full labs with sinks. Many teachers explained that their syllabus on enzymes included laboratory experiments, Powerpoint presentations, guided discussions and question-and-answer sessions. One of the most important questions that the survey addressed was weakness in the students' knowledge about enzymes. The following items were expressed by the majority of teachers as difficult areas for students:

1. Specificity
2. Enzymes vs. Substrates
3. Optimal Temperature
4. Optimal pH
5. Overall conclusion and understanding of experiments

When asked about engaging students, most of the teachers agreed that 3D models, interactive games and physical activity would suffice. Next, we requested a wish list from teachers regarding classroom resources. Many of the teachers requested more lab experiments and hands-on models of enzymes. The final question on the survey was intended to find teachers that would be willing to show us their classrooms, resources and teacher materials. One teacher extended an invitation.

Interviews

An interview was then conducted with Ms. April Chancellor, a ninth grade biology teacher at Lincoln High School, along with Niteka Harwell, a DISD administrator contact. They indicated that the suitcase must easily fit into the current curriculum or replace a component because teachers are not given extensive flexibility with their syllabuses. The syllabuses used in DISD classrooms are copyrighted by DISD and special permission must be granted to see these items. Many attempts were made to view a current syllabus but none were successful. The textbook that DISD recommends for ninth grade biology is *Holt Biology*. The common time frame for a class period is 55 minutes. They also indicated that from their experiences, students enjoy hands on materials and games. This meeting gave insightful information into an actual DISD classroom.

Another interview was scheduled with René McCormick. At the time of the interview, she was working for AP Strategies and helped write the book *Laying the Foundation*. This book was created to supplement a regular biology teacher's syllabus in order to prepare students for advance placement biology courses. The book provides teachers with lab experiments, classroom activities and recommended syllabi from the most successful teachers in Texas. The teachers' success rate was determined based on their students' standardized test scores. Ms. McCormick stated that *Prentice Hall Biology* and *Campbell Reece Biology* are textbooks that are often supplemented into many ninth grade biology classrooms. These texts provided addition references for current teaching materials on enzymes.

The final interview took place at the Dallas Museum of Nature and Science with Paul Vinson. He is currently the director of exhibits and theater services at the museum. His interview included a tour of the museum's workshop where all of the exhibits are constructed. Available resources for constructing the suitcase's components included large format printers, a workshop and materials such as silicone, plastic and vinyl.

The museum has previously constructed similar science suitcases for elementary level classes. We were able to search through these plastic suitcases and ask many questions. They were filled with a variety of games that had instructions attached to each component. The components were contained in large plastic bins with wheels and were stored on the lower level of the museum on a large shelving unit. Teachers are currently able to rent a suitcase for a $50.00 fee which includes drop-off and pick-up.

Designing the Module

Organization

In order to minimize confusion, I decided to fit all of the suitcase's components within a single case. The suitcase could be no larger than a standard sedan back door. The weight of the suitcase could also not exceed a manageable weight of eighty pounds. As I designed the components for this suitcase as described below, I often retreated back to this organization and revised decisions to work within these parameters.

Content Outline

A final list of components was then established. This list served as a guide when forming each component especially because many components were produced simultaneously and all of the components were constructed outside of their chronological order. The components included:

1. Homework Handout
2. Animation
3. Game
4. Hands-on Models
5. Laboratory Experiments
6. Pre and Post Quizzes
7. Instruction Manual

Creating the Suitcase Components

Advisory Committee

Before beginning this project, I gathered an advisory committee that would review materials for this suitcase. Each member brought expertise from different relevant areas. Lewis Calver, Chairman of the Biomedical Communications Graduate Program at UT Southwestern, and Kimberly Krumwiede, Associate Professor in the same program, are very familiar with focusing materials for specific audiences, 3D animations, artistic design and instructional writing. My content expert on enzymes was Dr. Joel Goodman, Ph.D, Professor of Pharmacology at the University of Texas Southwestern, Director of STARS and the grant director. He oversaw the development of the suitcase and reviewed all materials for scientific accuracy.

There were many people from the Dallas Museum of Nature and Science that helped with the development of this project. Steve Hinkley, the Director of Education at the museum was previously a high school biology teacher for ten years and gave personal knowledge on teaching materials for this age group. Paul Vinson, the Director of Exhibits and Theater Services currently contributes to the design and construction of all of the museum's exhibits. Paul, along with many others from the museum staff, have successfully created similar suitcases for elementary level students and had the workshop and tools for creating hands-on models.

In order to create the laboratory experiments, I worked with Kimberly Wilson who is a University of Texas Southwestern graduate student in the biochemistry department. She has experience writing lab write-ups and is currently studying in the area of enzymes. She helped develop lab experiments that related to ninth graders' daily lives.

Animation

The first step in creating this animation was to establish key objectives. After reviewing required concepts and teachers' survey responses, I devised a list of concepts that I would cover:

1. Substrates vs. enzymes
2. Catalysts
3. Reactions
4. Products
5. Biological reactions and reactants
6. Activation energy
7. Overall reaction conclusions
8. Active site
9. Specificity
10. Induced fit
11. Optimal temperature
12. Optimal pH

Before developing a script, I had to design two cartoon analogies. The objectives with these analogies were to portray a catalyst and optimal temperature and pH. Another objective was to include the same characters throughout both analogies. Some of the original analogy ideas included a gas station and a fire pit. The final analogies included a car as a catalyst, basketball players as the substrates, a basketball team as the product and the weather as the optimal temperature.

The next step was to write a script. Many drafts were written and revised before a final script was produced. Each revision was emailed to Dr. Goodman for scientific accuracy, Steve Hinkley for classroom relevance and Kimberly Krumwiede and Lewis Calver for age appropriateness and artistic flow. The final script included questions for classroom discussion and cartoon analogies to help the difficult concepts leave a lasting visual impression. After discussing the DVD layout, it was agreed that the questions would span ten seconds and a reminder to pause the DVD would be included in the final version to help teachers lead the class discussion. Below is a copy of the final script (Figure 3-1).

Animation Script

When molecules are freely moving in space, they often hit each other. If this collision causes the molecules to break apart or pull together to form something else, it is called a reaction. The original molecules are called substrates and the new ones formed are called products. Reactions in nature can be extremely slow and take years or even centuries! However, many reactions can happen faster if something is added to speed them up. This something is called a catalyst. A catalyst acts as an assistant to speed along a reaction. Think of you and your friends as substrates, a basketball team, which you want to form, is the product of the reaction and a car is a catalyst. You could each walk to the basketball courts but it might… take… forever. But if you all carpool you would get there and form your team in a fraction of the time.

Question: You and your friend place a pile of logs in the middle of a field and wait for lightning to ignite the wood. Your friend gets tired of waiting and pulls a match from his pocket, setting the pile ablaze. Name the substrates, catalyst and product.

Catalysts can also be found within your body. Many of these catalysts are called enzymes. Enzymes are complex proteins that help your body function properly. They help speed up normal body reactions that would happen very slowly on their own. Reactions within the body are also called biological reactions and the molecules that form these reactions are called biological reactants. Some examples of biological reactions are digestion and blood clotting. Digestion uses enzymes to break down the food you eat into nutrients for your body. When you have a cut, your body uses enzymes to form a clot so that you won't continue to loose blood.

Question: What would happen to you if these basic body reactions did not have the help of enzymes?

Most reactions require energy to occur. This energy is called activation energy; the amount of energy to activate the start of a reaction. Enzymes help lower the required activation energy by basically adding some of their own energy to the mix. The substrates don't need as much of their own energy because the enzyme is giving up some of its energy. This graph will show you a comparison of a regular reaction and an enzyme aided reaction. The y axis of the graph will show you the activation energy. The x axis of the graph will show you time. A regular reaction will require a lot of energy and take a long time. An enzyme aided reaction will require much less energy and take much less time. Without enzymes lowering the activation energy, simple human reactions might take minutes, hours, or even days.

Question: What is another name for a biological reactant?

Figure 3-1. Animation Script.

Now you understand why we need enzymes, but how do these catalysts actually work?
An enzyme has a special place on its surface for the substrate to make contact. This spot is called the active site. Think of an enzyme's active site as a keyhole on a lock and a substrate as a key. Only one key will fit into the keyhole. The active site has a very specific shape and will only allow certain substrates to dock. If the substrates are the right shape, they will dock at the enzymes active site and that is where the reaction occurs. If the substrates are not the right shape, they will not fit into the active site and must move on to find another enzyme. Because of this characteristic, scientists refer to enzymes as having specificity. This refers to their specific active site.

Question: Can any enzyme bind with any substrate? Why or why not?

Substrates, like all molecules, consist of atoms that are made of protons and neutrons with circulating electrons and are held together with chemical bonds. For a reaction to occur, the substrates must have enough energy to break apart these strong existing bonds. Enzymes give substrates enough energy to break apart these bonds. Remember, enzymes lower the activation energy for a reaction to happen by adding some of their own energy.

Question: What determines if a reaction will occur?

Let's look more closely at what happens to an enzyme during a reaction. After the substrates dock on the enzyme's active site, the shape of the site changes very slightly in order to fit tighter around the substrate: this is known as induced fit. After the reaction is over, the enzyme returns to its original shape and moves on to carry out the same reaction with other identical substrates. The induced fit is so small though that it is unnoticeable when looking at the entire reaction. The enzyme remains unchanged after the reaction is over, unlike the substrates whose bonds were broken to form other products. With the help of the enzyme, the same reaction can happen more frequently and more rapidly.

Question: Why is induced fit helpful for the reaction?

Enzymes are very fragile within their environment. Small changes in the temperature or acidity of the fluid surrounding an enzyme can change the structure of the enzyme.
Every enzyme has an optimal temperature and pH for which it will react the best. If taken outside its optimal temperature or pH, the enzyme can lose its shape, a process

Figure 3-1. Animation Script.

referred to as denaturation. When this happens, the shape of the specific activation site can be totally changed. If the shape is different, then the substrates that normally used that enzyme will not fit into the enzymes active site and therefore, the enzyme's original function is altered.

Question: How do you think an enzyme found in the human body would perform at 37° C?

Remember the car analogy; the players are the substrates, forming a basketball team is the final product and the car is the enzyme. A car has an optimal temperature range that it will move the best. If it is really cold, the car will not start and if it is really hot, the engine might over heat; either way, your car can't work very well. If the temperature were a normal day, the car could help you and your friends form a team a lot faster. The same goes for enzymes. They need to be within a certain temperature and pH to work the best.
Question: What kind of problem would happen if many digestive enzymes became denatured?

So, when talking about enzymes remember:

1. Biological substrates need catalysts, known as enzymes, to lower their activation energy to take part in a reaction.

2. Each enzyme has a very specific activation site where the substrates bind.

3. Denaturing can occur when enzymes are taken out of their optimal temperature and pH, rendering the enzyme catalyst ineffective.

This work was funded by a grant to the University of Texas Southwestern Medical Center at Dallas from the Howard Hughes Medical Foundation to support pre-college science education. A large thank you to the Dallas Museum of Nature and Science, the UT Southwestern Biomedical Communication Graduate Program and the STARS program at Southwestern.

Figre 3-1. Animation Script.

Next came story boarding. Before constructing a fully rendered story board, I produced a preliminary storyboard with minimal small sketches to be approved by my department faculty. This preliminary storyboard marked key points and gave me the opportunity to review some animation techniques that I had not previously worked with (Figure 3-2).

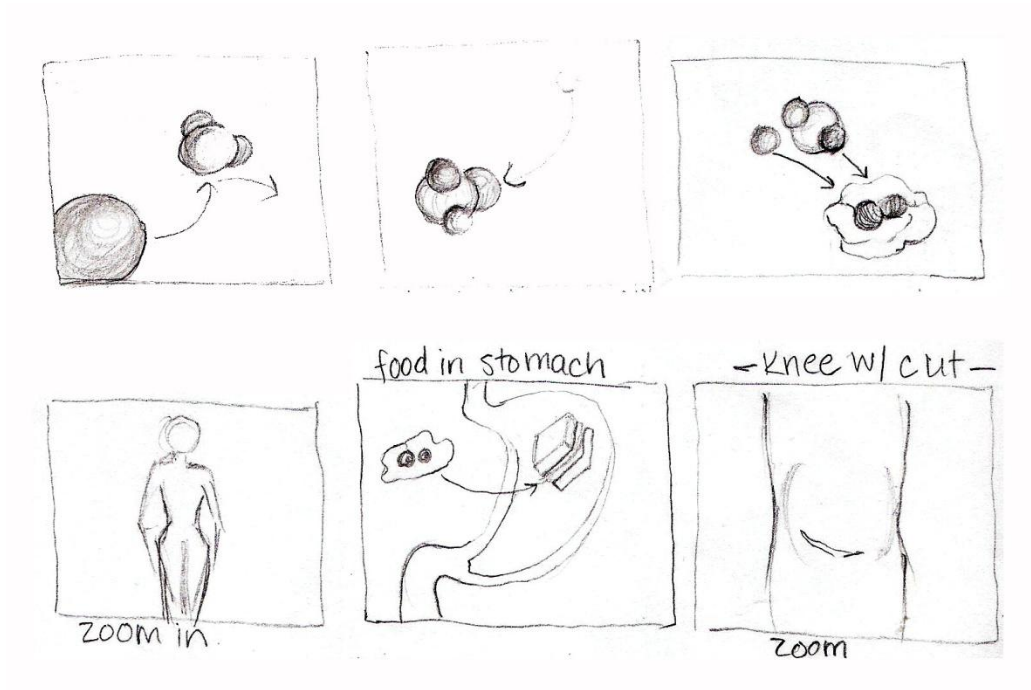


Figure 3-2. Select frames from preliminary storyboard.

I then produced a series of storyboards that showed the full progression of the animation (Appendix B). The entire story board was approved for scientific accuracy by Dr. Goodman and artistic flow by Kim Krumwiede and Lewis Calver.

I chose a cartoon style that was modern and appropriate for middle and high school students and avoided styles for younger age groups and adults. The characters were drawn as having slightly ambiguous ethnicities from multiple backgrounds. Finally, I chose to form a team of both males and females. Since the team was formed by friends and not a school or league, it did not require a single sex. The intention was that both male and female students could relate to the characters.

The final characters were drawn out on heavy white Bristol board using a fine permanent marker for the entire piece. I then retraced the outside of each character with a thicker permanent marker to give added visual appeal and interest (Figure 3-3).

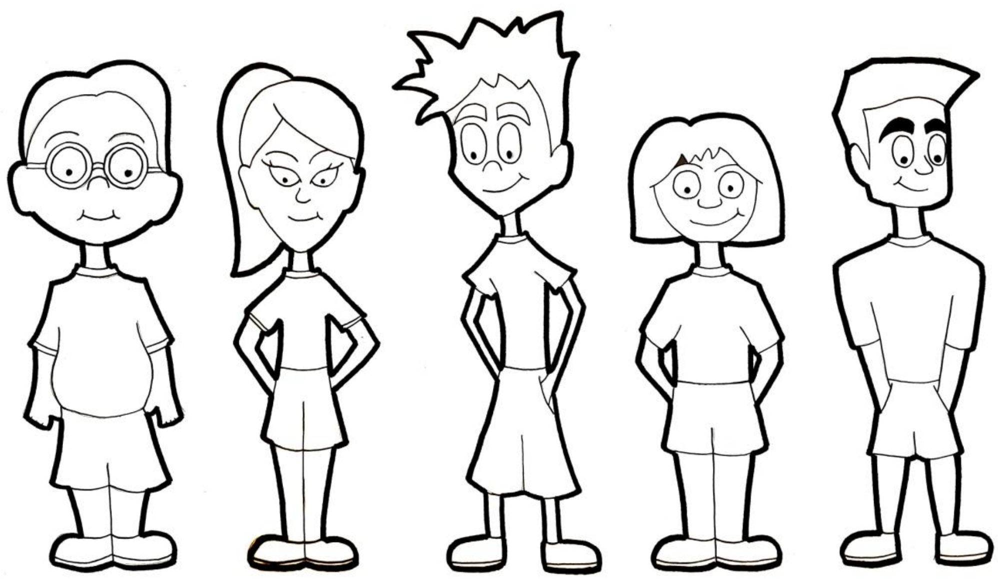


Figure 3-3. Cartoon Characters.

The final characters were then scanned into the computer and color was added using Adobe Photoshop ®. Small amounts of shadows and highlights were added for even more visual appeal. Two sets of clothing were painted onto each character. The first set were casual clothes used in the beginning of the *Forming a Basketball Team* analogy and the second set were uniformly green to resemble players' team jerseys used in the remaining analogies.

Based on my storyboards, I needed two sets of drawings for each character. The first set was for the walking sequence in the first analogy *Forming a Basketball Team*. For this scene, each character needed a profile drawing with a detached arm and leg. This provided the separate pieces needed to animate the characters to look like they were walking (Figure 3-4).

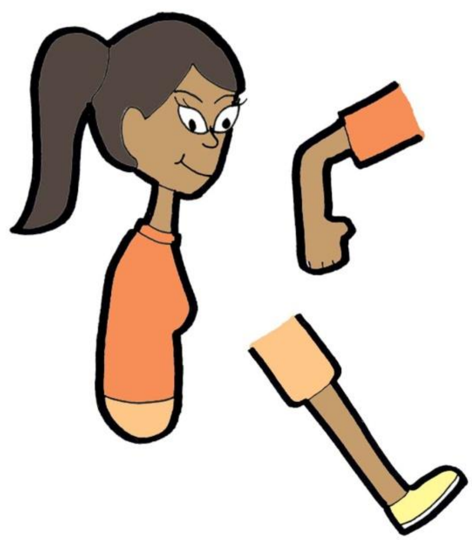


Figure 3-4. Walking character's pieces.

I then imported these character pieces into Adobe After Effects ® and animated their movements using key frames. Each character was animated with right arm forward/ left leg back, arms and legs at center and right arm back/left leg forward. When sandwiched together, these movements produced a seamless walking motion (Figure 3-5).

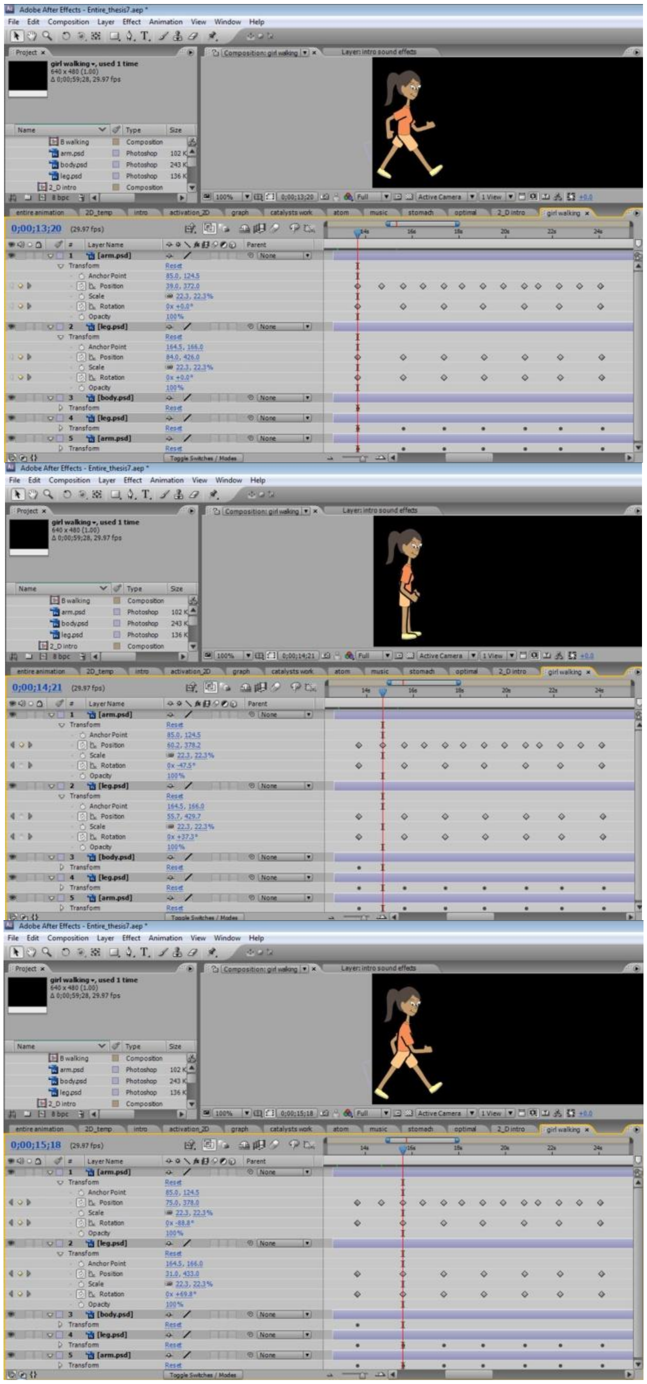


Figure 3-5. Walking sequence in After Effects®.

The next set of drawings was straight-on views of each character. These were used in *Forming a Basketball Team* along with the *Optimal Temperature* analogy. They required no special rendering and were therefore drawn in one piece. These characters where then imported into After Affects ® and animated with simple fades and position key frames.

My next step was to design the 3D model of my enzymes. I researched scientifically accurate depictions of enzymes before developing my model. The main inspiration for the basic shape was from surface models of proteins.

I chose to design a single enzyme base model and then change the shape of the active site and the color for each scene. This would minimize confusion for students trying to identify the enzymes.

I started off by forming a basic enzyme shape using blob mesh in Studio 3D Max®. I then turned the mesh into a polygon and booleaned a basic active site from the top of the enzyme (Figure 3-6).

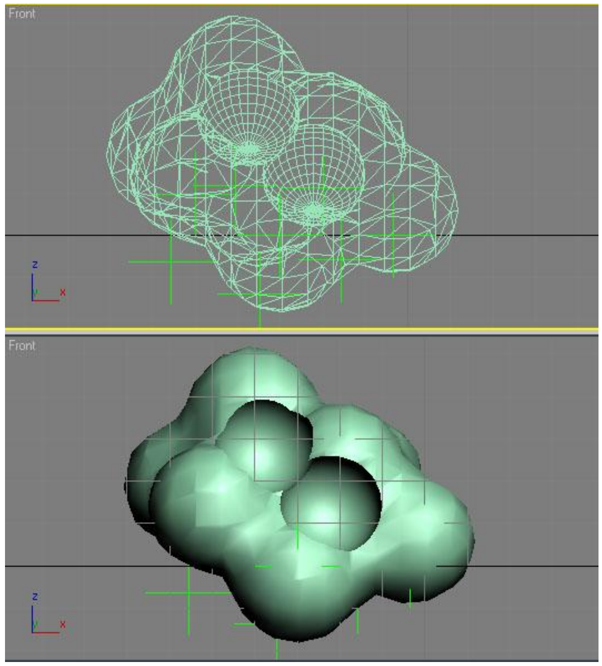


Figure 3-6. Enzyme’s Basic Shape.

Next, I produced a particle cloud with metaparticles and chose the enzyme as the *Object Based Emitter*. After adjusting the size and amount of particles, this left a bumpy texture that slightly resembled a surface filling model. I would then snap shot a mesh copy of the particle system in order to create a model with fewer vertexes that could be easily manipulated (Figure 3-7).

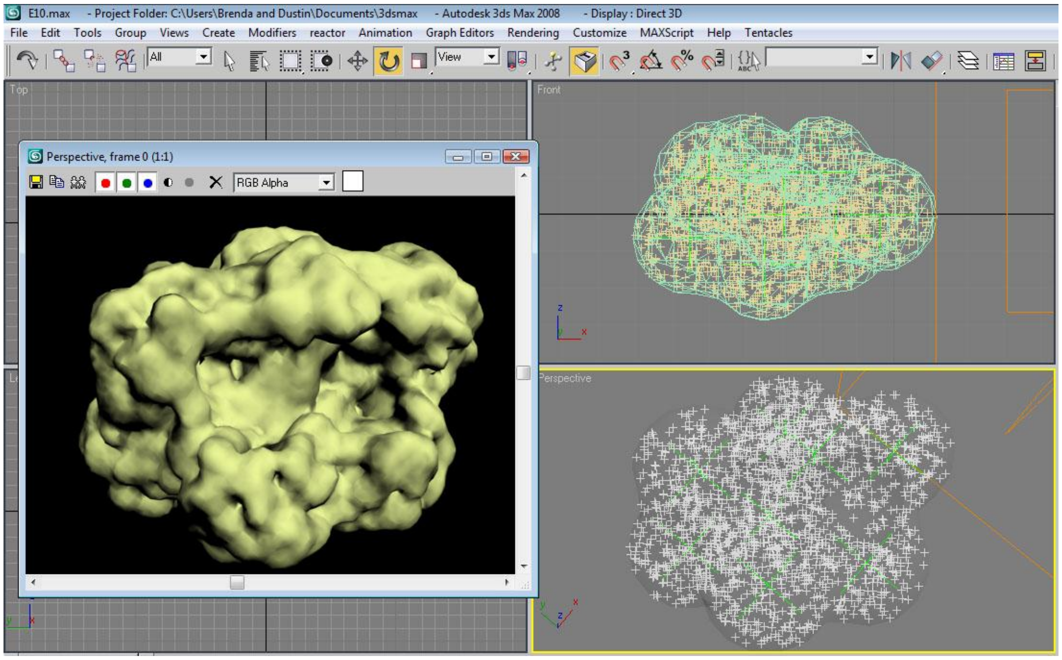


Figure 3-7. Enzymes's Basic Texture.

I took this enzyme model into Z-Brush and that is where I distinguished each scene's individual active site. I strayed from a standard surface model in this area because I felt that the active site of a standard protein was not obvious enough for an inexperienced viewer. I used brush tools set to *subtract* in order to shape a smoother more obvious active site (Figure 3-8).

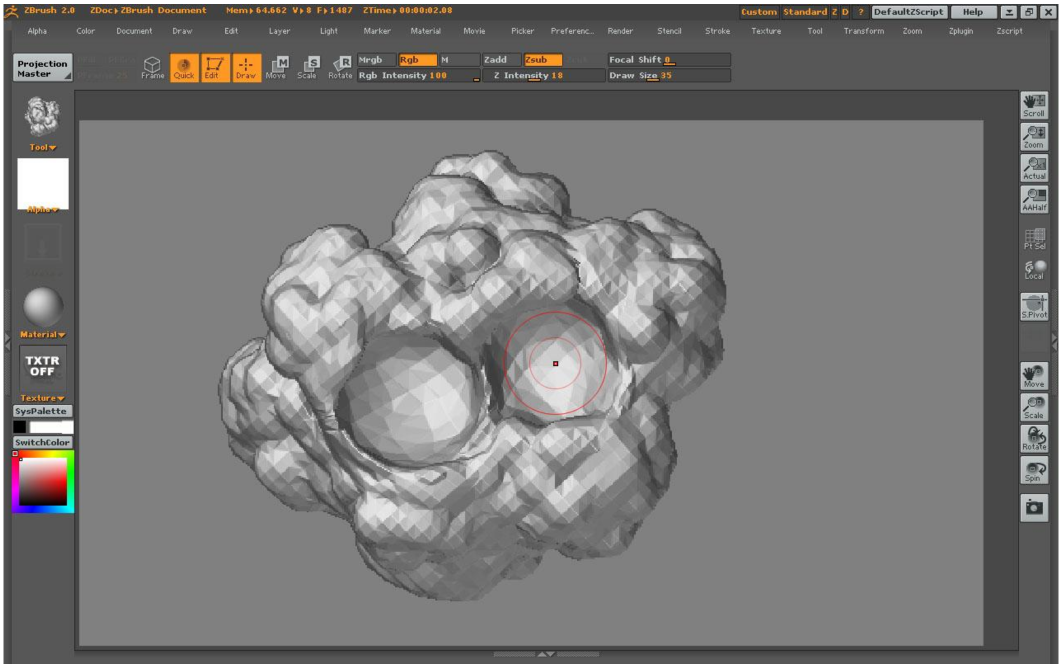


Figure 3-8. Enzyme's Unique Active Site in Z-Brush.

As mentioned previously, this step was done to the active site of each scene's enzyme in order to create a unique enzyme for each part while still minimizing confusion among students. The unique enzyme was then imported back into the scene, turbo smoothed and a cellular bump map was added.

The next models produced were substrates. Initially, I tried rendering the substrates using blob mesh but this feature did not allow the substrates to separate after a reaction. I then produced the substrates using simple spheres that overlapped each other at chemical bond sites (Figure 3-9).

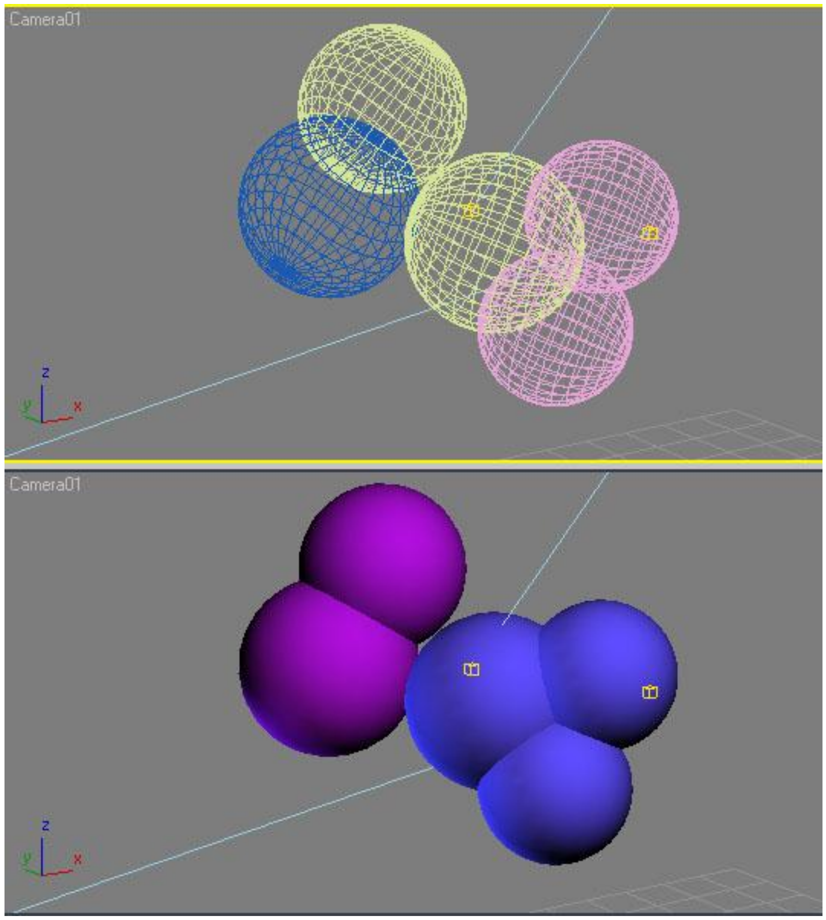


Figure 3-9. Simple Substrate.

In order to animate the reaction, each substrate contained spheres for before and after the reaction. The spheres needed prior to the reaction were given a full opacity material with cellular bump maps. The spheres needed after the reaction were given a zero percent opacity of the same material. All of the spheres were grouped after the materials and opacity were added in order to create smooth movement during the animation. The reaction was shown by animating the material's opacity. For example, one substrate would contain 3 spheres before the reaction. Once the reaction occurred, the material on one sphere of this substrate would be changed to zero percent opacity in order to make it appear that the substrate had lost one of its spheres. This gave the illusion that one sphere had been given to the other substrate involved in the reaction.

The final production piece of the animation was individual scene backgrounds. I started by creating a template background that contained three to four colors selected from my color palate. These colors were painted onto a black background in Photoshop using an *oil medium wet flow* brush and a *soft round brush*. The color was concentrated in the lower half of the template and gradually faded off towards the top. Finally, dim white highlights were added to the piece at sporadic locations to add some visual dimension (Figure 3-10).

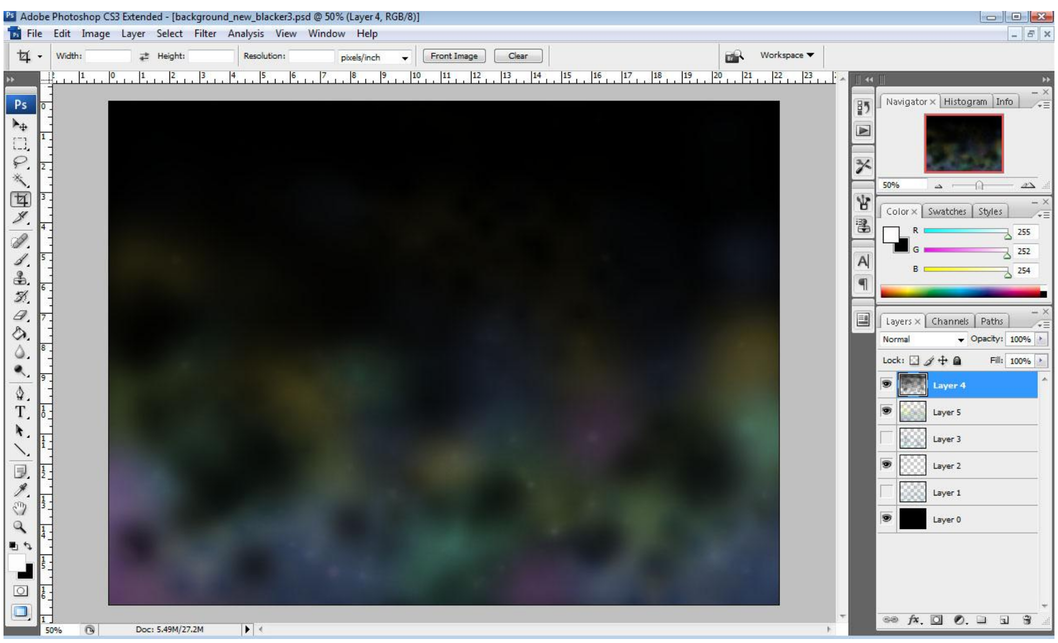


Figure 3-10. Background Template.

Each scene required an individual background that contained color selections from that scene. These backgrounds were produced using the template background and selecting scene colors from my color palate.

Once the models were produced in 3D Max® they were animated using simple key frame animation. Each movement was carefully timed to match the script narration.

Next, I scheduled professional narration by Bruce DeBose at Medical Television (Med TV) located on UTSW's south campus. Bruce has previously narrated for many television shows including some on Public Broadcasting Services (PBS). His clear tone and professional readings were approved by my thesis committee and are intended to be used by subsequent suitcases. He was given a script with highlighted words for emphasis and using the professional quality tools at Med TV, we produced a WAV file to later be edited onto my animation.

After each 3D and 2D scene was created using either 3D Max® or After Effects® and the narration was recorded, it was time to edit the entire animation together. I initially started editing in Adobe Premiere Pro® but soon realized that the quality of the 2D animation was lost by exporting into this program. To fix this, I edited my entire animation in After Effects® which maintained the original quality of the characters. In After Effects® I started laying out each sequential animation on my timeline. I then added *CCLight Ray* effects to each reaction in order to simulate an energy burst. Next I added copyright-free sound effects to the reactions, bouncing basketball, car, crowd cheers, and lock and key. These sounds effects were dimmed as to not subtract from the narration. I then added the narration to parallel events in the animation. Next, I added ambient music to the background that was also dimmed like the sound effects. Finally, I added text with *Arial Regular* font for each class discussion question and highlighted terms. Once the entire animation was complete, I exported the project as a high quality QuickTime® movie at H.264 compression.

I then imported the movie into Adobe Encore®. Within Encore® I created a template that utilized the branding techniques previously described. This template had options to play the entir animation or to jump to selected chapters. Chapters were then established for each section following a discussion question. The following chapters were created by right clicking on the Encore timeline at those points and selecting "Add Chapter Point":

1. Introduction
2. Biological Reactants
3. Activation Energy
4. Active Site
5. Molecule Anatomy
6. Induced Fit
7. Denaturation
8. Optimal Temperature and pH
9. Review

Initially, I thought that I would only give the option to play the enter animation but after speaking with teachers, I decided to create these chapters. This would then allow the teacher to easy replay chapters that students required extra review for. The final DVD was created and then a label was produced using the branding techniques.

Instructions for playing the animation were constructed and placed within the Teacher Instructions Booklet and were also added to the cover of the DVD (see Appendix C).

Look

One challenge of this project was to create branding that would be carried throughout the entire suitcase. After starting the animation, I began to develop strategies to brand the components of the suitcase. To start, I came up with a color palate to utilize throughout the entire project (Figure 3-11). I chose to work with subtle hues of gold, green, blue and purple. I strayed from the primary colors of pure red, yellow and blue because many elementary toys use those colors. I wanted the colors to appeal to an older audience. This color palate unified my animation, game, models, labs and handouts.

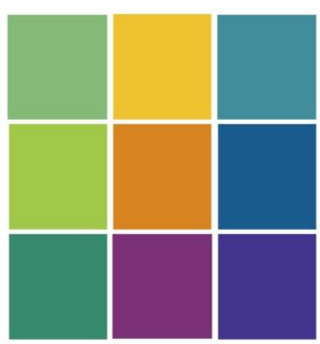


Figure 3-11. Color palate.

I went further into the branding once I designed the laboratory handouts. These were the first handouts to be produced from this suitcase and set the stage for the homework and instruction booklets. This layout included both a blue and yellow color bar that was chosen from my color palate (Figure 3-12).

Figure 3-12. Handouts color bar for branding.

The yellow color bar was used as a header for all of the hardcopy documents and labels. The blue color bar was used for subheading on all of the same documents. These color bars were made fifty percent transparent in order to print clearly on a black and white copier. If the colors were left at full saturation, a muddy grey bar was left when reproduced in this fashion.

Another area for unification was in my font selection. The font that chose was *Arial Regular*. This font transitioned easily from hardcopy handouts to animations, from white back grounds to black, and maintained its clarity from large format to extremely small.

Another area for branding was in my images. I chose to use a still image from my animation of an enzyme and two substrates on the majority of my components. These components include the suitcase label, teacher instructions booklet cover, student handouts booklet cover and homework handout (Figure 3-13).

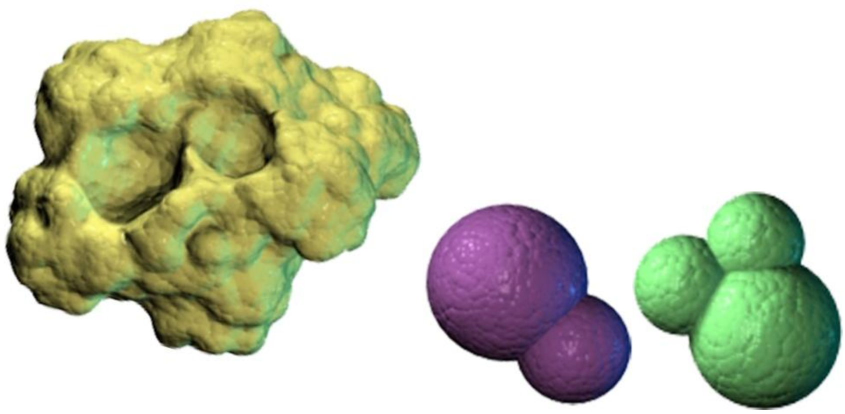


Figure 3-13. Enzyme and substrate models for branding.

The final area for branding was a title. I settled on *Enzyme Instigator* as an overall title for this suitcase because enzymes basically "instigate" a reaction. The name was short while still being catchy enough to stick in viewers memories. This title was included on all documents as a header and also as a footer on subsequent pages. This was done so that all documents pertaining to this suitcase could be identified if found individually.

Game

After starting the animation, I quickly began the process of designing a game. Based on research and interviews, I settled on a format similar to Jeopardy®. My first game was designed with three categories (definition, short answers and long answers) and nine point levels for each category. I redesigned that game into five categories (molecules, enzymes, wild card, reactions and analogies/synonyms) and five point levels for each category. This allowed my board dimensions to be closer to a square than a long rectangle. Questions were developed based on the information presented to the students in the animation along with reading material from current ninth grade biology text books. These questions were approved by Kim Krumwiede, Lewis Calver, Steve Hinkley and Dr. Goodman for age appropriateness and scientific accuracy.

My initial designs combined a collaborative game with the hands-on models. After testing this prototype on students, I realized that this approach was too complex and confusing. I then separated these two components and focused on the game as a single element.

I designed the entire board using components previously describe to brand this project. I utilized the blue color bar for the title along with *Arial Regular* font throughout. I then added the enzyme and substrate images to the header. I settled on a black background in order to minimize the appearance of inevitable dirt and grime. Next, I chose category colors based on my color palate. The final step was developing a suitable name. I chose to call my game Jeopardase, which combines Jeopardy® with the common enzyme suffix of, –ase.

The material of the board needed to be sturdy enough to withstand general wear and tear yet light enough hang on board clips or sit in a chalk reservoir. I teamed with Jorge

Escobar of the Dallas Museum of Nature and Science to resolve these issues. He is currently the museum's graphic design expert and works on projects involving print and unique materials on a regular basis. We initial thought of using a thin aluminum sheet with magnets for the game cards but decided that this would create a heavy product. Our final material included light-weight, black PVC sheet board with an adhesive vinyl print of my game. The game cards were printed using the same vinyl yet they were adhered to white PVC sheet board. Each card was secured to the board using Velcro®. The final product was light and durable (Figure 3-14).

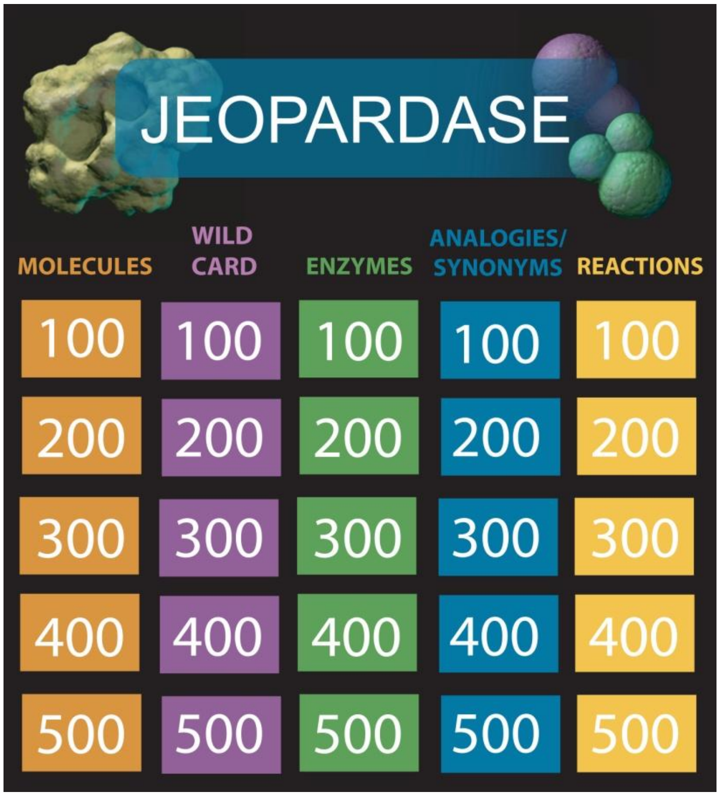


Figure 3-14. Jeopardase Game.

Instructions for the game were constructed using helpful images to guide the teacher through a quick set up and progression of the game. These instructions are located in Appendix C.

Hands-on Models

Simultaneous to producing the animation and game, I began the design of hands-on models. My objectives were the following:

1. To produce a durable product that could withstand rough handling from students.
2. To make an enzyme that allowed only one set of substrates to dock on the active site in order to emphasize specificity.
3. To make two other sets of substrates that would not fit into the active site
4. To form the models similar to my 3D animation models.
5. To use magnets in the active site and base of the substrates to represent the energy that enzymes add to reactions.

Nearly every interviewed teacher requested these models and I felt very strongly about producing a quality product that was fun and interactive.

My first prototype was produced using blue Crayola Model Majic® modeling foam. This foam could be sculpted into any shape and would air dry to a very light weight hard foam consistency. I sculpted this foam into a shape similar to my 3D enzyme model and then pressed magnets into the active site and covered them with a thin layer of the modeling material. I then created substrates that would fit snuggly into the active site. I added magnets with opposing poles into the base of these substrates. Once the models dried, the substrates would fit into the enzyme's active site only one way because of the magnets' force. The problems with this prototype were the modeling material and magnet strength. The material dried so quickly that it was very difficult to form and the magnets strength barely gave a noticeable pull (Figure 3-15).

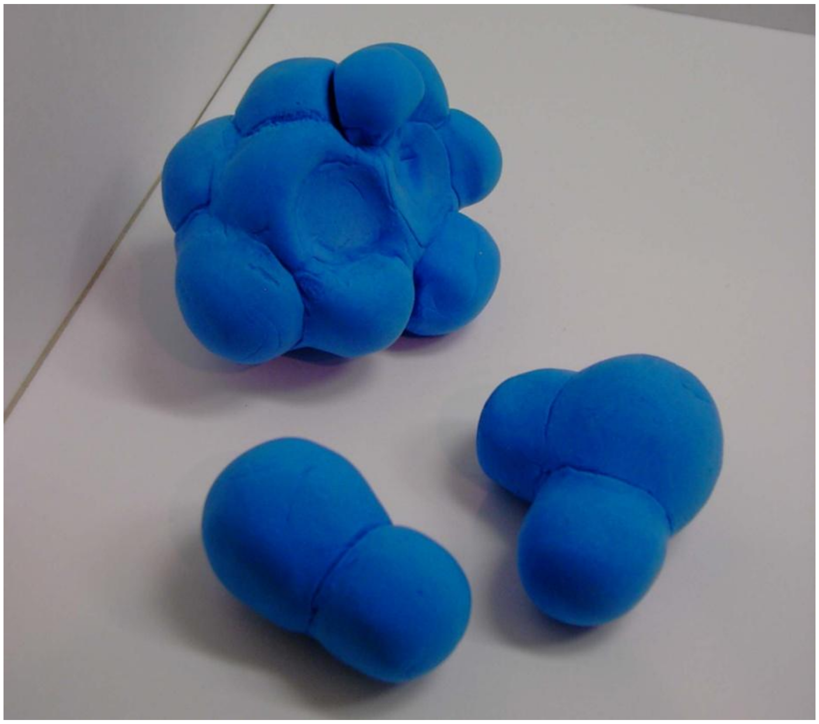


Figure 3-15. First Hands-on Model Prototype.

My second design included a four inch enzyme model with baked in magnets. I formed the enzyme with Sculpy®, pressed the magnets into the active site and covered them with more clay. The clay was very pliable and could be easily shaped and smoothed without drying and cracking. In order to create a stronger pull with the magnets, I combined two magnets and added both to the site. I then repeated these steps with the substrates. Next, I baked the models at 275°F for twenty minutes until they were very hard and durable. These models were then painted with glossy acrylic craft paint. The problems with this prototype were that when baked, the magnets lost a small amount of power and the models weighed a significant amount for their small size. Also, while the clay was very hard after baking, it would shatter if dropped on a hard surface (Figure 3-16).

Figure 3-16. Second Hands-on Model Prototype.

After consulting with Greg Contestible, an exhibit artist at the Museum of Nature and Science, I decided that the next model would be sculpted form professional grade Sculpy® and two piece silicone molds would be made of each model. From this mold, a model would be cast out of smooth cast plastic. Various carving tools were used to mimic the crevices and texture of my model as well as a cut golf ball pressed into the surface of the clay to create bumps similar to my digital model. Some of the limitations that we endured were:

1. Making a model with limited undercuts for the silicone molds.
2. Forming the active site at an angle that would easily pop apart the correct substrates with magnetic help.
3. Developing a specific active site shape that was subtle enough not to easily indicate which substrates were correct.

The final enzyme was eight inches long and had an active site with a specific sized rim that would only allow one size of substrate to settle (Figure 3-17).

Figure 3-17. Final Enzyme Model.

One set of substrates were then formed to fit snuggly into the enzymes active site. The other two sets were made slightly larger than the active site. This prevented them from fitting into the site yet prohibited the outcome from being obvious.

The next steps involved pouring the silicone molds that would allow multiple copies of these models to be created. The enzyme and substrate models were carefully molded using a silicone material that created a relief of each model. Pour holes were added to the molds to create an entrance for the plastic solution which was then poured. The final result was a tough plastic model for each carved enzyme and substrate that could be easily reproduced. Full instructions for creating these models are located in Appendix D.

The next step was determining proper placement for the magnets. I bought industrial strength magnets with pull strengths ranging from two to sixteen. These magnets were much stronger than the magnets used for the first two prototypes. First we tried placing the magnets within the molds before pouring the plastic solution. We created frames using metal wiring that suspended within the molds (Figure 3-18).

Figure 3-18. Initial Magnet Placement.

We thought that this would allow a cleaner final product. The problem was that every time we completed the mold, the magnets moved ever so slightly during the drying process and would therefore not connect to their counterpart.

The next try involved drilling. We poured a plastic model, let it set and drilled into the active site where we believed the magnets should be placed. We used a drill bit the same size as the magnets and saved the dust from the plastic. We combined this dust with a clear silicone and filled the holes after placing magnets inside. This combination created a final model that was clean, durable, and snapped apart after entering the active site. Full instructions for making these models are in Appendix D.

In the final steps, I matched the plastic dyes to colors found on my color palate. I chose yellow for the enzyme, purple for the correct substrates and green and blue for the incorrect substrates. A hard wood base was cut to ten by seven inches and stained ebony. A clear silicone block was cut to five by five inches and adhered to the center of the wooden block. The enzyme was then adhered to the silicone block. This base gave the enzyme presence and created a sense of floating on top of the wooden block. I then purchased transparent colored, square, acrylic containers from The Container Store®. I chose blue, green and purple containers to match the colors of the substrates that would be going inside. I used these containers not only to hold the models within the suitcase but also to serve as bases during the teacher demonstration of these models. I turned the lids upside down and adhered three inches of foam to the inside. I then carved out small circular grooves that helped the substrates stand upright when placed into these bases. I purchased a handled container for the enzyme model so that teachers could pull it out of the suitcase using the handles instead of tugging at the model itself. Finally, I labeled each of the containers using the yellow color bar and *Arial Regular* font. The enzyme was titled Trypsin, the correct substrate was titled Protein with Peptide Bonds, the blue substrate was titled Fats and the green substrate was titled Carbohydrates (Figure 3-19).

(**Figure 3-19**. Models and Bases)

I chose these titles because they were subtle enough not to give away the answer to students. Some enzymes have names very similar to the substrates that they react. Within their homework handout is a question asking them "with which substrates does trypsin react?" If the students take the initiative to answer this question, they will know which substrate fits into the enzyme's active site.

The final product was three pairs of substrates with corresponding containers and bases and one enzyme on a wooden base within a handled plastic container.

As described within the *Game* section, these models were initially going to be incorporated into the game. I designed the models as the second part to the game. After a team had reached 600 points from answering Jeopardase questions, they could try picking the correct substrates from the three choices. If the students chose the wrong set of substrates, they would not fit into the active site and the team had to wait until their next turn to try again. If the team chose the correct set of substrates, they had won the game.

I tested this game design on nine current students of the Biomedical Department. This initial designed proved to be very confusing and therefore I decided to develop a separate teacher demonstration with these models that the students could later manipulate. The instructions for this teacher demonstration are located within Appendix C.

Laboratory Experiments

The next components that I developed were the laboratory experiments. I worked with Kimberly Wilson, a doctoral student from the Biochemistry Department at UTSW to design these labs. Our objectives with these labs were to create simple experiments that utilized aspects of the students' daily lives to show optimal temperature and optimal pH. The labs also needed to be relatively low in cost and contain products that teachers could easily obtain.

We brainstormed many labs that included luciferase from fire flies, detergent, gelatin and fruit juice, milk with vinegar and horseradish. In the end we settled on using a gelatin and fruit juice lab to describe optimal temperature and a milk with rennet lab to describe optimal pH. The gelatin lab was designed after looking at experiments such as those created by Anne McDonald and Michael O'Hare regarding enzymes and jello. The milk lab was formed from looking at experiments such as "Rennin Investigation" by Tamsin Chipperfield.

Next, we wrote a rough draft of the labs and I tested each in my kitchen which included similar tools to a high school science lab.

The initial draft of the gelatin lab included using three different juices and testing all of them at three temperature intervals on a slice of gelatin. The three juices were pineapple, kiwi and papaya. The theory was that each fruit juice's enzymatic behavior would work best at a certain temperature. The problem with the lab was that there was not a significant difference between the three juices and it took over an hour to perform. Each juice broke down the gelatin to a similar degree. Kimberly and I revised the lab to include only pineapple juice and a colored slice of gelatin. Using fewer juices also made the total time spent performing the lab less than 55 minutes which is a normal class period. Using a colored slice of gelatin made the results more obvious. The final lab showed students what would happen to pineapple enzymes if placed in a cold, room and hot water bath. The juice was then poured over a thin slice of blue gelatin and timed for eight minutes to see the results. The final outcome was that the room temperature juice, which was close to that of the natural environment of a pineapple, broke down the protein matrix within the gelatin. The cold juice's enzymatic power was halted and therefore showed little results of breaking down the gelatin. The hot juice's enzymes, which was cooled down to room temperature before adding to the gelatin, were denatured from the extreme temperature and therefore also showed little results of breaking down the gelatin. Overall, the lab was simple to execute and gave the students a glimpse of optimal temperature.

The second lab used a milk solution and rennet to describe optimal pH. The initial lab contained five different pH levels ranging from four to eight. Each pH buffer was added to a tube of rennet solution and both were then added to a milk solution. The theory was that rennet, which is an enzyme in a calf's stomach that breaks down the mother's milk, would break down the milk solution better at a pH level close to the natural environment of the stomach. The lab was successful but time consuming. The pH 4 solution broke down the milk into tiny flakes while the pH 8 solution did nothing to the milk. In order to complete the lab within a given class period, we revised the experiment to use only pH 4, pH 6 and pH 8.

After successfully creating the labs, Kimberly and I produced a liter of each solution which would be enough for 6 teachers' classes. The following directions describe the process for reproduction:

1. pH 4 : Combine 9.9 grams of Sodium Ascorbate into a glass beaker of 500 mL of water. Place the contents on a stir plate with the pH reader inside. Next add one molar hydrochloric acid until the solution reaches pH 4. Next add another 500 mL of water to reach a desired amount of one liter. Double check the pH with the reader.
2. pH 6 : Combine 9.7 grams of MES into a glass beaker of 500 mL of water. Place the contents on a stir plate with the pH reader inside. Next add one molar hydrochloric acid until the solution reaches pH 6. Next add another 500 mL of water to reach a desired amount of one liter. Double check the pH with the reader.
3. pH 8 : Combine 6.1 grams of Tris into a glass beaker of 500 mL of water. Place the contents on a stir plate with the pH reader inside. Next add one molar hydrochloric acid until the solution reaches pH 8. Next add another 500 mL of water to reach a desired amount of one liter. Double check the pH with the reader.

After testing this lab on teachers, we found that the pH 4 solution did not break down the milk. We looked at the three variables of the lab, powdered milk, rennet tablets and pH solutions, to determine the cause. Initially, the pH solutions for the lab would be prepared once a year in a bulk batch, after our findings we realized that this was not a possibility. After using a fresh batch of pH 4 solution, the experiment worked perfectly. Even through the old pH solution was still reading a correct pH value, the Ascorbate had potentially oxidized in the plastic storage container and turned a rusty orange color. We revised the lab to accommodate this issue. We only filled the container with half a liter of the solution and then indication on the restocking form that the solution needed to be remade every 2-3 months. While the other solutions worked, they might also need to be made more frequently than previously anticipated.

The final lab instructions were designed using the yellow color bar for the header and the blue color bar for the subheadings. I used large sized numbers throughout the procedure along with check off boxes next to each step. These allowed students to easily follow the procedure and check off steps as they proceeded. I also included photographs of many of the steps so that visual learners could follow effortlessly.

Finally, I designed teacher instructions for the set up and progression of each lab. These instructions included extra photographs of the lab results along with tentative answers for the data analysis section of the lab. The teacher instructions can be seen in Appendix C. The full student version of the lab can be seen in Appendix E.

Inside the suitcase I included many lab supplies for these experiments. The supplies included in the case are three pH solutions at 4, 6 and 8, a strainer, two ice cube trays, one mL pipettes, powered milk, plastic knives, gelatin packets, rennet tablets, blue food dye, pH strips and thermometers. The supplies not included in the case are beakers, test tubes, grease pencils, test tube racks, paper plates, and a pineapple. These supplies are either standard high school lab supplies or easily purchased.

Homework

My intention behind the homework handout was to expose the students to the complex concepts of enzymes and review a few theories that they should have learned in prior lessons. One of these review concepts was pH. I gave a short description of pH to students as a review for the many times that pH is covered in this suitcase. I tried to cover the basic objectives mentioned from the teacher surveys in order to expose the students to these terms as many times as possible.

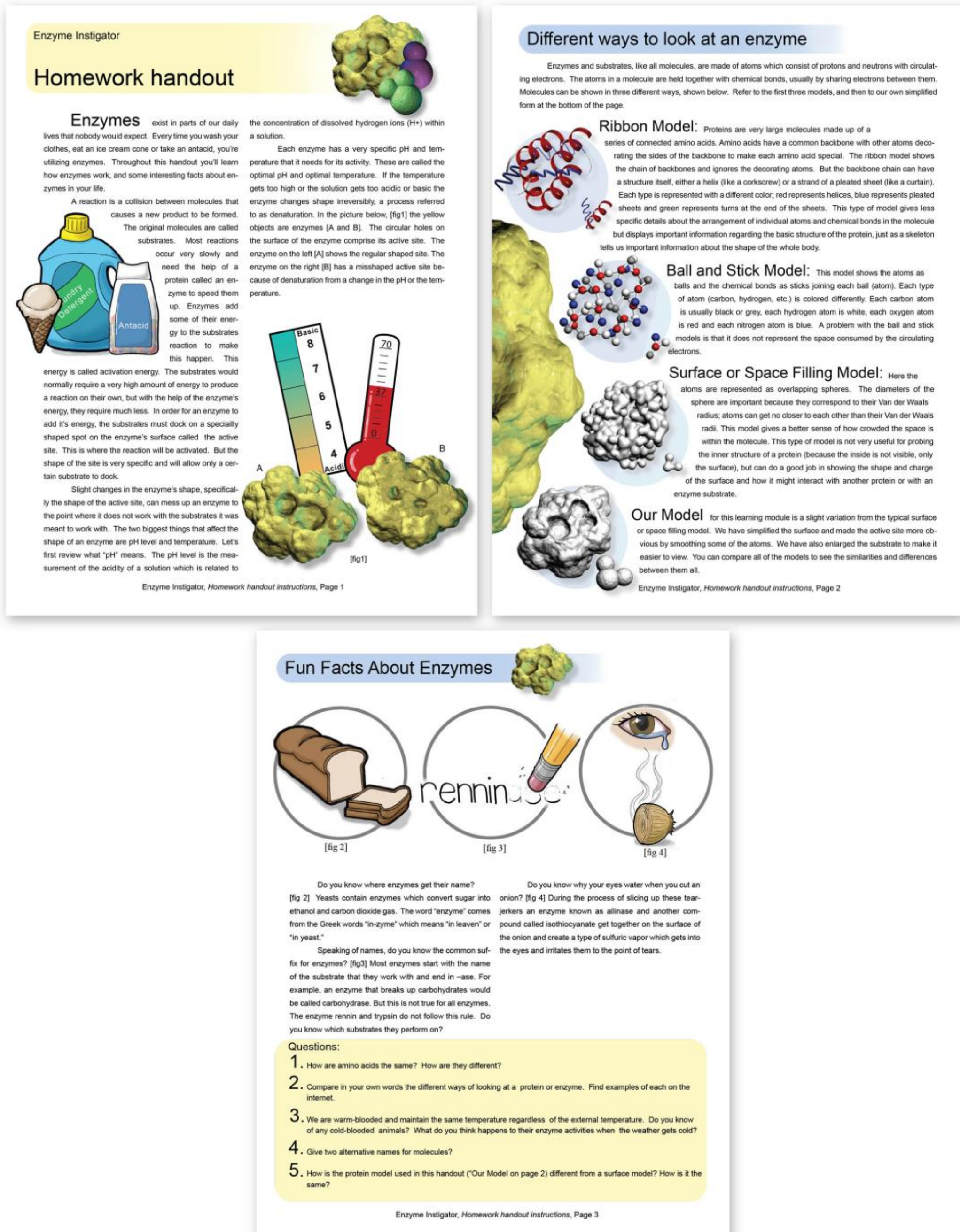
When designing this homework handout, Dr. Goodman and I felt that it was very important to show students the various ways that proteins can be depicted. As previously described in the *Animation* section, I chose to develop the enzymes in this suitcase after a surface model. I dedicated the entire second page of the homework handout to describing the different scientific portrayals of proteins and enzymes. The main objective behind this addition was to give students a visual reference to link the enzymes found within this suitcase to enzymes portrayed throughout science. Many books simply give students these images and never link the concepts to each other.

Another area that I added to the homework handout was fun facts. These facts compiled to spark students' interest and carry concepts about enzymes into their everyday lives.

These facts were found using internet searches from sources such as Dictionary.com for the yeast reference and Genome News Network for the onion reference.

Several revisions were made to the handout including justifying the text to follow the current textbooks' style, highlighting key terms, and varying the image sizes for added visual flow.

The final homework included references to enzymes in students' daily lives, pH, optimal temperature, different protein images, fun facts and homework questions. I used the yellow color bar for the header and the blue color bar for the subheadings. I produced images to tie into the text that were simple and bold with few tiny details so that when reproduced on a standard black and white copy machine these images would maintain their original clarity. I also added the enzyme and substrate images from the section on branding to the header of this document to tie it into the other documents of this suitcase. A hardcopy of the homework handout is located in the *Student Handouts Booklet* and a PDF file of the document is located on the *PDF documents* CD (Figure 3-20).



Enzyme Instigator

Homework handout

Enzymes exist in parts of our daily lives that nobody would expect. Every time you wash your clothes, eat an ice cream cone or take an antacid, you're utilizing enzymes. Throughout this handout you'll learn how enzymes work, and some interesting facts about enzymes in your life.

A reaction is a collision between molecules that causes a new product to be formed. The original molecules are called substrates. Most reactions occur very slowly and need the help of a protein called an enzyme to speed them up. Enzymes add some of their energy to the substrates reaction to make this happen. This energy is called activation energy. The substrates would normally require a very high amount of energy to produce a reaction on their own, but with the help of the enzyme's energy, they require much less. In order for an enzyme to add it's energy, the substrates must dock on a speciailly shaped spot on the enzyme's surface called the active site. This is where the reaction will be activated. But the shape of the site is very specific and will allow only a certain substrate to dock.

Slight changes in the enzyme's shape, specifically the shape of the active site, can mess up an enzyme to the point where it does not work with the substrates it was meant to work with. The two biggest things that affect the shape of an enzyme are pH level and temperature. Let's first review what "pH" means. The pH level is the measurement of the acidity of a solution which is related to the concentration of dissolved hydrogen ions (H+) within a solution.

Each enzyme has a very specific pH and temperature that it needs for its activity. These are called the optimal pH and optimal temperature. If the temperature gets too high or the solution gets too acidic or basic the enzyme changes shape irreversibly, a process referred to as denaturation. In the picture below, [fig1] the yellow objects are enzymes [A and B]. The circular holes on the surface of the enzyme comprise its active site. The enzyme on the left [A] shows the regular shaped site. The enzyme on the right [B] has a misshaped active site because of denaturation from a change in the pH or the temperature.

[fig1]

Enzyme Instigator, *Homework handout instructions*, Page 1

Different ways to look at an enzyme

Enzymes and substrates, like all molecules, are made of atoms which consist of protons and neutrons with circulating electrons. The atoms in a molecule are held together with chemical bonds, usually by sharing electrons between them. Molecules can be shown in three different ways, shown below. Refer to the first three models, and then to our own simplified form at the bottom of the page.

Ribbon Model: Proteins are very large molecules made up of a series of connected amino acids. Amino acids have a common backbone with other atoms decorating the sides of the backbone to make each amino acid special. The ribbon model shows the chain of backbones and ignores the decorating atoms. But the backbone chain can have a structure itself, either a helix (like a corkscrew) or a strand of a pleated sheet (like a curtain). Each type is represented with a different color; red represents helices, blue represents pleated sheets and green represents turns at the end of the sheets. This type of model gives less specific details about the arrangement of individual atoms and chemical bonds in the molecule but displays important information regarding the basic structure of the protein, just as a skeleton tells us important information about the shape of the whole body.

Ball and Stick Model: This model shows the atoms as balls and the chemical bonds as sticks joining each ball (atom). Each type of atom (carbon, hydrogen, etc.) is colored differently. Each carbon atom is usually black or grey, each hydrogen atom is white, each oxygen atom is red and each nitrogen atom is blue. A problem with the ball and stick models is that it does not represent the space consumed by the circulating electrons.

Surface or Space Filling Model: Here the atoms are represented as overlapping spheres. The diameters of the sphere are important because they correspond to their Van der Waals radius; atoms can get no closer to each other than their Van der Waals radii. This model gives a better sense of how crowded the space is within the molecule. This type of model is not very useful for probing the inner structure of a protein (because the inside is not visible, only the surface), but can do a good job in showing the shape and charge of the surface and how it might interact with another protein or with an enzyme substrate.

Our Model for this learning module is a slight variation from the typical surface or space filling model. We have simplified the surface and made the active site more obvious by smoothing some of the atoms. We have also enlarged the substrate to make it easier to view. You can compare all of the models to see the similarities and differences between them all.

Enzyme Instigator, *Homework handout instructions*, Page 2

Fun Facts About Enzymes

[fig 2] [fig 3] [fig 4]

Do you know where enzymes get their name? [fig 2] Yeasts contain enzymes which convert sugar into ethanol and carbon dioxide gas. The word "enzyme" comes from the Greek words "in-zyme" which means "in leaven" or "in yeast."

Speaking of names, do you know the common suffix for enzymes? [fig3] Most enzymes start with the name of the substrate that they work with and end in –ase. For example, an enzyme that breaks up carbohydrates would be called carbohydrase. But this is not true for all enzymes. The enzyme rennin and trypsin do not follow this rule. Do you know which substrates they perform on?

Do you know why your eyes water when you cut an onion? [fig 4] During the process of slicing up these tear-jerkers an enzyme known as allinase and another compound called isothiocyanate get together on the surface of the onion and create a type of sulfuric vapor which gets into the eyes and irritates them to the point of tears.

Questions:

1. How are amino acids the same? How are they different?
2. Compare in your own words the different ways of looking at a protein or enzyme. Find examples of each on the internet.
3. We are warm-blooded and maintain the same temperature regardless of the external temperature. Do you know of any cold-blooded animals? What do you think happens to their enzyme activities when the weather gets cold?
4. Give two alternative names for molecules?
5. How is the protein model used in this handout ("Our Model on page 2) different from a surface model? How is it the same?

Enzyme Instigator, *Homework handout instructions*, Page 3

Figure 3-20. Final Homework handout.

Finally, a teacher version of the homework handout was produced with answers to the questions highlighted in red and italicized. This version is located in the *Teacher Instructions Booklet* and also in Appendix C.

Quizzes

The quizzes included in this suitcase are suggested questions to test students' knowledge about enzymes before and then after this suitcase is presented to them. The questions were developed from current textbook's questions regarding enzymes along with previous TAKS questions on the subject. These questions can be revised to accommodate testing performed by STARS and AP Strategies in subsequent years. A hardcopy of the quiz is located in the *Student Handouts Booklet* and a PDF file of the document is located on the *PDF documents* CD.

Finally, a teacher version was produced with answers to the questions highlighted in red and italicized. This version is located in the *Teacher Instructions Booklet* and also in Appendix C.

Instruction Manual

As previously mentioned, instructions for each component of the suitcase were produced and combined into one *Teacher Instructions Booklet*. Keeping these elements together would help prevent losses and enable the teacher to easily access and necessary instructions in one convenient location. This booklet includes:

1. <u>About</u>: A short section about the author and designer of this suitcase.

2. Suitcase components: A section showing individual photographs of each component of the suitcase along with a photo of the packed suitcase for easy reference when returning the case. Each of these photos contains a key indicating the images contents.

3. Overall suitcase instructions: An eight page document introducing the teacher to the suitcase. It contains brief instructions for each component, a recommended syllabus and five option syllabi.

4. Homework handout: A copy of the homework handout is located here along with red italicized answers for each question.

5. Animation Q and A: This is a document to go along with the animation. It contains the questions located throughout the animation along with their time location and answers. This is document is to help the teacher lead a class discussion on these questions.

6. Jeopardase game: This section give set up and progression instructions for the Jeopardase game.

7. Optional game rewards: These are optional prizes for the first, second and third place winners of the Jeopardase game. Teachers are informed that they can make copies of these rewards and hand them out to the winners or reward them with different prizes of the teacher's choice.

8. Hands-on models, teacher demo: This section includes the setup and progression of the teacher demonstration of the hands-on models. There are photographs to accompany many of the instructions along with check boxes for the teacher to follow.

9. Lab 1: This contains the set up and progression of Lab 1 (gelatin and fruit enzymes). It gives teachers instructions for prepping the lab the day before and also setting up the lab on the day of. It also includes extra photographs of the result along with answers to the data analysis.

10. Lab 2: This contains the set up and progression of Lab 2 (milk and rennin). It gives teachers instructions for prepping the lab the day before and also setting up the lab on the day of. It also includes extra photographs of the result along with answers to the data analysis.

11. Pre and Post Quiz: This section includes a copy of the quiz along with the answers to each question.

The entire booklet is divided using color coded tabs that give easy reference to each of the above sections. It was produced on a spiral binding to allow the booklet to lay flat when in use. Each page was laminated for durability and waterproofing. Most of the sections include check boxes for the teachers to follow. The cover of the booklet shows a still image from the animation. While the images are not the exact branding images of the enzyme and substrates, it utilizes these models in a slightly varied form. The title is set in front of the yellow color box to complete the booklets branding.

Additional Components

Three remaining components were compiled for the completion of this suitcase. I compiled a PDF documents CD which contained Adobe PDF documents of the suitcase components. These documents include Lab 1, Lab 1 in large format, Lab 2, Lab 2 in large format, homework handout, homework handout in large format, the animation script in case students need to follow along, pre-quiz, post-quiz and the entire *Teacher Instructions Booklet*. This CD was created in case teachers wanted to print directly from their computer instead of making photocopies of the documents. Large formats of Labs 1 and 2 along with the homework handout were created for students with reading disabilities.

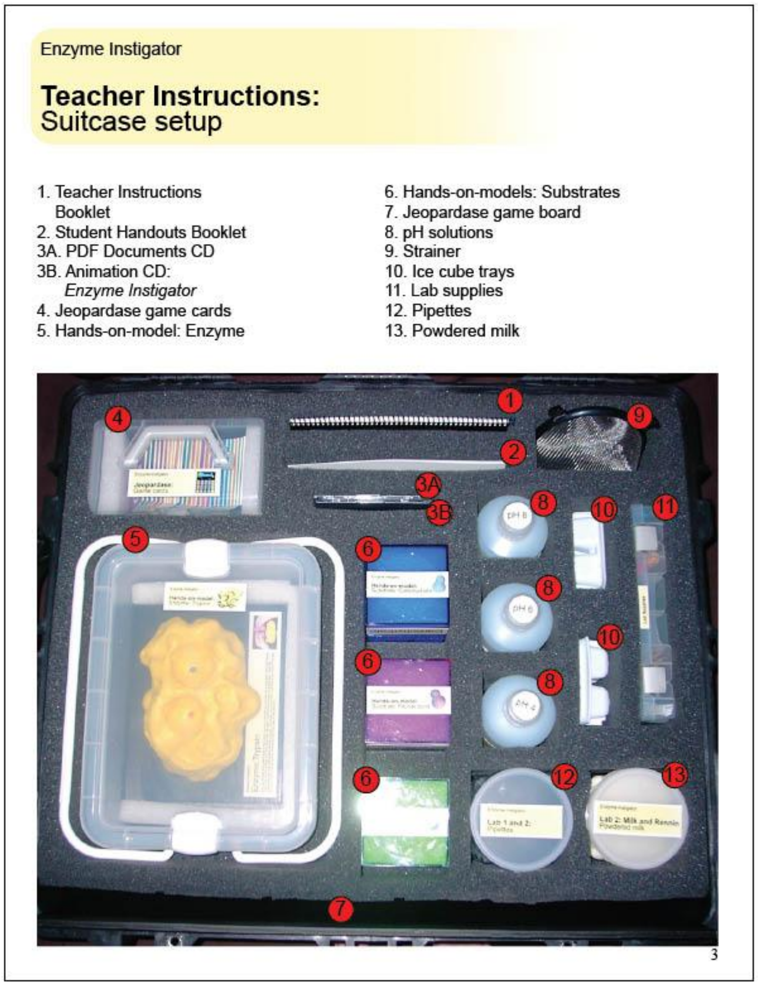
I then compiled a *Student Handouts Booklet*. This booklet contained the hardcopy student versions of each lab, homework, quizzes and glossary. I designed the booklet the same way that I designed the *Teacher Instructions Booklet* with tabs, laminated sheets and spiral binding.

The final document was a restocking list for the suitcase components. This list contained the amounts of each component that needed to be inside the case. The people assigned to handle the case could look at this document and make sure that all of the pieces are stocked and filled.

Suitcase

Next, I designed the packaging of the suitcase. I purchased a black Pelican® case, catalog number 1690. This suitcase is waterproof, contains wheels and a handle for easy transportation, has a lifetime guarantee against breakage or defects and includes a metal reinforced hole for a padlock. This case also includes Pick N'Pluck® foam that can be sculpted to snuggly fit any shape and sized item. Choosing this case ensured that the contents would be safe and secure while transported among multiple classrooms.

After receiving this case, I started to design the layout of the components. I began by laying out all of the components on top of the foam. The list of components included: *Teacher Instructions Booklet, Student Hardcopy Booklet*, PDF documents CD, animation DVD, Jeopardase game cards, Jeopardase game board, enzyme model in handled container, three substrate models in containers, three pH solution bottles, a strainer, two ice cube trays, pipettes in a plastic container, powered milk in a plastic container, and a divided container with plastic knives, gelatin packets, rennet tablets, blue food dye, pH strips and thermometers. Once I had laid out each component with at least one inch in between them, I started to pull out the foam blocks. There are four layers of foam blocks and each component required a different number of blocks to be pulled out. The Jeopardase board required special attention. I had to pull out all four layers of foam and trim three inches from one length of the foam. I then cut three inches from the corresponding foam of the lid. This allowed a spot large enough to easily slide the game board in and out of the case (Figure 3-21).


Enzyme Instigator

Teacher Instructions:
Suitcase setup

1. Teacher Instructions Booklet
2. Student Handouts Booklet
3A. PDF Documents CD
3B. Animation CD: *Enzyme Instigator*
4. Jeopardase game cards
5. Hands-on-model: Enzyme
6. Hands-on-models: Substrates
7. Jeopardase game board
8. pH solutions
9. Strainer
10. Ice cube trays
11. Lab supplies
12. Pipettes
13. Powdered milk

3

Figure 3-21. Packed suitcase components.

The next step was to design the outside label of the case. I started with the same enzyme and substrate image used on the booklet covers. I then added a yellow color bar for the title *Enzyme Instigator*. Next, I added the logos of the four sponsors in front of a blue color bar. The final step was to take photographs describing the transportation of the suitcase. The photos included unlatching the handle, rolling the case, loading the case into a minivan and loading the case into the back seat of a sedan. The label also includes the 65 pounds packed weight of the case (Figure 3-22).

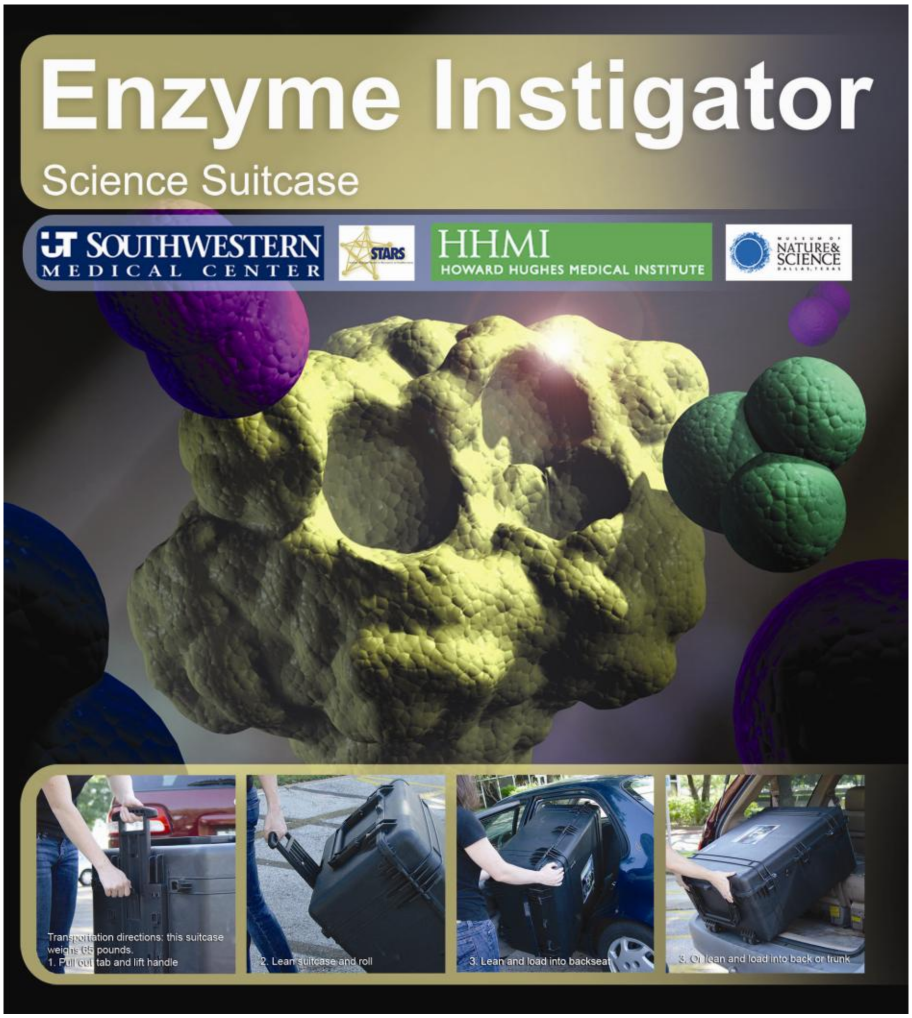


Figure 3-22. Suitcase Label.

Continued Usage Considerations

One of the objectives of this project, was to create components that could be easily restocked over the duration of this suitcase. Taking this into consideration, each component was designed to fulfill this objective. A working documents DVD was given to STARS and the Biomedical Communications Department containing editable versions of each document and the required supplemental items such as labels and instructions. The following directions apply for each component:

1. Teacher Instructions and Student Handouts Booklets: Each booklet can be reproduced by printing the documents from the PDF CD, cutting out the tabs from the *Tabs* document in the *Instuctions* folder, gluing them into their appropriate spot and then having the entire booklet laminated and bound with a spiral binding.
2. PDF and Animation Discs: The two discs can be burned and labels can be printed from the *Instructions* folder of the working documents DVD.
3. Suitcase: The actual suitcase was purchase online through Pelican Cases. This case has a lifetime guarantee and can be replaced if something breaks. The label can be printed from the Instructions folder onto Vinyl paper with an adhesive backing. A clear sheet protector should be added on top of the label.
4. The hands-on models can each be reproduced using silicone models stored at the museum. Directions for the completion of these models are in Appendix D.

5. Powdered milk, rennet tablets, blue food dye, plastic knives and gelatin: These products can be bought at nearly any grocery store. Amounts for each item are located in Appendix H.

6. Thermometers, pH strips and pipettes: These products were all ordered from Cole-Parmer Instruments Company and can be repurchased from there.

7. Jeopardase: The game board and card are both created as Illustrator files. These file can be printed from the *Jeopardase* folder onto vinyl paper with an adhesive backing. Then adhere these products onto PVC sheeting as indicated in the *Game* section of this chapter and cut them down to size.

8. Solutions: The pH solutions for this project can be reproduced using the directions in the *Laboratory Experiments* section of this chapter.

9. Containers: All of the containers for this project were purchase from The Container Store®.

CHAPTER FOUR
Results

Survey Development

After the entire suitcase was complete, I performed an informal demonstration of the components for seven teachers from DISD schools participating in the STARS Triathlon. During this presentation, I showed teachers the proper use of each component and guided them through the *Teacher Instructions Manual*. To evaluate the ease and effectiveness of the components, as well as determine whether the goals and objectives had been met, a survey was developed (see Appendix F). The survey was created using a 5-point Likert scale ranging from Strongly Agree (SA) to Strongly Disagree (SD). Twenty four statements were given pertaining to the goals and effectiveness of the animations, and teachers were asked to check the box that corresponded to their level of agreement with the statement. Also included in the survey, were three background questions regarding the age level and subjects that the teachers instruct. Additional questions were added at the end of the survey to gain information on the components that they enjoyed the most and least, along with the available resources to these teachers. The survey was created in Adobe InDesign®. Spaces were also provided for all survey participants' to add comments after each question. This survey was developed to obtain current ninth grade teachers' opinions about the ease and usefulness of the components.

Demonstration and Survey

Seven teachers chosen for the Triathlon participated in the demonstration and survey. These teachers were from the surrounding community high schools and teach biology to ninth grade students. They will also receive first access to using the suitcase in the following school year. The survey was distributed to the teachers at the beginning of this demonstration. Throughout the demonstration, I gave the teachers time to fill out portions of the survey that pertained to the prior information. They were also encouraged to leave additional comments.

Survey Results

All of these seven teachers taught regular biology and five also taught pre-AP biology. In compiling the results for each of the ten statements in the survey, the statistics were calculated, and a bar graph comparing the result was created (Table 4-1).The additional questions were then reviewed and evaluated (See Appendix G).

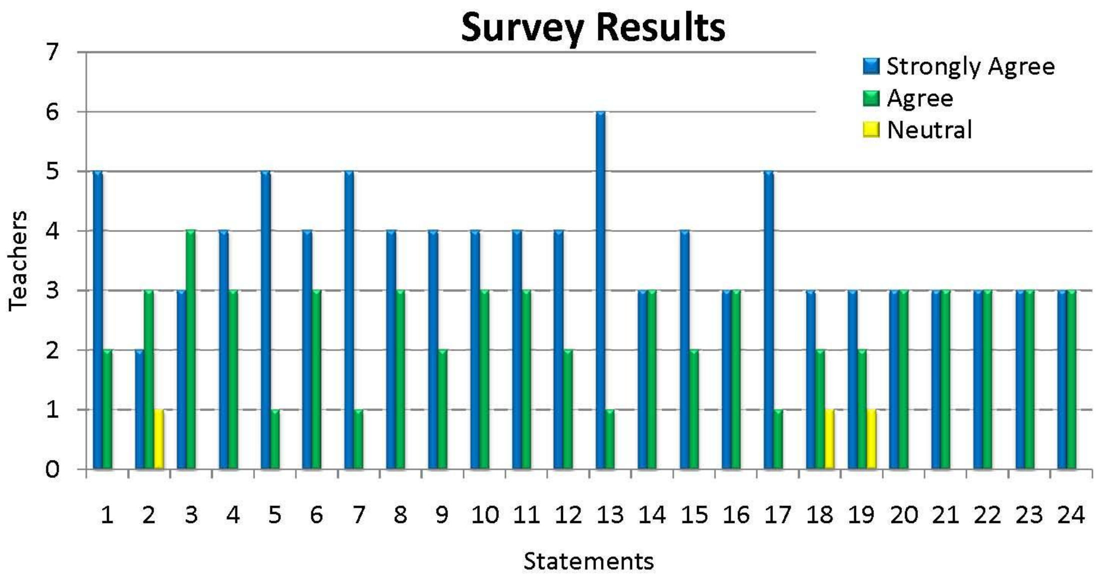


Table 4-1. Survey Results.

Statement 1: The Teacher Instructions Booklet was designed in a clear and easy to understand format.

Five teachers strongly agreed and two teachers agreed. The positive response to this statement shows the teachers felt it was an easy teaching tool. Two teachers commented that they "loved the tabs!" and thought the "tabbed format is wonderful."

Statement 2: The *Homework handout* included helpful inforation to engage students in the complex concepts of enzymes.

Two teachers strongly agreed, three teachers agreed and one teacher was neutral. The neutral teacher commented "I think maybe the 'different ways to look at enzymes' page is irrelevant to the material that students need to know" and "might be too complicated." This answer was foreseen when creating the document. The objective of this case is to give students information that will lead them to advanced placement courses. While this information is not required for standardized testing, it is important for a full scientific understanding of the subject. One of the teachers that agreed with the statement commented "I would like at least 5 questions on the homework assignment." This suggestion was a positive improvement to the homework and therefore two additional questions were developed and added to the final handout.

Statement 3: The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading.

Three teachers strongly agreed and four teachers agreed. Overall, everyone agreed this was an effective way to lay out the answers.

Statement 4: The instructions for playing the animation were clear and helpful.

Four teachers strongly agreed and three teachers agreed. Overall, everyone agreed that playing the animation would be easy. One teacher commented "Great."

Statement 5: The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions.

Five teachers strongly agreed and one teachers agreed. One goal while creating the animation was to involve the students in a class discussion. The positive results from the teachers that answered this question support the successful completion of this goal. One teacher who strongly agreed commented that the questions were "very appropriate for all levels (high and low levels of learners)." This statement suggests that this suitcase will smoothly transition into a variety of biology classrooms.

Statement 6: The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion.

Four teachers strongly agreed and three teachers agreed. Throughout the creation of this entire suitcase, designing instructions that were easy to use and follow was a top priority. The positive results of this statement supported that I had accomplished this priority.

Statement 7: The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics.

Five teachers strongly agreed and one teacher agreed. Respondents agreed, suggesting that the analogies would be successful in the classroom.

Statement 8: The animations clearly described many of the complex concepts of enzymes.

Four teachers strongly agreed and three teachers agreed. Two teachers commented that it would be helpful if I related substrates to reactants. Making a change like this was not possible for the animation. Instead, I opted to add a few sentences to the homework assignment regarding this topic.

Statement 9: The animation would appeal to students.

Four teachers strongly agreed and two teachers agreed. One teacher commented that her students "would find it funny." Of the teachers that responded, all agreed that the students would find the animation appealing.

Statement 10: The teacher instructions on the Jeopardase board game clearly described the full setup of the game.

Four teachers strongly agreed and three teachers agreed. Respondents agreed, suggesting that the instruction were easy to understand.

Statement 11: The question board was easy to display and use during the progression of the game.

Four teachers strongly agreed and three teachers agreed. Three teachers mentioned that they would appreciate having the game set to an interactive Smart Board®. All of the teachers agreed that game was easy to use.

Statement 12: The game created a fun atmosphere that would spark friendly competition between my students.

Four teachers strongly agreed and two teachers agreed. The teachers had the opportunity to play the game and all of those that responded, they agreed that it created a fun atmosphere.

Statement 13: The teacher instructions on the hands-on model demonstration were clear and helpful.

Six teachers strongly agreed and one teacher agreed. The teachers were very excited about the hands-on models. They all thought the demonstration was clear and easy to follow. Two teachers thought the models were so helpful that they requested enough models for the entire class to play with. A few teachers commented "Amazing" and "Love it!"

Statement 14: The teacher instructions of the laboratory experiments were clear and helpful.

Three teachers strongly agreed and three teachers agreed. After the teachers performed these labs by following my instructions they were asked to complete these statements. Of the six that answered, they agreed that the labs were clear to understand. One teacher added “the check-off boxes are neat.”

Statement 15: The laboratory experiments were easy to understand and follow.

Four teachers strongly agreed and two teachers agreed. Six of the teachers found the labs simple to follow. One teacher added that “in the directions, have the students label pH strips. Also, use a pipette to put pH solution on the pH strips.” This comment was in relation to the section of Lab 2: Milk and Rennin, where the students are asked to check the pH of the rennin and pH solution. When testing this lab, I used four inch long strips of pH paper and dipped it into the test tube. The final suitcase contains 3 inch long strips which do not reach the bottom of the tubes. This was a great suggestion and corrections were made to the final lab document.

Statement 16: The labs were good examples of optimal temperature and pH of enzymes.

Three teachers strongly agreed and three teachers agreed. One objective of this suitcase was to teach students about optimal temperature and pH. The positive results indicated that this objective was met.

Statement 17: The photographs throughout the laboratories helped reinforce the procedures of the experiments.

Five teachers strongly agreed and one teacher agreed. One teacher commented the “photographs are extremely helpful.” Of the six teachers that answered, all agreed that the photos were a positive addition to the labs.

Statement 18: The transportation instructions located on the outside of the suitcase were easy to understand.

Three teachers strongly agree, two teachers agreed and one teacher was neutral. Most of the teachers felt that the instructions gave clear descriptions for transporting this suitcase.

Statement 19: The actual suitcase was easy to transport.

Three teachers strongly agree, two teachers agreed and one teacher was neutral. This statement was intended to gather information about the teacher’s opinions of the large suitcase. Overall, the teachers agreed that the case was easy to transport. One teacher commented “most definitely.”

Statement 20: The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase.

Three teachers strongly agree and three teachers agreed. Overall, the teachers agreed that the photographs were a helpful guide for the components of the suticase.

Statement 21: The components of this suitcase will be easy to incorporate into my current curriculum of enzymes.

Three teachers strongly agree and three teachers agreed. One of the objectives for the project was for the components to easily transition into a teacher's current curriculum. Overall, the teachers agreed with this statement.

Statement 22: The components of this suitcase will enhance my current curriculum of enzymes.

Three teachers strongly agree and three teachers agreed. This statement was designed to find out the teacher's overall opinion on this suitcase. Overall, the teachers agreed that the case would improve their teaching materials on enzymes.

Statement 23: The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS.

Three teachers strongly agree and three teachers agreed. Another objective of this project was to bridge the gaps between current learning materials on enzymes and what is required on standardized test.

Statement 24: I would recommend this suitcase to other science teachers.

Three teachers strongly agree and three teachers agreed. This statement was meant to see if the teachers enjoyed this suitcase enough to recommend it to their colleagues. The six teachers that reponded agreed.

Additional Questions

Each teacher was then asked an additional four questions. These questions were designed to see which components the teachers liked, which they disliked and what resources they currently have available to use.

Question 25: Which component of the suitcase do you think was most effective?

Two chose the labs, one chose the animation, one chose the animation along with the models and one chose the animation combined with the models and labs. Two people commented that all of the components will be effective.

Question 26: Which component of the suitcase do you think was least effective?

Two chose the homework handout and four did not answer. One teacher stated “N/A”. This may have indicated that most of the teachers did not feel that any of the components were ineffective.

Question 27: What type of machine do you currently have access to play movies and animations in your class room?

All of the teachers have access to PC computers with a projector, none of the teachers have access to a MAC and three of the teachers had access to TVs with DVD players.

Question 28: Check the boxes next to the components that you currently have for teaching students about enzymes:

Four stated that they have homework with only text, one stated s/he has homework with illustrations and crossed out the word "color", one stated s/he has access to 3D animations, none of them have access to board games, one of them stated s/he has hands-on models but commented that she makes the students create them on their own, six teachers stated that they have access to laboratory experiments. Overall, many of the components that I created are not currently available to all ninth grade biology teachers.

Additional Comments

One teacher felt so strongly about the successfulness of this suitcase that she wrote at the bottom of the page "This is 100 [times] better than what I have in my classroom now. Please build more." This teacher accounted for two out of the three neutral checks throughout this entire survey. These neutrals were on statements 18 and 19 indicated that although she did not completely agree with those statements, she would still want more of these suitcases produced, further emphasizing the success of this project.

CHAPTER FIVE
Conclusions and Recommendations

Project Summary

The purpose of this thesis was to create a portable science suitcase that ninth grade biology teachers can utilize in teaching the complex concepts of enzymes. The goal was achieved by creating visual aids that conveyed the dynamic structure of enzymes, producing a 3D animation with 2D character analogies, designing a game that created a fun and competitive environment, fabricating hands-on models that could be used in a demonstration, developing lab experiments that pertained to students everyday lives and combining all of the components into one easy to use suitcase.

For each component, I constructed initial ideas and storyboards and had them approved by my committee. The homework was produced using Photoshop® to illustrate the images and InDesign® to compile the information. The animation was rendered in 3D Studio Max® and After Effects® and the final piece was rendered as a QuickTime movie from After Effects®. Next I designed the Jeopardase game in Illustrator® and printed the entire piece onto vinyl before adhering it to PVC sheeting. I then designed magnetized enzyme and substrate models that could be demonstrated by the teacher prior to student interaction. Next, I designed two lab experiments that showed the students optimal temperature and optimal pH. The final documents were compiled in InDesign®. Finally, I assembled teacher instructions for all of the components and packed the suitcase with the pieces. Each component of the suitcase was branded using techniques previously described. The final case contained enough resources for a biology teacher to make use of for up to one week.

An evaluations was completed based on a survey of seven teachers in order to determine the ease and effectiveness of the suitcase and how closely it achieved my goals and objectives. There was an overall positive response to all twenty four statements.

Conclusion

The surveys gave extremely positive comments on all of the components of the suitcase. The teachers enjoyed the final product so enthusiastically that they wanted more identical suitcases to be produced.   One of the areas that proved to be innovative and helpful was the hands-on models. Only one teacher expressed using hands-on models in their previous classes and yet all of the teachers agreed that they were useful ways to demonstrate the complex concepts of enzymes. The teachers thought the models were so helpful that they wanted enough for the entire class to utilize. An area for concern was the transportation of the large suitcase because many people that initially viewed the case thought that it would be cumbersome and would not fit into a standard sedan. The teachers agreed that although the suitcase was large in size, transportation would be easy. Based on the responses given from the teachers, the goal and objectives of this thesis were achieved.

Suggestions for Further Research

An initial area for futhur research is to test the suitcase in class rooms and determine if the students' test score actually rise.

Another area would be to evaluate if more students sign up for advanced placement courses after viewing this suitcase.

This project might serve as a model for future suitcases. The components designed for this suitcase are specific to enzymes and might be less appropriate for other areas.

Another area for further research would be that of Smart Boards®. This board is an interactive dry erase board that utilizes a projector. Teachers can use this board for presentations and games. Not all of the teachers involved in my survey had access to a Smart Board® but it seemed to be a resource that many schools were leaning towards.

Additional, research could be conducted to translate all of the documents within this case into Spanish. While all of DISD schools teach in English, many students know Spanish as a first language. This might benefit some of the schools with ESL (English as a second language) students.

APPENDIX A
Pre-Project Surveys

RESPONSE 1 90

RESPONSE 2 107

RESPONSE 3 109

RESPONSE 4 110

RESPONSE 5 112

From: "Steve Hinkley" <Shinkley@natureandscience.org>
To: "Brenda Harrison" <Brenda.Harrison@UTSouthwestern.edu>
Date: Wednesday - October 3, 2007 9:44 PM
Subject: RE: Science Suitcase questions

Hi Brenda and Jennifer,

Attached are a few documents - enzyme labs and brief curricular descriptions. I hope these are helpful.

s

From: Brenda Harrison [mailto:Brenda.Harrison@UTSouthwestern.edu]
Sent: Wed 10/3/2007 1:17 PM
To: Steve Hinkley; Jennifer Hulsey
Subject: Science Suitcase questions

We know you've been out of town but we just wanted to follow up on you answering these questions.

. 1. What resources do you have available from the school? (ie.
> computers for each student? computers that can feed into overhead
> projectors? lab desks with sinks?) And are these computers capable of
> running a large animation?
>
> 2. Do you teach either of these topics; enzymes and/or organelles?
>
> 3. If so, could you send us a copy of your syllabus for each topic? Are
> there specific videos, books, handout, or models that you use? If so,
> could you give us names or titles?
>
> 4. How long are your class periods? And how many days do you spend on
> each of these topics?
>
> 5. What areas of the current curriculum and accessable tools do you find
> lacking? helpful?
>

> 6. Do you notice any specific areas of these topics that students really
> have a hard time grasping?
>
> 7. What ways could you see ninth grade students getting engaged in these
> topics? (ie. 3d models, interactive "games", physical activity, etc.)
>
> 8. Do you have any wishes or ideas for teaching these topics? (ie.
> resources to teach them that the schools do not offer teachers)
>
> 9. Are you willing and/or able to talk further about these topics in the
> future? Maybe even in person?
>
>
>
> Brenda Harrison
> Jennifer Hulsey
> Biomedical Communications
> UT Southwestern Medical Center
>

Name ______________________________

What Can Enzyme Concentration Do?

Objectives:

- Students will prepare various dilute solutions from a 100% enzyme solution.
- Students will determine how enzyme concentration affects reaction rate.
- Students will correctly line graph the observed data.

Materials:

- Medicine cups for dilutions
- Catalase stock or grind a 1 square cm of liver in a 100 mL of water.
- clear vial
- forceps
- filter paper disks (18)
- Hydrogen Peroxide (H_2O_2)
- Gloves, aprons, and eye protection
- paper towel
- watch or clock with a second hand
- metric ruler

Background:

Enzymes are molecular substances found in cells which act as "matchmakers" aiding chemical reactions. Not only do enzymes economize energy usage, but also provide a variety of other functions. Liver cells uses an enzyme (**catalase**) to rid itself of a poisonous substance (**hydrogen peroxide**). The rate at which this occurs depends on the amount of catalase that is available. In this lab we are going to measure the time it takes for a disc of filter paper, soaked with different concentrations of enzyme, to make its way to the top of a plastic vial filled with peroxide.

Procedure:

- Put on a safety goggle and apron.
- Make a series of dilutions of the enzyme catalase using the following table.

Final Quantity Needed	Concentration of Final Solution	mL of Catalase	mL of Water
10 ml	100%	10	0
10 ml	80%	8	2
10 ml	60%	6	4
10 ml	40%	4	6
10 ml	20%	2	8
10 ml	0%	0	10

- Use a marking pencil and mark the enzyme solutions as follows: 100%, 60%, 60%, 40%, 20%, and 0%.
- Fill a clear vial with 20 mL of hydrogen peroxide.
- Using your forceps, pick up one filter paper disk and submerge it in the 100% enzyme solution for 5 seconds. Continue to hold the disk with the forceps.
- Remove the disk from the solution and blot it dry, for five seconds, using your paper towel.
- Drop the disk in the hydrogen peroxide and measure the time it takes for the disk to rise up from the bottom. **Begin timing as soon as the disk touches the surface of the hydrogen peroxide**.
- Use the metric ruler to measure the distance the disk sinks into the hydrogen peroxide. multiply by two to determine the entire distance the disk traveled. Enter the time and distance the disk traveled in the column for Trial 1 in the data table below.

% Catalase	Time in seconds				Distance in millimeters				Reaction Rate mm/s
	Trial 1	Trial 2	Trial 3	Avg.	Trial 1	Trial 2	Trial 3	Avg.	
100									
80									
60									
40									
20									
0									

- Repeat the above steps for the remainder of the solutions. Remember to use clean filter paper each time you use a different solution. Enter the times and distances for trial 2 and 3 in their appropriate columns.

Analysis:

1. Which concentration of catalase had the fastest reaction time? ______________________

2. Which concentration of catalase had the slowest reaction time? _____________________

3. What is catalase?____

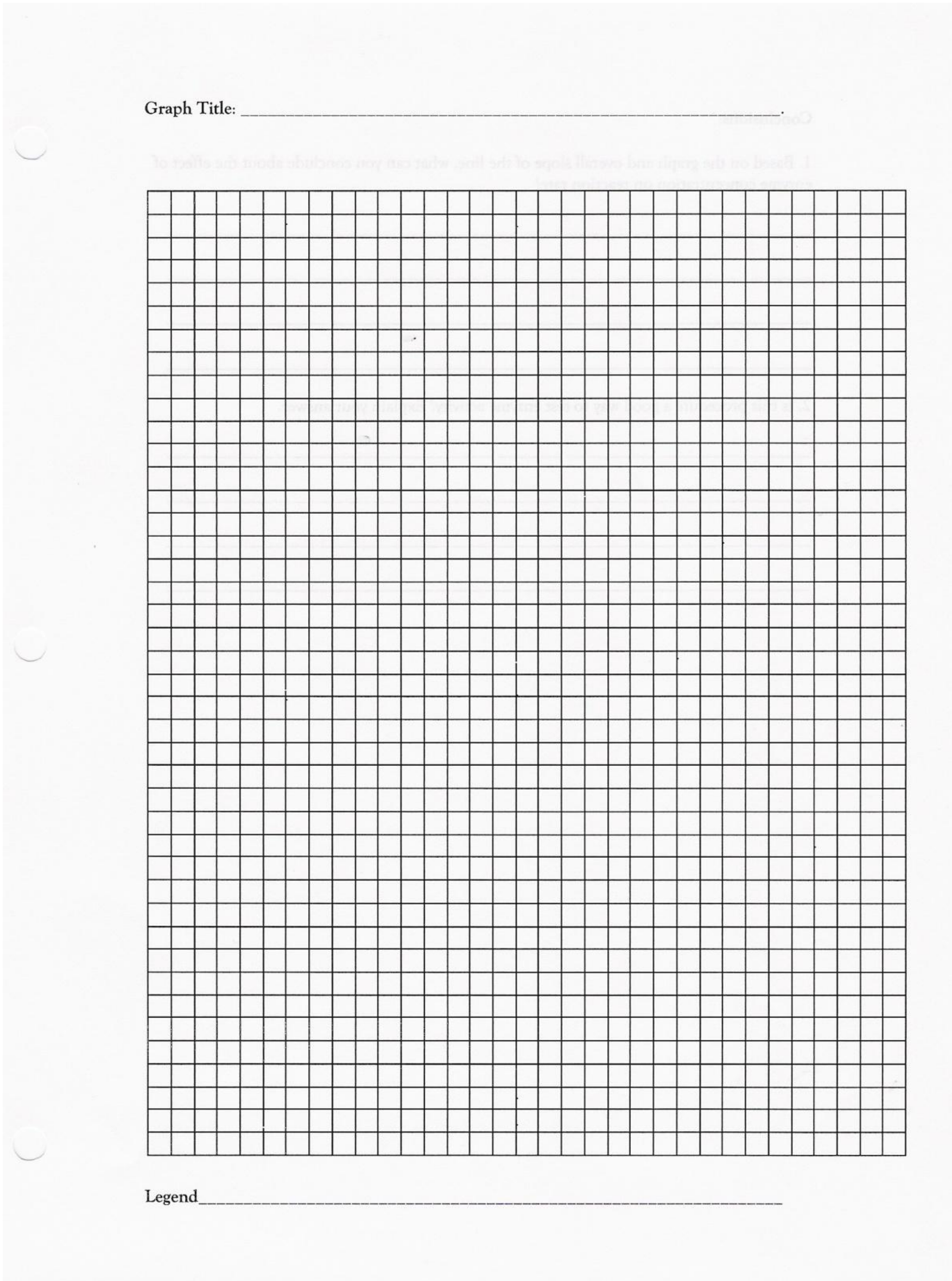
4. Where can catalase be found?____

5. How do we know catalase is present in the above compounds?_____________________

____

6. What type of organic compound is catalase? __________________________________

7. Produce a line graph of the above data. Use the **enzyme concentration** as the independent variable and the **reaction rate** as the dependent variable.



Graph Title: ____

Legend____

Conclusions:

1. Based on the graph and overall slope of the line, what can you conclude about the effect of enzyme concentration on reaction rate?

____

____

____

____

2. Is this procedure a good way to test enzyme activity? Explain your answer.

____

____

____

____

Enzymes and the effect of inhibitors and other factors on enzyme efficiency

Objectives:

1. To study reaction rates of an enzyme-mediated reaction.
2. To study the effects of environmental variables on enzyme function.
3. To collect, graph, and analyze data relating to the reaction.

Purpose:

This exercise is designed to enhance the understanding of enzyme-substrate interactions. The activity should take only a short period of time and ideally be used in conjunction with the actual biochemical experiment.

Materials:

Per group: 50 pennies, masking tape, gloves

Procedure:

TRIAL 1 – NORMAL ENZYME-CATALYZED REACTION

While not looking at the pile of pennies and using one hand, one member of each team will attempt to pick up pennies and place them in groups of six on the table. You will have eight time periods of ten seconds in which to complete this step, with a short break between each period. Other team members will count and record the number of ***complete*** sets of 6 pennies in each trial period. If a set is incomplete at the end of any time period, it can be completed during the next time period, and will count for that trial. Place this data into Table I - Team Data.

TRIAL 2 - DENATURATION

After the pennies have been redistributed on the table, a different member of your group will have the task of picking up pennies in the same fashion, with one exception: in this trial the hand used to pick up the pennies will be taped around all four fingers to represent the partial **denaturation** (change in the structural conformity) of the enzyme. Enzymes, like all proteins, tend to change shape at high temperatures, when in contact with strong acids or bases, or when exposed to heavy metal ions.

Question: Do you expect the number of pairs to be greater or less than in the previous test? Explain your answer.

After running this test for eight periods of 10 seconds (I will time you), record data into Table I - Team Data.

TRIAL 3 - ROLE OF COENZYME

After the pennies have been returned to the table, another team member will perform the penny selecting task. However, this time she will have the help of a teammate, representing the role of a **coenzyme**. The student acting as the coenzyme will be picking up pennies and placing them in the hand of the enzyme catalyst's hand for the ten second time duration. The coenzyme individual may look at the pennies on the table during the time period, but the enzyme catalyst may not. As before, eight time periods will be used and data recorded into Table I- Team Data.

TRIAL 4 - COMPETITIVE INHIBITORS

In this trial the enzyme catalyst will pick up pennies as before but false coins will be added to the pennies and mixed throughout. The false coins represent a **competitive inhibitor,** which diminish your ability to stack pennies *because they utilize (compete for) the same active site*. You will again be given eight time periods of 10 seconds in which to complete as many groups of 6 pennies as possible. Teammates, please record the data in Table I-Team Data.

TRIAL 5 - ALLOSTERIC INHIBITORS

In this last trial any member of the team who wishes will retrieve pennies as before but will be handicapped by taping a tennis ball to the palm of the hand. Obviously, this object may interfere with your ability to pick up the pennies, as it binds to a different part of your hand but ultimately alters the shape of the site at which the pennies are picked up. In this way, the tennis ball represents an **allosteric inhibitor**. You will again be given eight time periods of ten seconds in which to compile as many groups of 6 pennies as possible. Teammates, please record the data in Table I-Team Data.

TABLE I - TEAM DATA

Time Periods	Trial 1 Groups	Trial 2 Groups	Trial 3 Groups	Trial 4 Groups	Trial 5 Groups
0-10					
10-20					
20-30					
30-40					
40-50					
50-60					
60-70					
70-80					

Compile team data for each trial. Record the totals for each trial at each time interval in Table II-Class Data. In order to calculate the total number of pennies selected at any time period, use the following equation: Total # selected = the sum of all previously # selected.

Analysis:

Prepare a graph of Table I - Team Data by plotting time on the independent axis and number of penny groups on the dependent axis. This will result in a linear graph with five lines illustrating the results of the five sets of trial data.

To avoid error, plot and draw graph line for each trial separately.

Questions:

1. In this activity, what was the enzyme represented by? The substrate? The active site? The coenzyme? The inhibitor(s)? The reaction?

2. In trial I, did the rate eventually decrease? If so, what could have been added to maintain the initial rate?

3. If more substrate (pennies) were present in Trial I at the beginning, would the initial rate have been higher? Why or why not?

4. If we assume that the enzyme is represented by the hand, what happened to the active site during Trials 2 and 5?

5. Why does an enzyme not work as well if its active site is changed?

6. What environmental factors affect enzyme shape?

7. What effect did inhibition have on the reaction rate?

8. How might chemicals affect you if they acted like the false coins and tennis ball (inhibitors) during your bodily reactions?

Honors Bio Lab: Gastric Digestion and Enzyme Function

Purpose:

The purpose of this lab is to understand the fundamental makeup and function of enzymes (such as substrate specificity) and to understand how chemical processes that occur in the body are due chiefly to the presence of enzymes that are designed to perform optimally at specific temperature and pH limits in accordance with their location in the body.

Background:

Enzymes, as you have learned, are generally protein-based molecules (occasionally RNA/protein complexes called ribonucleoproteases) that facilitate chemical reactions in living organisms by reducing the amount of energy input required by those organisms. Enzymes are involved in both endergonic and exergonic (non-spontaneous and spontaneous) processes; in exergonic reactions, the enzyme serves to lower the amount of energy input required to "jump-start" a subsequent series of energy-releasing reactions. For example, in the transfer of energy stored in glucose to ATP, enzymes facilitate every step of the process; most notably, they facilitate the initial breakup of glucose that requires an input of 2 ATP. Once this first "hill" is overcome, the remainder of the energy-yielding reactions occur spontaneously, emitting a net of 36 ATP for each molecule of glucose broken down.

In this lab, you will be experimenting with various processes of digestion that occur in the body. In doing so, you will learn the types of enzymes that allow these processes to take place. Specifically, you will observe how these particular enzymes have substrate specificity and also function optimally at very specific temperatures and pH levels.

Procedure:

GASTRIC DIGESTION

Glands in the stomach wall secrete gastric juices containing hydrochloric acid and the enzyme pepsin (a peptidase). These gastric juices aid in the digestion of protein.

With a glass marking pencil, label three test tubes with your group's initials and number them 1GD, 2GD and 3GD. Place one scoop of albumin (rich in protein) in each. Add the following: Test tube 1 should receive 5 mL 0.4% pepsin solution; test tube 2 should receive 5 mL 0.2% HCl, and test tube 3 should receive 5 mL of gastric juice (a combination of pepsin and HCl). Stir each test tube to mix the contents well. Place the test tubes in an incubator at 37 degrees Celsius for one hour. Then remove the test tubes from the incubator. Add 2 to 3 drops of biuret reagent to each test tube and shake. Record the color changes below.

Test Tube	Color before biuret	Color after biuret
1GD		
2GD		
3GD		

1. Biuret reagent reacts with the products of gastric protein digestions (peptides and proteoses) to give a pink-violet color. Whole proteins yield a purple color. In which test tubes did protein digestion occur? Prove your assertion.

2. Why was the incubator set at 37 degrees Celsius? Hypothesize what would have happened if the samples were not incubated, and explain your projection.

3. What is the effect of pH on the enzyme pepsin? Prove your assertion.

INTESTINAL DIGESTION

Digestion begins in the mouth and stomach and is completed in the small intestine. Secretions of the pancreas contain enzymes which complete the digestion of carbohydrates, proteins, and lipids.

With a glass marking pencil label two test tubes with your initials and number them 1ID and 2ID, respectively. To each add 10mL of litmus milk solution. To test tube 1 add one scoop of pancreatin powder; to test tube 2 add a few drops of distilled water. Shake gently to mix the contents. Place the test tubes in an incubator at 37 degrees Celsius for one hour. Then remove the test tubes and observe the color changes. Record the colors.

Test Tube	Color before incubation	Color after incubation
1 ID		
2 ID		

1. Acid production is indicated by a color change in the litmus solution to dark pink-purple. Milk contains proteins and lipids. Why would the digestion of these substances affect the pH of the milk solution?

INTESTINAL DIGESTION

With a glass marking pencil, label three test tubes with your initials and number them 3ID, 4ID and 5ID respectively. Add 5 mL of 5% starch solution to each. To test tube 3 ID, add 5 mL pancreatic solution; to test tube 4 ID add 5 mL water; to test tube 5 ID add 5 mL boiled pancreatic solution. Shake gently to mix the contents. Place the test tubes in an incubator at 37 degrees Celsius for 30 minutes. Then remove the test tubes. Add 2 to 3 drops of iodine-potassium-iodide solution to each test tube. Swirl to mix the contents. The presence of starch will be indicated by a purple-black color. The absence of starch is indicated by a light brown color. Record your observations.

Test Tube	Color before I-K-I	Color after I-K-I
3 ID		
4 ID		
5 ID		

1. What has happened to the starch in test tube 3ID?

2. What is the product of starch breakdown?

3. Why do the results in test tube 5ID differ from the results observed in test tube 3ID?

then they watch a movie called "x", then they can research on www.website, and then they are quizzed on chapter 3-4 from the text "x")

Many teachers the organelle lesson by constructing concept maps, having students create foldables with pictures and organelle functions, or matching organelles with functions on handouts, students color and label cell organelle and write functions. Many teachers have students construct 3-dimensional cell models with labeled cell organelle. Teacher may show animations of cell structure and organelle function from websites, CD Rom's that are textbook ancillaries or videos of cell organelle purchased from science vendors or from the web.

When teaching enzymes teachers can show illustrations of the "lock and key model" or "induced fit" of enzyme and substrate. Again teacher handouts, videos or animations can be used. Samples of enzyme specificity and enzyme action are shown using catalase as an example. Graphs of enzyme activation energy changes are discussed and analyzed. Many other enzymes are illustrated and taught throughout the curriculum such DNA polymerases, helicases, restriction enzymes, etc.

4. Do you notice any specific areas of these topics that students really have a hard time grasping?

Students need a complete understanding of these topics to pass standardized tests required by the state.

5. What ways could you see ninth grade students getting engaged in these topics? (ie. 3d models, interactive "games", physical activity, etc.) **All of the items mentioned above are great.**

Lab:

Liquid Nitrogen/ Properties of Water as it freezes (Mike Silver)

1.3 Carbon

Concepts:

-tetravalent properties are critical to forming chemical backbone for large molecules called macromolecules; variation is the key to complexity of life

-carbon backbone + functional group(s) = macromolecule/MONOMER

1.4 Macromolecules

Concepts:

-Carbohydrates: CH_2O

-monosaccharide/polysaccharide (energy/storage, structure)

-assembling polysaccharides

-Lipids

-fats/oils (energy storage, insulation, protection)

-mono = fatty acid, long hydrocarbon chain

-fat: saturated and unsaturated, difference

-nonpolar, reject water

-cholesterol: backbone of steroids

-also in blood (HDL, LDL)

-phospholipids: importance in membrane structure

-polarity creates semi-permeable barrier w/protein channels

-Proteins

-polypeptide, monomer: amino acid

-can be folded into multiple structural varieties

-shape/conformation determines function (chaperonins)

-most diverse group of macromolecules: structure, immunity, recognition, enzymes, small energy (deamination for use in Krebs), transport (uniport, symport, antiport), etc.

-Nucleic Acids

-monomer: nucleotide, know structure

-store instructions for chemical reactions/ basis of all life

-two basic types: DNA, RNA

-show assembly of DNA, uniqueness

-chromosome: assemblage of DNA/proteins

Labs:

Visualization of DNA (Carolina)

Analysis of Precut λDNA – **Formal write-up**

****QUIZ****

Supplemental:

Macromolecule Structure Handout

Worksheets on DNA splicing/RFLP banding

1.5 Metabolism

Concepts:

-anabolic/catabolic, endergonic/exergonic

-first and second laws of thermodynamics

-organisms are constantly restructuring molecules to provide energy

-all input originally comes from sun

-energy coupling reactions (role of **ATP** as a product of exergonic used to drive endergonic)

1.6 Enzymes

Concepts:

-speed up reactions by lowering E_A, not consumed in reaction, "-ase" suffix

-enzyme-substrate complex/ substrate specificity

-coenzymes (usually vitamins/minerals – inorganic typically)

-found in locations to assist the logical progression of a reaction (ex: respiration)

-regulation (inhibition, heat speeds up then degrades, allosteric)

Labs:

Enzyme function (pennies)

Enzyme function (digestion and factors that affect rates of rxn.) (Carolina)

Unit Assessments:

Problem Set 1 (molecular structure, water, monomers)

Problem Set 2 (polymers, DNA, enzymes)

Graphical understanding of rates of reactions

----- Original Message -----

From: "Brenda Harrison" <Brenda.Harrison@UTSouthwestern.edu>

To: <canzaldu@dallasisd.org>; <lvaladez@dallasisd.org>;

<sross@dallasisd.org>; <vireyes@dallasisd.org>; <martha-m-lee@sbcglobal.net>

Sent: Wednesday, August 22, 2007 7:09 PM

Subject: teacher's opinions needed for Museum of Nature and Science

We are medical illustration students at UT Southwestern and we were given your emails from the Jeannie Han with the Stars group. We were asked to create "science suitcases" for the Museum of Nature and Science on topics that students have consistently scored poorly on during tests. These suitcases can be used for free by any teachers in the area to encourage their students to learn more and hopefully have the topics really "stick". I was chosen to create one on "enzymes" and another girl in our program, Jennifer, was chosen to work on "organelles". So the bulk of our questions revolve around the problems that teachers face trying to teach these subjects.

We were wondering if you could give us the contact information for some high school science teachers that would be willing to answer the following questions.

1. What resources do you have available from the school? (ie. computers for each student? computers that can feed into overhead projectors? lab desks with sinks?)

Many teachers have all of these items. Many teachers now have access to In-focus machines to project animations in the classroom.

- full computer
- sinks/labs

2. Do you teach either of these topics; enzymes and/or organelles?

All teacher in the district must teach these topic. These topics are part of the required content that must be taught based on Texas State requirements called TEKS.

3. If so, could you give us a brief description of the lessons for each topic? (ie. we let the students do a science experiment called "x",

6. Do you have any wishes or ideas for teaching these topics? (ie.

resources to teach them that the schools do not offer teachers)

Each school has differences in the items available. However,

hands-on manipulative models for classroom investigation are needed

for both topics.

7. Are you willing and/or able to talk further about these topics in the future? Maybe even in person? **OK**

Again, thank you so much for taking the time to answer some questions. We are really trying to make something that teachers can utilize and students can enjoy.

Brenda Harrison

Jennifer Hulsey

UT Southwestern

Biomedical Communications Department

CC: "Martha Lee" <mlee@dallasisd.org>, "Brenda Harrison" <Brenda.Harrison@UTSouthwestern.edu>

1. What resources do you have available from the school? (ie. computers

for each student? computers that can feed into overhead projectors? lab

de[illegible] 'th sinks?)

* single computer + overhead projector

I teach at Townview Magnet Center. We have computers, but not for each student. The teachers have computers, and most have laptops as well. The computers can be linked to projectors which display information on a screen for students. There are several SMART Boards that we can "check out". All instructors have televisions and DVD players in their rooms, some have VCRs as well.

2. Do you teach either of these topics; enzymes and/or organelles?

I teach both of these topics

3. If so, could you give us a brief description of the lessons for each

topic? (ie. we let the students do a science experiment called "x", then

they watch a movie called "x", then they can research on www.website, and

then they are quizzed on chapter 3-4 from the text "x")

I use guided discussion, followed by role-playing, followed by some sort of experiment, followed by question answering session.

4. Do you notice any specific areas of these topics that students really

have a hard time grasping?

no

5. What ways could you see ninth grade students getting engaged in these

topics? (ie. 3d models, interactive "games", physical activity, etc.)

I feel that students are more lively to learn from a hands on situation, although I think that especially for enzymes a game would be very useful.

6. Do you have any wishes or ideas for teaching these topics? (ie.

resources to teach them that the schools do not offer teachers)

7. Are you willing and/or able to talk further about these topics in the

future? Maybe even in person?

yes

From: "KAREN MACVEY" <KMM112500@msn.com>
To: <Brenda.Harrison@UTSouthwestern.edu>
Date: Thursday - August 23, 2007 3:59 PM
Subject: suitcase project

Hi Brenda,

I received info regarding your suitcase project....and would like to help. I just started a new job as Science Facilitator for Garland ISD after teaching 19 years in Dallas. I am also a former grad student from UTSW DCMB and especially appreciate your efforts in helping public schools with science lessons.

ALL high schools in Texas MUST teach about both organelles and enzymes. They are part of the state curriculum known as TEKS (you can view these essential knowledge and skills yourself on the Texas Education Agency website.) Students must be able to identify organelles within the cell, relate structure to function, and identify cells (prokaryote vs eukaryote, plant vs animal) based on the presence or absence of identifying organelles. What compounds the difficulty students have in this area is that different teachers use different definitions of "organelle", some teachers and textbooks call any part of any cell an "organelle" while others more strictly use the term to define membraneous compartments. Students can usually identify plant and animal cells, while having more difficulty differentiating eukaryote/prokaryote cells. They usually can identify the structure and function of the nucleus but are much less successful with any other cell parts. In a typical lesson that I have done, students are usually shown an introductory video or powerpoint that discusses/shows examples of different cell types and associated organelles' structure and function. Then we use cell models where the students place the organelles in their appropriate locations within each cell type. Following this, we also model a virus as comparison. To end the lesson, the kids make a venn diagram comparing components of eukaryote cells, prokaryote cells, and viruses. Throughout the lesson, I have the kids color and label diagrams of each type as homework assignments. In honors classes, an added project is given - students compare a cell type of their choice to any other system (school, library, factory, etc) and make comparisons with 10 organelles; eg. the nucleus in the animal cell is like the principal's office in the school because it is the control center for the system. In my opinion, this project is what really cements the info for the kids. It also seems that kids do much better when they are presented with a wide variety of different types of activities with this content.

Enzymes are a much less important topic according to the state (fewer TEKS and much less emphasis on TAKS). Kids basically need to know that enzymes are proteins that act as catalysts, that environmental factors such as temperature and pH have an effect on reaction rates, and that enzymes aren't used up in the reaction. I usually discuss enzymes in conjunction with digestion - something most of them are familiar with. I show them video clips of enzymes and substrates, followed by a paper model lab where kids have to cut out models of enzymes and match them with their complementary shaped substrates and then predict what the product or products might look like. We also do a wet lab using catalase from both liver and potato. Kids vary the temperature (hot, room, cold) and pH (acid, neutral, basic) and compare the speed of bubbling when hydrogen peroxide is added to either the liver or potato. Bubbling speed is ranked 0-5 and the data graphed and compared. They seem to get the vocabulary confused a lot, enzyme and substrate are often reversed in their minds. They also have a hard time relating to enzymes as proteins within cells. They think the liver IS the enzyme or the potato IS the enzyme. For homework, I have kids draw and label a diagram of an enzyme/substrate reaction showing before, during, and after the reaction has occurred. This seems to help a lot. I think a good 3D model would be a great aid for this lesson but I have not found or created one. Well, I hope some of this info is useful to you and please feel free to email me again directly if you have other questions. Again, thanks so much for working to help these kids learn!

Karen MacVey
Science Facilitator
Sachse High School
Garland ISD

From: "Holly Bishop" <bishoph@hpisd.org>
To: <Brenda.Harrison@UTSouthwestern.edu>
Date: Sunday - August 12, 2007 7:49 PM
Subject: Re: teachers' opinions' needed for thesis

Sounds like an interesting project! I for one appreciate you doing this. Here are the answers to your questions.

1. What resources do you have available from the school? (ie. computers for each student? computers that can feed into overhead projectors? lab desks with sinks?)
I teach in a high school. We have a computer lab we have limited access to where each student will have a computer. The teacher computer in every classroom feeds into a projector system. We have access to a full lab at any time with plenty of sinks.

2. Do you teach either of these topics; enzymes and/or organelles? Yes - I teach Biology.

3. If so, could you give us a brief description of the lessons for each topic? (ie. we let the students do a science experiment called "x", then they watch a movie called "x", then they can research on www.website, and then they are quizzed on chapter 3-4 from the text "x")
Oh gosh. I'm still in summer brain mode. With organelles we do a project called "Sell a Cell Organelle" where they make up a magazine type ad and a commercial along with a paragraph describing their organelle. They try to "sell" their organelle to the class. (each group of 3-4 gets a different organelle.) We watch a video, but I can't remember what it's called about organelles as well. I give PPT notes with pictures. They'll test on it along with mitosis. For enzymes, we do a liver and apples lab where they see the effects of ph, temperature, etc. on catalase and catecholase. We do some PPT notes, we do a salivary enzyme lab where their spit is used. They'll do a review and test over it. And of course, chapter reading is assigned, but they rarely do it. And there's probably a quiz or two in there somewhere. I could tell you better if I were at school with my outline from last year in front of me. I'm just doing this from memory.

4. Do you notice any specific areas of these topics that students really have a hard time grasping?
Optimal temperature for some is difficult. They don't always understand just how important enzymes are for life to exist. The term catalyst is difficult for them to grasp. Specificity is hard sometimes.

5. What ways could you see ninth grade students getting engaged in these topics? (ie. 3d

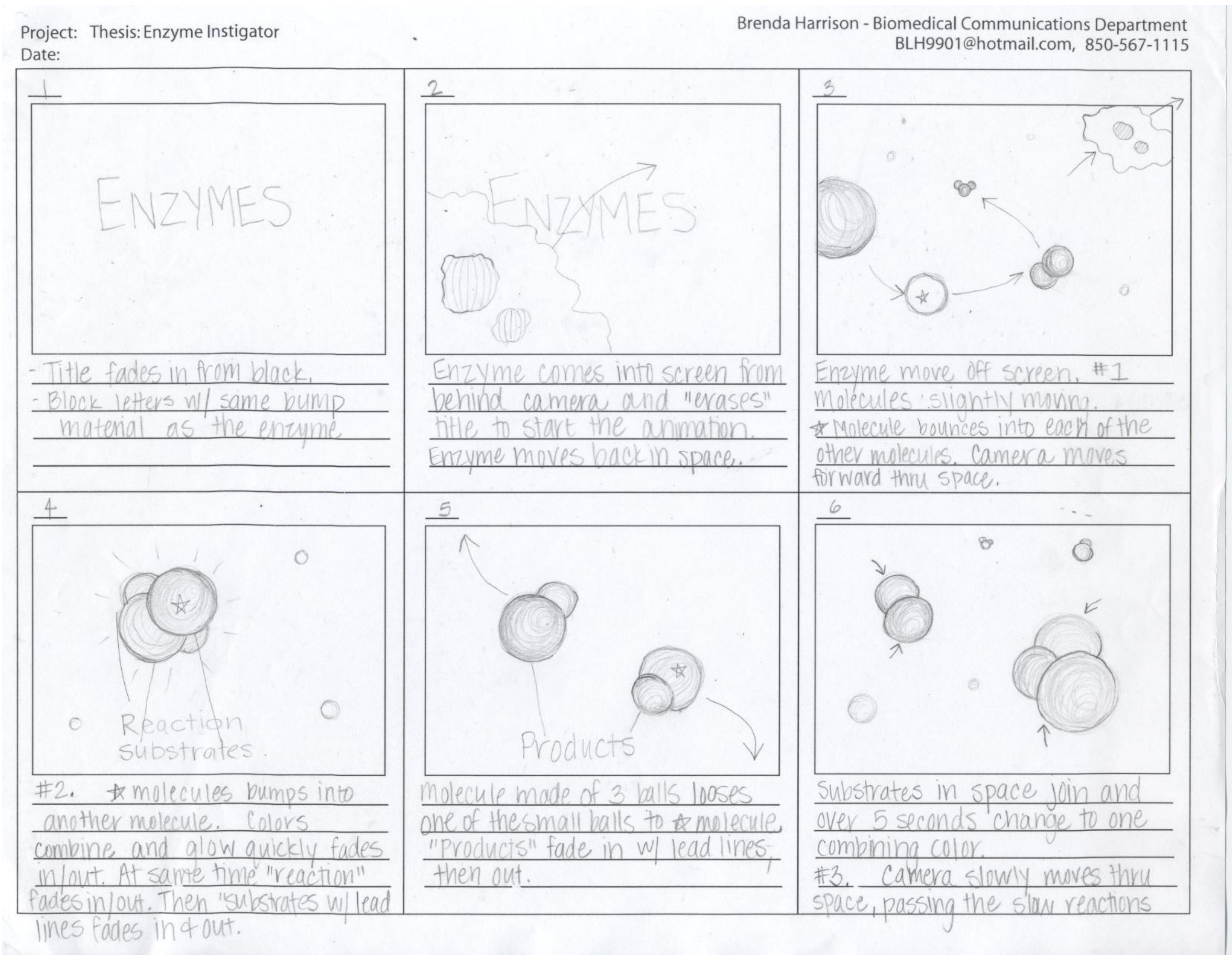
models, interactive "games", physical activity, etc.) You could demonstrate by having two kids wander around the room blindfolded and see how long it takes them. Then use someone to be a catalyst and join them and see how much quicker it is. For organelles, make the cell like a factory or town or something and have them model how/what each organelle does.

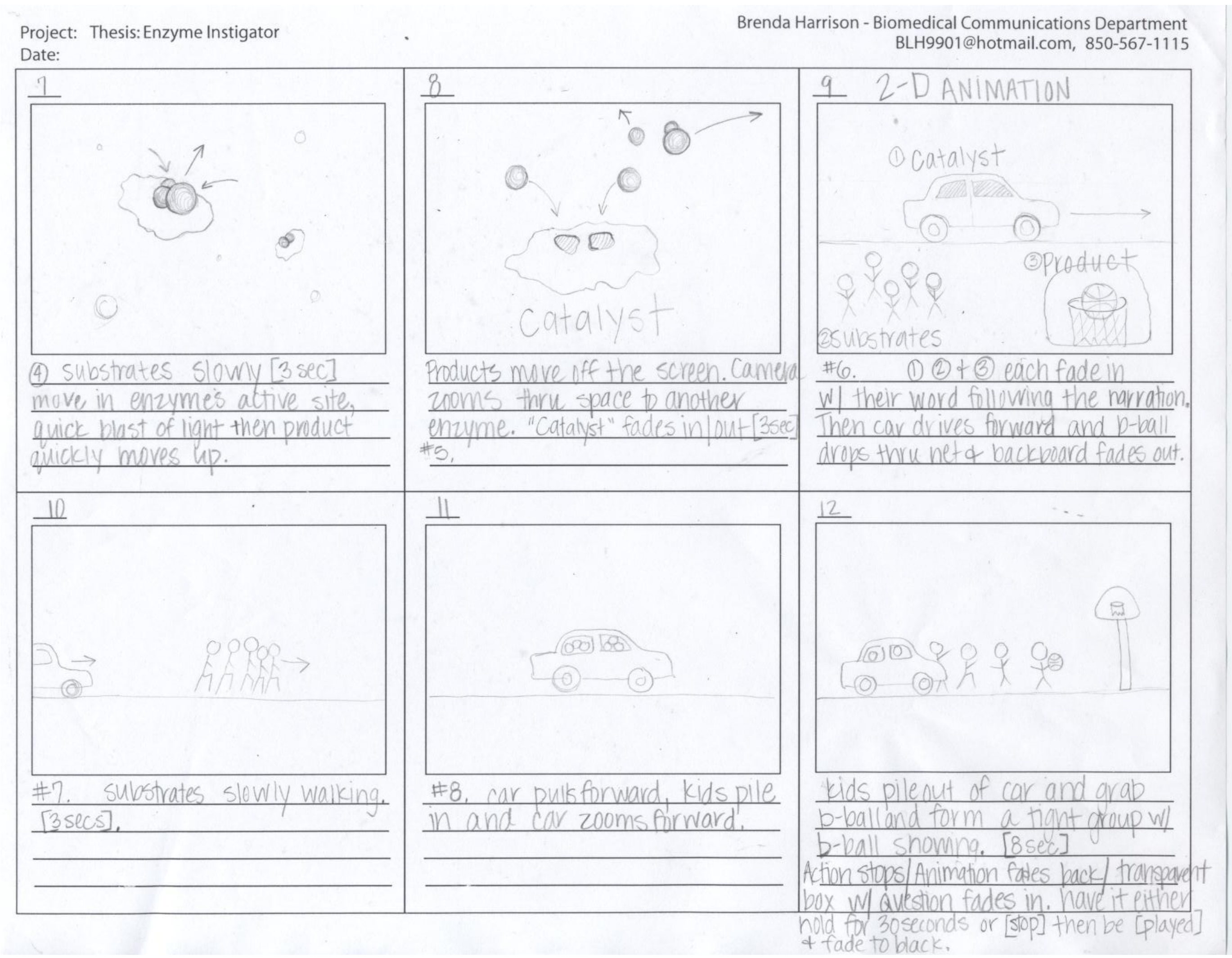
6. Do you have any wishes or ideas for teaching these topics? (ie. resources to teach them that the schools do not offer teachers) Not that I can think of right off. Ideas for more labs maybe.

7. Are you willing and/or able to talk further about these topics in the future? Maybe even in person? Certainly - 214.263.0518

I hope this was somewhat helpful. Give me a call if you need more info!
Holly

APPENDIX B
Storyboards

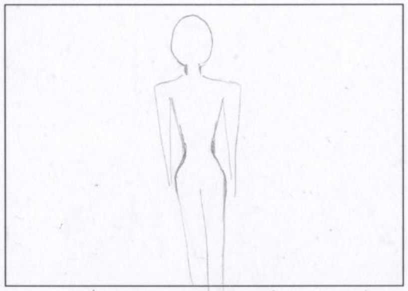

Project: Thesis: Enzyme Instigator
Date:
Brenda Harrison - Biomedical Communications Department
BLH9901@hotmail.com, 850-567-1115
1
ENZYMES
- Title fades in from black.
- Block letters w/ same bump material as the enzyme.
2
ENZYMES
Enzyme comes into screen from behind camera and "erases" title to start the animation. Enzyme moves back in space.
3
Enzyme move off screen. #1 Molecules slightly moving. ☆ Molecule bounces into each of the other molecules. Camera moves forward thru space.
4
Reaction
Substrates
#2. ☆ molecules bumps into another molecule. Colors combine and glow quickly fades in/out. At same time "reaction" fades in/out. Then "substrates w/ lead lines fades in & out.
5
Products
Molecule made of 3 balls looses one of the small balls to ☆ molecule. "Products" fade in w/ lead lines, then out.
6
Substrates in space join and over 5 seconds change to one combining color.
#3. Camera slowly moves thru space, passing the slow reactions


Project: Thesis: Enzyme Instigator
Date:
Brenda Harrison - Biomedical Communications Department
BLH9901@hotmail.com, 850-567-1115
7
④ substrates slowly [3 sec] move in enzyme's active site, quick blast of light then product quickly moves up.
8
Catalyst
Products move off the screen. Camera zooms thru space to another enzyme. "Catalyst" fades in/out [3sec] #5.
9 2-D ANIMATION
① Catalyst
② substrates
③ Product
#6. ① ② + ③ each fade in w/ their word following the narration. Then car drives forward and b-ball drops thru net + backboard fades out.
10
#7. substrates slowly walking. [3 secs].
11
#8. car pulls forward, kids pile in and car zooms forward.
12
kids pile out of car and grab b-ball and form a tight group w/ b-ball showing. [8 sec]
Action stops/Animation fades back/ transparent box w/ question fades in. have it either hold for 30 seconds or [stop] then be [played] + fade to black.

Project: Thesis: Enzyme Instigator
Date:

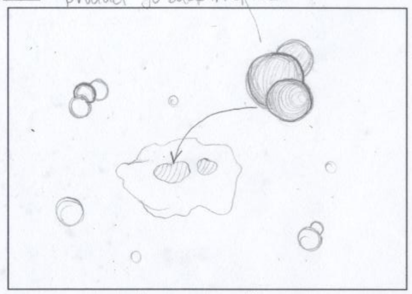
Brenda Harrison - Biomedical Communications Department
BLH9901@hotmail.com, 850-567-1115

13



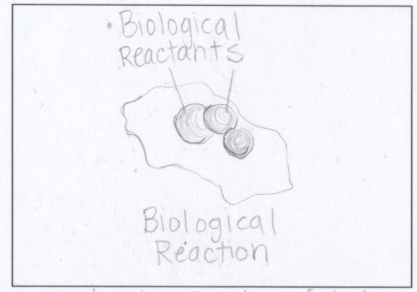
#9. androgenis figure fades in from black. Camera zooms in. [3 secs]

14 have sub. move from front + then product go back in space.



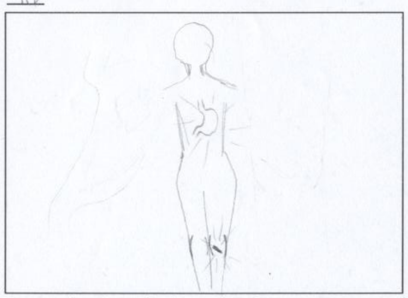
#10. substrates all around the enzyme trying to start a reaction. Substrates of the same color move one at a time into active site where burst of light and then product moves out.

15



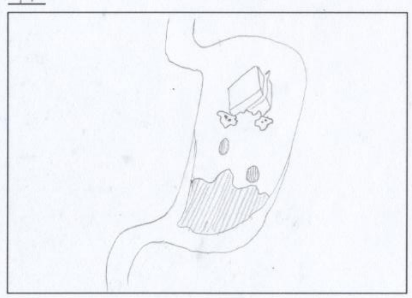
#11 "Biological Reaction" fades in w/ dialoge, then out.
"Biological Reactants" w/ lead lines fades in w/ dialogue, then out.
Fade to black.

16



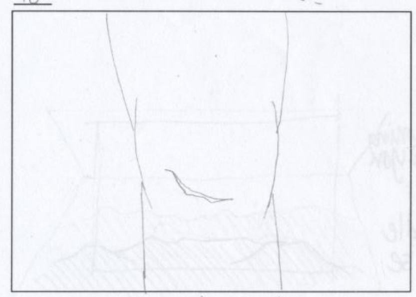
#12 body fades in from black w/ glowing stomach and cut on knee.

17



#13 zoom into cross section of stomach w/ sandwich. Show small enzymes pulling small pieces of sandwich off + the pieces falling into the watery mush at bottom of stomach.
Zoom out to body (16)

18



#14 Zoom into red cut.

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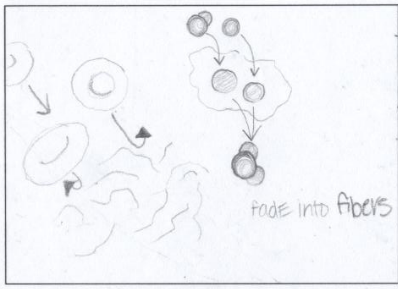
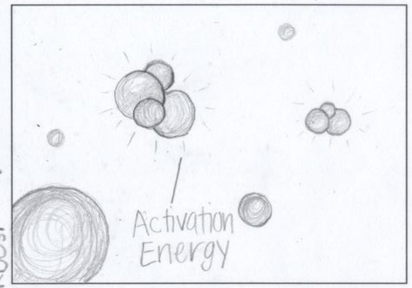
19



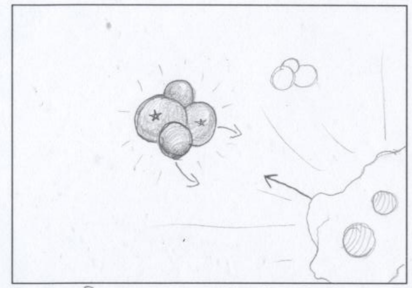
zoom into cut. #14. show substrates going into active site, then product going into / fading into growing fibers which are stopping the forward movement of RBCs. Action stops / fades back / 50% opacity square w/ question fades in.

20



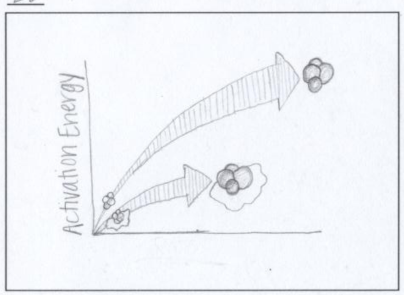
#15. Substrates are slowly moving around space. A few subs. are trying to react. This is shown by weak light flickering like a light bulb burning out. "Act. Energy" fades in and holds for [ ]sec. Camera moving slowly forward to see Rxns.

21



#16. Enzyme moves in from behind camera w/ a very bright glow light. ☆Substrates and Enzyme move into middle of screen, join @ activation site and quickly release a product after blast of light. Enzyme continues back in space.

22

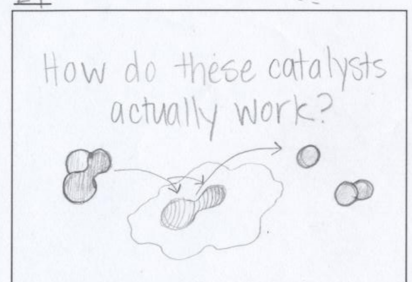


#17. "Act. Energy", the lines of graph and a small version of subs. + subs./Enzyme rxn fade in over 3sec. Arrows and Rxns grow + move right. Subs./Enzyme rxn take 2sec. While subs. rxn moves slower @ 6sec. Camera waits for enzyme rxn, then zooms + follows subs. rxn, then backs out to view entire graph. Fades to black.

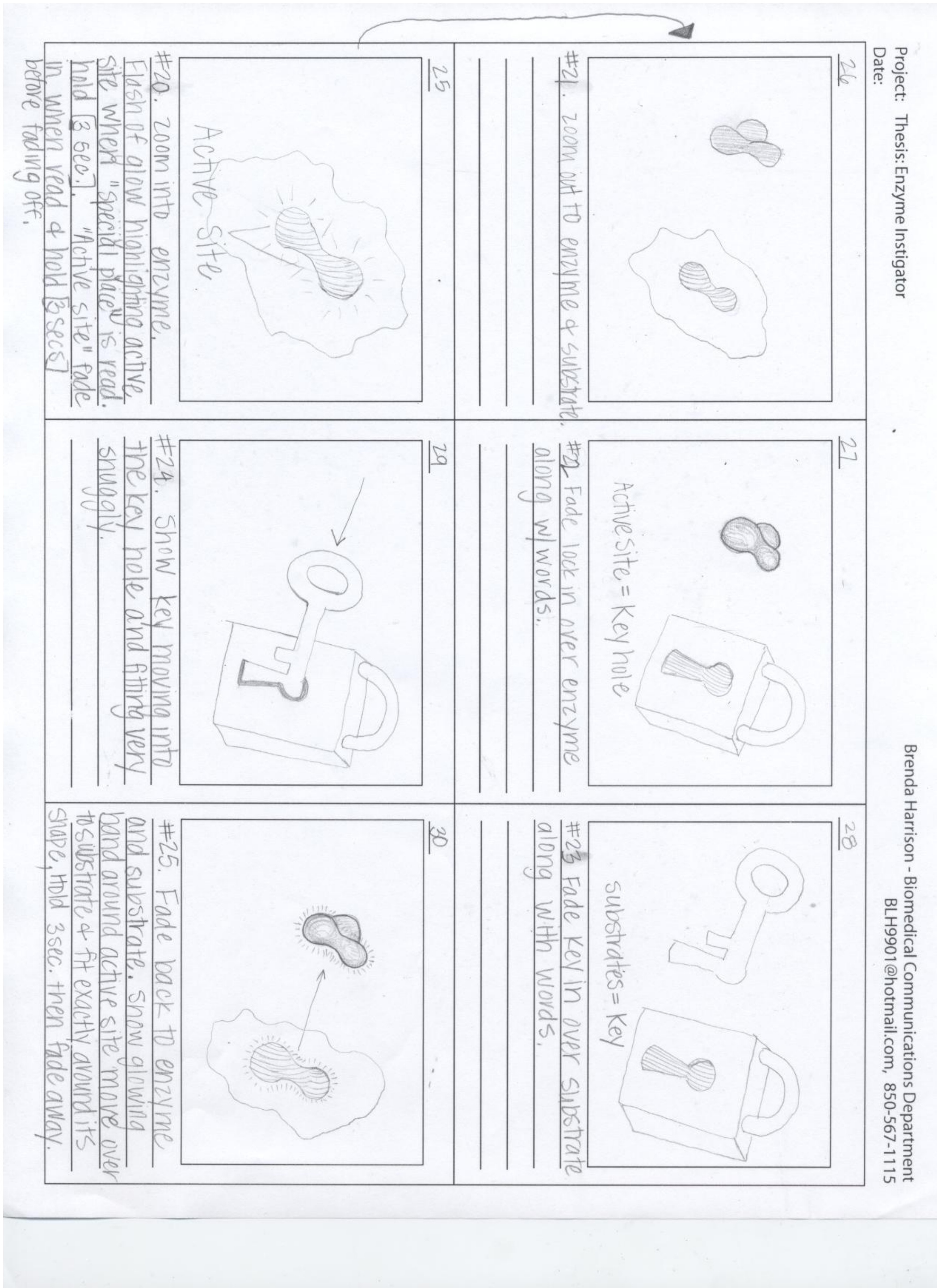
23

#18. Stomach + knee w/ cut fade in w/ dim glow. Action stops / fades some / box w/ Question fade in.

24



#19 Words fade in from black. @ same time → enzyme fades in and shows substrates entering active site + then products exiting. Burst of light @ rxn and show start movement of enzyme. Words and products fade fade after [ ]sec.


Project: Thesis:Enzyme Instigator
Date:
Brenda Harrison - Biomedical Communications Department
BLH9901@hotmail.com, 850-567-1115
26
#21. zoom out to enzyme & substrate.
27
Active site = Key hole
#22 Fade lock in over enzyme along w/ words.
28
substrates = Key
#23 Fade key in over substrate along with words.
25
Active Site
#20. zoom into enzyme. Flash of glow highlighting active site when "special place" is read. hold [3 sec]. "Active site" fade in when read & hold [3 secs] before fading off.
29
#24. Show key moving into the key hole and fitting very snuggly.
30
#25. Fade back to enzyme and substrate. Show glowing band around active site "move over to substrate & fit exactly around its shape, hold 3sec. then fade away.

Project: Thesis: Enzyme Instigator
Date:

Brenda Harrison - Biomedical Communications Department
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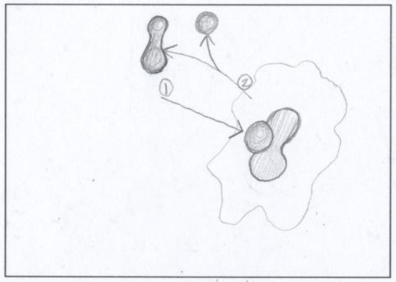
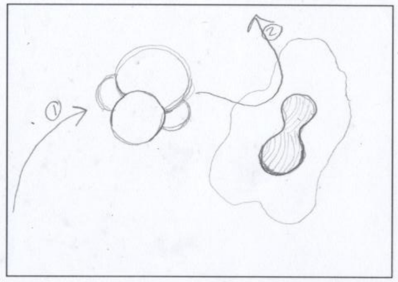
31



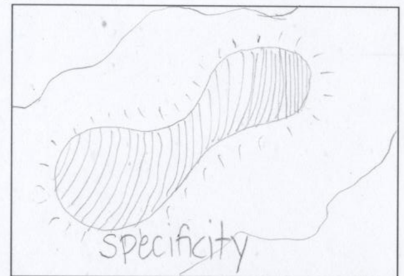
#26. Show substrate move into active site, break apart w/ burst of light (energy) and products move away.

32



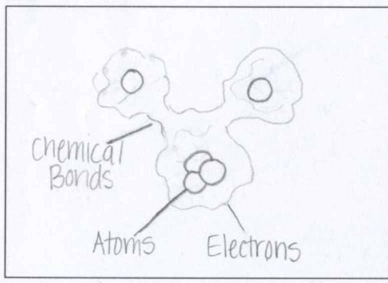
#27. Show a substrate come in from behind camera w/ a very obvious different shape. Show it try to enter active site, not fit and move on into distance.

33



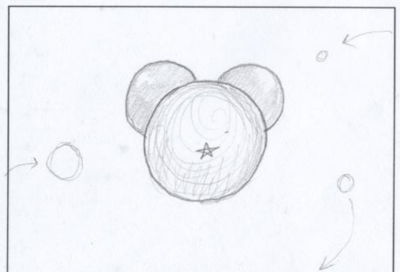
#28. Zoom into enzyme. Fade "specificity" + glowing band around active site w/ script. hold (3sec) then zoom + fade to black @ same time.

34



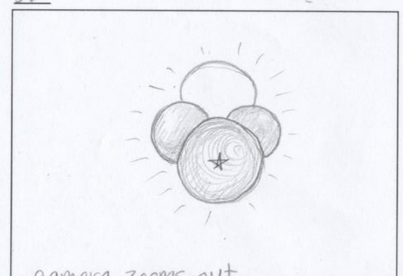
#29. Start zoomed in on the large middle atom. Zoom out while showing moving smokey electron cloud around atoms. Have tags fade in w/ script. All tags hold for 3 sec.

35

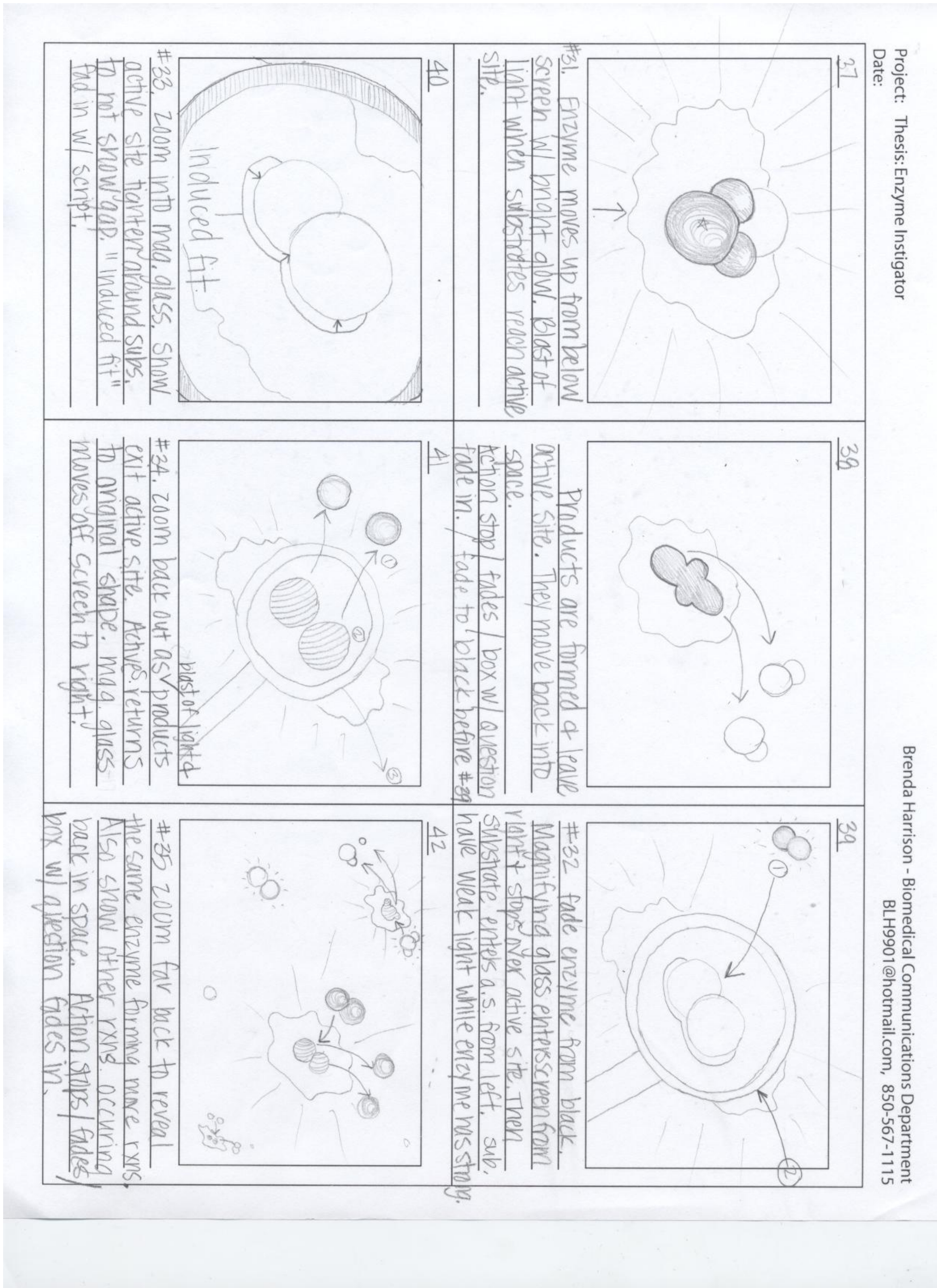


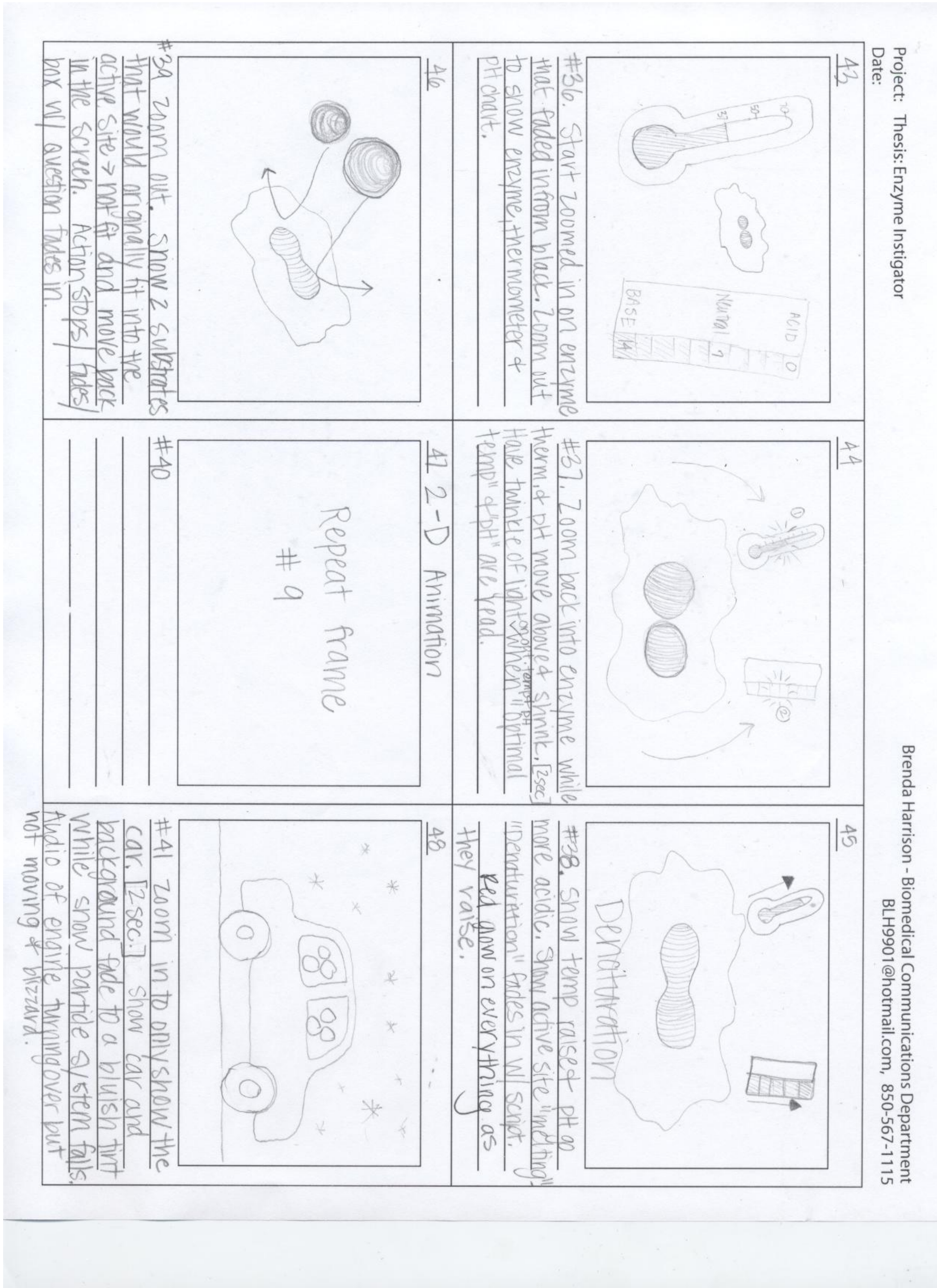
Have "space filling" model fade in over the atoms and electrons (2sec). Have some other substrates move into the screen, some closer than others.

36



camera zooms out.
#30. Show another substrate push next to substrate and a weak glow come off them. Show substrates struggling by glow fading in and out.


Project: Thesis: Enzyme Instigator
Date:
Brenda Harrison - Biomedical Communications Department
BLH9901@hotmail.com, 850-567-1115
37
#31. Enzyme moves up from below screen w/ bright glow. Blast of light when substrates reach active site.
38
Products are formed & leave active site. They move back into space.
Action stop / fades / box w/ question fade in. / fade to black before #39
39
#32 fade enzyme from black. Magnifying glass enters screen from right & stops over active site. Then substrate enters a.s. from left. sub. have weak light while enzyme has strong.
40
Induced fit.
#33. Zoom into mag. glass. Show active site tighten around subs. to not show "gap." "induced fit" fad in w/ script.
41
blast of light & products
#34. Zoom back out as products exit active site. Active s. returns to original shape. mag. glass moves off screen to right.
42
#35 zoom far back to reveal the same enzyme forming more rxns. Also show other rxns. occurring back in space. Action stops / fades / box w/ question fades in.



Project: Thesis: Enzyme Instigator
Date:
Brenda Harrison - Biomedical Communications Department
BLH9901@hotmail.com, 850-567-1115
43
ACID 0
Neutral 7
BASE 14
#36. Start zoomed in on enzyme that faded in from black. Zoom out to show enzyme, thermometer & pH chart.
44
#37. Zoom back into enzyme while therm. & pH move above & shrink. [2sec] Have twinkle of light when "optimal temp" & "pH" are read.
45
Denaturation
#38. Show temp raise & pH go more acidic. Show active site "melting" "Denaturation" fades in w/ script. Red glow on everything as they raise.
46
#39 Zoom out. Show 2 substrates that would originally fit into the active site → not fit and move back in the screen. Action stops / fades / box w/ question fades in.
47 2-D Animation
Repeat frame # 9
#40
48
#41 Zoom in to only show the car. [2 sec.] Show car and background fade to a bluish tint while snow particle system falls. Audio of engine turning over but not moving & blizzard.

Project: Thesis: Enzyme Instigator
Date:

Brenda Harrison - Biomedical Communications Department
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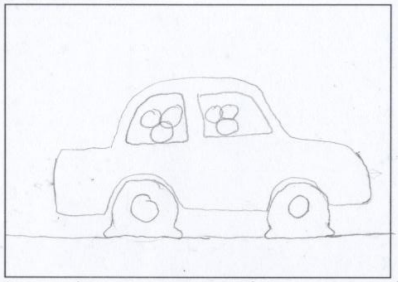
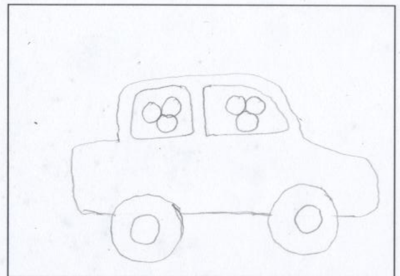
49



#42. Show car and background fade to red tint. [2sec] Show tires melt to ground. Audio of engine on but sticky sound & fire crackles.

50



#43 Show car fade back to normal color. Audio of birds chirping. Then show car moving forward.

51

Repeat of Frame #12

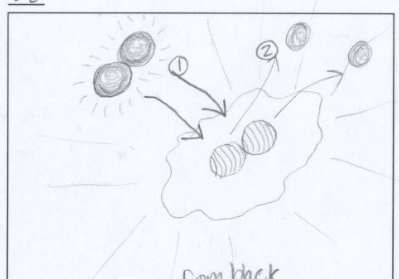
#44 Substrates get out of car and clump together w/ a basket ball.

52

Repeat frame #44.

#45 fade to enzyme, temp and pH. Have a glow twinkle in over opt. temp. & pH w/ script. Action stops/ fades/ box w/ question fade in!

53

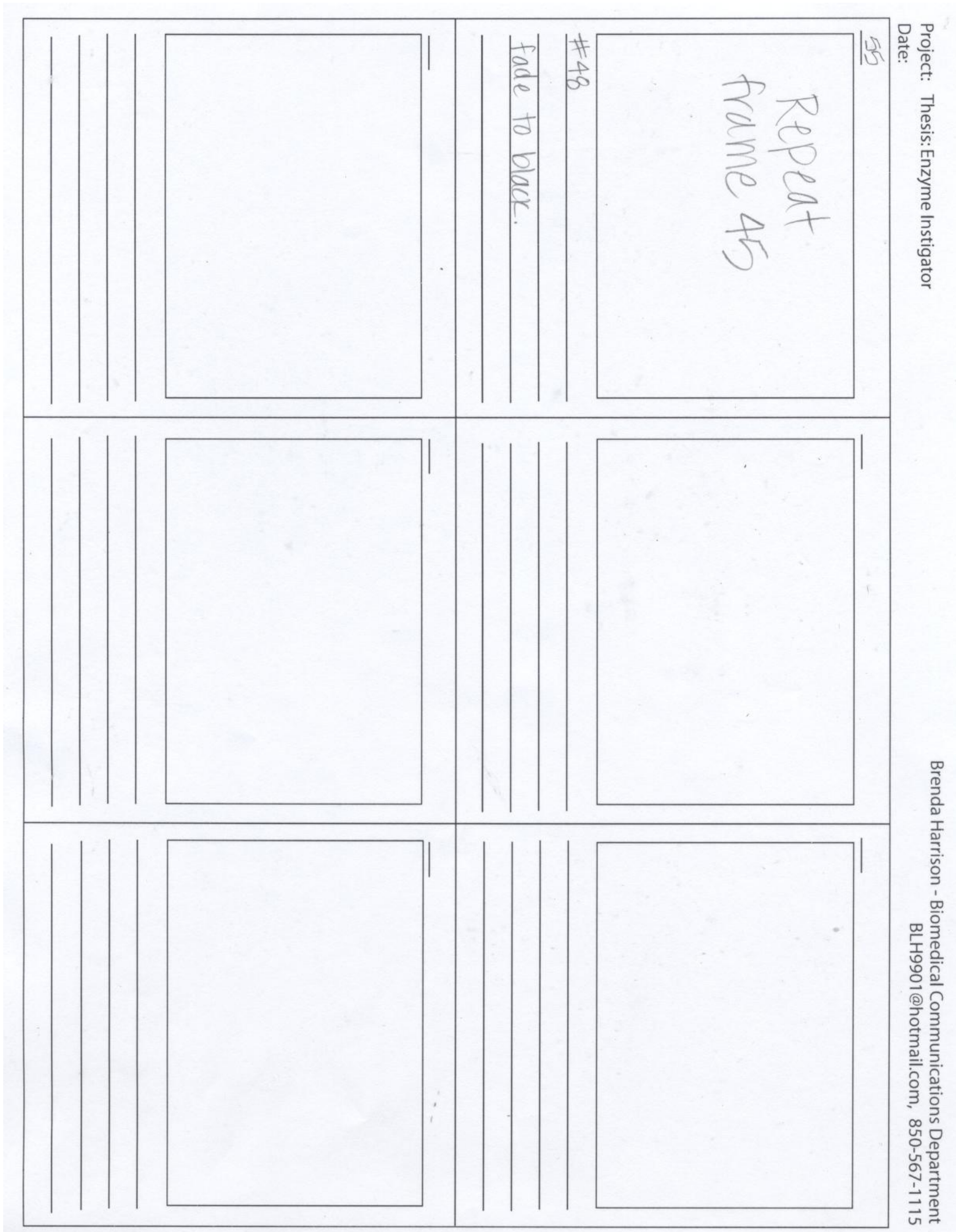


#46 fade in from black bright enzyme and weak-glow substrates. Show subs. enter active site and blast of light. Then show products exit. Fade to black.

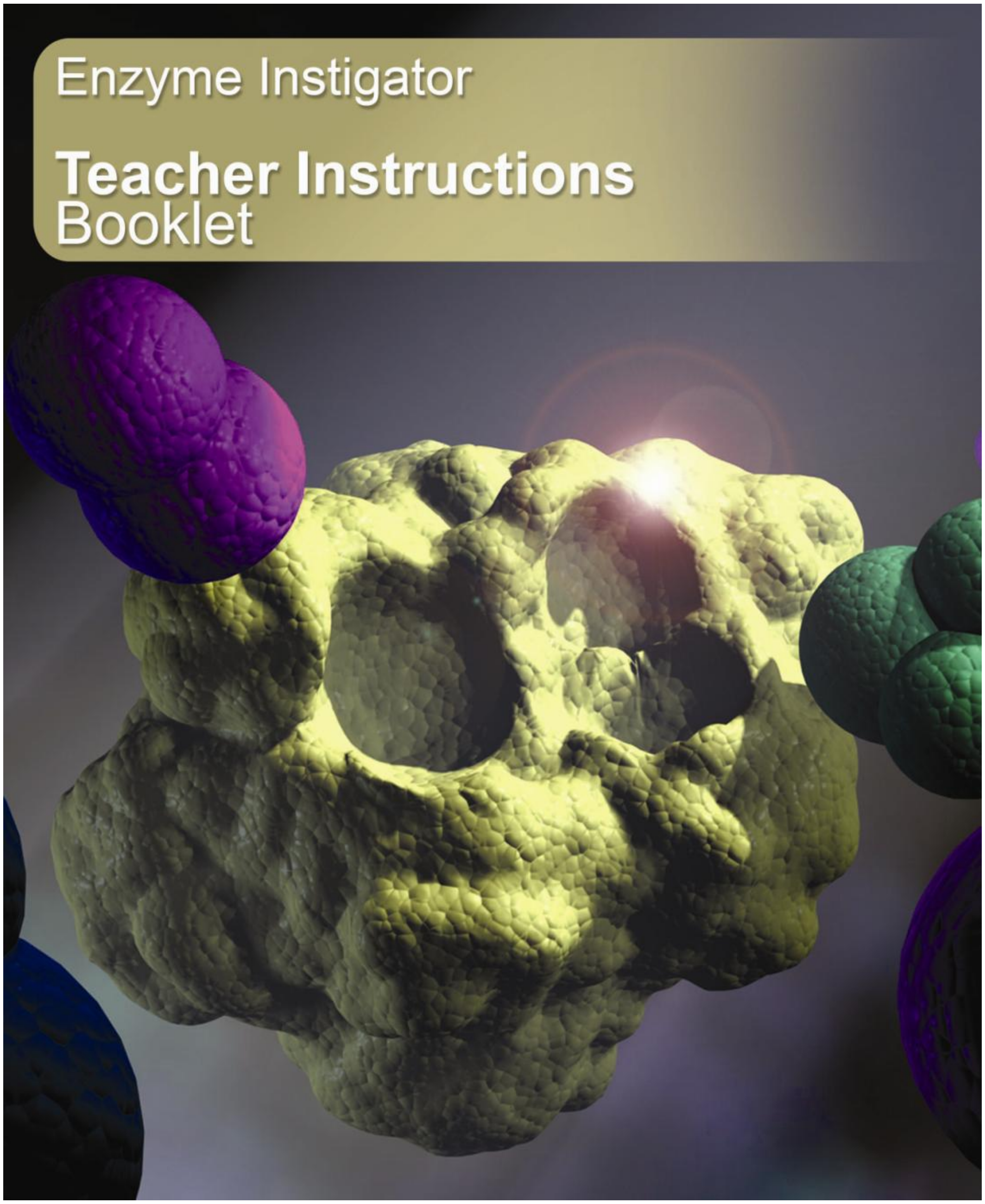
54

Repeat frame #30

#47. Show glowing band around active site move over & fit exactly around substrates.


Project: Thesis: Enzyme Instigator
Date:
Brenda Harrison - Biomedical Communications Department
BLH9901@hotmail.com, 850-567-1115
55
Repeat frame 45
#48
fade to black.

APPENDIX C
Teachers Instructions Booklet


Enzyme Instigator
Teacher Instructions
Booklet

Enzyme Instigator

Table of contents

Read this booklet before introducing the contents of this suitcast to your students.

About	page 1
Suitcase Components	pages 2-3
Overall suitcase instructions	pages 4-11
Homework handout	pages 12-14
Animation: Q and A	page 15
Jeopardase game	pages 16-18
Optional game rewards	page 19
Hands-on-models teacher demo	pages 20-23
Lab 1	pages 24-30
Lab 2	pages 31-36
Pre and Post Quiz	pages 37-39

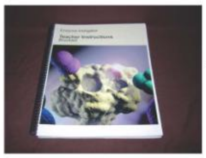
About the author / designer

Brenda McArthur received her bachelor's degree from Florida State University in 2005 with a major in art and a minor and biology. She then attended the University of Texas Southwestern Medical Center at Dallas. There she received a Master of Arts in Biomedical Communications in 2008.

Enzyme Instigator was developed as her thesis project in partial fulfillment of the requirements for her master's degree. It was her intent and goal to produce a portable science suitcase to assist ninth grade biology teachers in demonstrating the complex details of enzymes. She began research for the project in June 2007. This research included interviews with many DISD high school science teachers, exploring the strengths and weaknesses of current materials, studying the learning styles of ninth grade students and developing innovative teaching tools concerning enzymes. The project concluded thirteen months later marking the completion of her degree.

Enzyme Instigator

Teacher Instructions: Individual suitcase components



1. Teacher Instructions Booklet

2. Hard copies

3A. PDF Documents CD

3B. Animation DVD: *Enzyme Instigator*

4. Jeopardase game cards

5. Hands-on-model: Enzyme

6. Hands-on-models: Substrates

7. Jeopardase game board

8. pH solutions

9. Strainer

10. Ice cube trays

11. Lab supplies

12. Pipettes

13. Powdered milk

Enzyme Instigator

Teacher Instructions:
Suitcase setup

1. Teacher Instructions Booklet
2. Student Handouts Booklet
3A. PDF Documents CD
3B. Animation CD: *Enzyme Instigator*
4. Jeopardase game cards
5. Hands-on-model: Enzyme
6. Hands-on-models: Substrates
7. Jeopardase game board
8. pH solutions
9. Strainer
10. Ice cube trays
11. Lab supplies
12. Pipettes
13. Powdered milk

Enzyme Instigator

Teacher Instructions:
Overall Suitcase Instructions

This suitcase has been designed to help you as a teacher easily translate some of the confusing concepts of enzymes, engage your students in ways that relate to their everyday lives and reinforce what is found in current text books and standardized tests. The resources found inside this suitcase are flexible enough to span an entire week of classes or take up one short period. The intent of this suitcase is to provide teaching tools that will help every type of learning style found in the classroom.

This suitcase is divided into six parts. The order found on pages 2-6 is a *recommended syllabus* for using this suitcase but you can rearrange the components in the order that fits your class the best. Directly following the *recommended syllabus* is a list of alternative arrangements for this suitcase. A hard copy of each printable item (pre-test, homework, laboratory experiments and post-test) is located within the *Student Handouts Booklet*. Copies can be made on any copy machine, preferably a color copier, but a black and white copier will suffice. There are also Adobe PDFs of each document on the disk *Enzyme Instigator: PDF documents*. You can load this disk directly onto any computer and print the desired documents from there. Finally, the suitcase has a metal reinforced lock hole on the outside. You can use a personal lock at this site to ensure the safty of this suitcase while inside your classroom. Please remember to remove the lock before returning the case.

Recommended Syllabus

Day 1

Pre-test:

(10-15 minutes)

- ❑ A hard copy is located within the *Student Handouts Booklet* and a PDF file is located on the *PDF documents CD.* You can either make copies from the booklet or print copies directly off of the CD.
- ❑ Hand this short quiz out to students during the first day of this suitcase.
- ❑ After the students have seen everything in the suitcase, they will be handed another short quiz.
- ❑ Comparing the scores of these two quizzes will help make the future suitcases even better.

Homework hand out:

(60-90 minutes)

- ❑ Hand this out on the first day, but only after the students have taken the pre-test. A hard copy is located within the *Student Handouts Booklet* and a PDF file is located on the *PDF documents CD.* You can either make copies from the booklet or print copies directly off of the CD.
- ❑ You can allow the students to look at it during class time and/or take the hand out home.
- ❑ Make sure that they understand to read over the entire document and answer the questions at the end.
- ❑ You can also supplement addition material from your selected textbook.

Day 2

Animation

(10 minutes from start to finish, up to 60 minutes depending on question discussion time)

- ❑ There are two things that you will need from the suitcase; the *Enzyme Instigator Animation DVD* located within the respective labeled case, and the *Animation Questions and Answers* located within in the *Teacher Instructions Booklet.*
- ❑ There is also a large format document of the narration from the animation incase any students need to have the words printed out in front of them. This document is located on the CD labeled *PDF documents* and is titled "Animations Script".
- ❑ The animation should be shown on the second day.
- ❑ This animation will continue to repeat the complex concepts of enzymes.
- ❑ This animation can be played on a computer and then projected onto a large screen by simply loading the DVD into the computer, double clicking on the *Enzyme Instigator* icon and hitting the play button.
- ❑ It can also be played on a DVD player connected to a television by loading it into the player and selecting *Enzyme Instigator* in the main menu.
- ❑ Once the animation starts, there will be many questions read aloud to the students.
- ❑ Pause at these questions and allow students to discuss the answers or write down the answers to turn in later.
- ❑ The answers to these questions are located within the *Teacher instructions Booklet* in the section labeled "Animation Questions and Answers".
- ❑ Keep these questions handy, along with control to pause the animation when these questions come up.

Day 3

Game

(20-40 minutes)

- ❑ If the animation takes an entire day, the game can be started on the third day.
- ❑ The game is set up like a Jeopardy game where teams try to answer questions for points.
- ❑ Directions for the *Jeopardase* game are located within the *Teacher Instruction Booklet* under the tab " Jeopardase Game".
- ❑ The game easily follows the animation because many of the questions in the game are taken directly from the animation.
- ❑ This game will stimulate the students drive to compete and their willingness to collaborate with peers in their team.

Hands-on models: Teacher Demo

(20-40 minutes)

- ❑ The hands-on models are located within the suitcase and are labeled "Hands-on models".
- ❑ There are four models total; a yellow enzyme and three substrate pairs that are purple, blue and green.
- ❑ The instructions for this demo are located in the *Teachers Instructions Booklet* under the tab "Hands-on models: Teacher Demo".
- ❑ The models will show students the specificity of enzymes and describe the basic concepts of enzymes.
- ❑ The models are a great way to reach all three of the learning styles.
- ❑ The words you say during the demo help the auditory learner, the models movement will help the visual learner and playing with the models themselves will help the kinesthetic learner.

Day 4

Laboratory experiments:

(Each lab takes approximately 40 minutes and have approximately 30 minutes of set up work for the night before)

- ❑ There are two labs; *Milk and Rennin* and *Gelatin and Fruit Juice*.
- ❑ A hard copy of each lab is located within the *Student Handouts Booklet* and a PDF file is located on the *PDF documents CD.* You can either make copies from the booklet or print copies directly off of the CD.
- ❑ There are teacher instructions/setup for each of these labs located in the "Laboratory" tab of the *Teacher Instruction Booklet*.
- ❑ There is a large format document of the narration from the animation incase any students need to have the words printed out in front of them. This document is located on the *PDF documents CD* and is titled *Animation Script*.
- ❑ These labs can be split up among the class (half of the class can do one of the labs and the other half can do the other lab) or they can perform one lab one day and the other lab the next day.
- ❑ These labs will cover optimal temperature and optimal pH of enzymes.
- ❑ Most of the materials for these labs are located within this suitcase.
- ❑ The lab supplies not included in the suitcase are test tubes, beakers, stir sticks, grease pencils, small plates, stop watches (or access to a clock with a second hand) and test tube racks.
- ❑ To find out how many you need of each and which supplies you need to supply yourself, please refer to the teacher instructions for each lab.

Day 5

Post-test: (10-15 minutes)

- ❑ Hand this short quiz out to students after they have viewed the contents of this suitcase.
- ❑ Comparing the scores of the pre-quizzes and post-quizzes will help make the future suitcases even better.

Returning the Suitcase

- ❑ Please make sure that all of the contents of the suitcase get replaced into their correct spot within the suitcase. You can double check by comparing the contents to the photo of the packed suitcase at the front of this booklet.
- ❑ This will ensure a smooth transport and transition for the following teacher.

Additional variations

on the contents of this suitcase:

This suitcase can be utilized in many different ways. The recommended syllabus will give students the best opportunity to learn the complex concepts of enzymes. In the circumstance that you need a different syllabus, many options involving time and order have been provided below. Feel free to use the best option for your class or design one that fits better.

Option 1

Day 1 Pre-test: Give them the test during the last five minutes of the class prior to this suitcase.

Homework hand out: Let them take this home to look over and answer the questions.

Day 2 Animation: Let the students watch the entire animation but only stop for two minutes at the questions and let them write them down and turn in after the animation.

Day 3 Game: Play the entire board game with the students immediately after the class begins.

Laboratory experiments: Divide the class into laboratory teams (four students each). Then give half of the class lab 1 and the other half lab 2.

Post-test: Hand the post test out during the last five minutes of the class period.

Option 2

Day 1 Pre-test: Give them the test during the last five minutes of the class prior to this suitcase.

Homework hand out: Let them take this home to look over and answer the questions.

Day 2 Animation: Let the students watch the entire animation and pause the DVD at the questions for the entire class to participate in discussions.

Day 3 Game: Play the entire game.

Hands-on models: Teacher demonstration: Perform the entire teacher demo and let the students play with the models for the remainder of the class period.

Day 4 Laboratory experiments: Divide the class into laboratory teams (four students each). Then give half of the class lab 1 and the other half lab 2.

Post-test: Hand the post test out during the last five minutes of the class period.

Option 3

Day 1 Pre-test: Give them the test during the last five minutes of the class prior to this suitcase.

Day 2 Homework hand out: Hand this out as students enter the classroom and allow them to read and answers the questions for the first half of the class.

Animation: For the second half of the class period, let the students watch the animation and pause the DVD at the questions for class discussion.

Day 3 Laboratory experiments: Divide the class into laboratory teams (four students each). Then give half of the class lab 1 and the other half lab 2.

Post-test: Hand the post test out during the last five minutes of the class period.

Option 4

Day 1 Pre-test: Give them the test during the first five minutes of the class.

Animation: Let the students watch the animation and pause the DVD at the questions for class discussion.

Homework hand out: Hand this out as students leave the class.

Day 2 Laboratory experiments: Divide the class into laboratory teams (four students each). Then give half of the class lab 1 and the other half lab 2.

Post-test: Hand the post test out during the last five minutes of the class period.

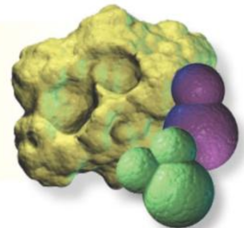
Option 5

Day 1 Pre-test: Give them the test during the first five minutes of the class.

Animation: Let the students watch the animation and pause the DVD at the questions for class discussion.

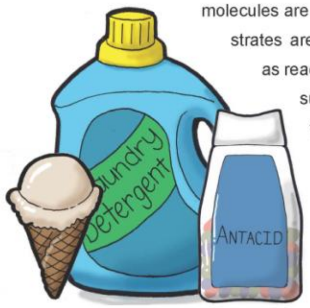
Post-test: Hand the post test out during the last five minutes of the class period.

Teacher Instructions: Homework handout



Enzymes exist in parts of our daily lives that nobody would expect. Every time you wash your clothes, eat an ice cream cone or take an antacid, you're utilizing enzymes. Throughout this handout you'll learn how enzymes work, and some interesting facts about enzymes in your life.

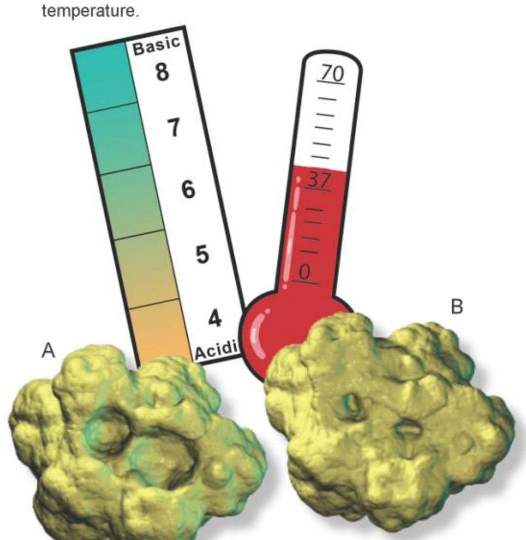
A reaction is a collision between molecules that causes a new product to be formed. The original molecules are called substrates. Substrates are also often referred to as reactants. This refers to the substrate being the reactants of the reaction.



Most reactions occur very slowly and need the help of a protein called an enzyme to speed them up. Enzymes basically add some of their energy to the substrates reaction to make this happen. This energy is called activation energy. The substrates would normally require a very high amount of energy to produce a reaction on their own, but with the help of the enzyme's energy, they require much less. In order for an enzyme to add it's energy, the substrates must dock on a specially shaped spot on the enzyme's surface called the active site. This is where the reaction will be activated. But the shape of the site is very specific and will allow only a certain substrate to dock.

Slight changes in the enzyme's shape, specifically the shape of the active site, can mess up an enzyme to the point where it does not work with the substrates it was meant to work with. The two biggest things that affect the shape of an enzyme are pH level and temperature. Let's first review what "pH" means. The pH level is the measurement of the acidity of a solution which is related to the concentration of dissolved hydrogen ions (H+) within a solution.

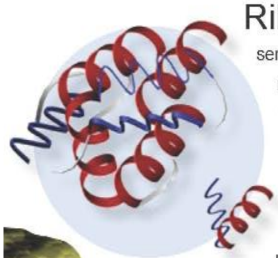
Each enzyme has a very specific pH and temperature that it needs for its activity. These are called the optimal pH and optimal temperature. If the temperature gets too high or the solution gets too acidic or basic the enzyme changes shape irreversibly, a process referred to as denaturation. In the picture below, [fig1] the yellow objects are enzymes [A and B]. The circular holes on the surface of the enzyme comprise its active site. The enzyme on the left [A] shows the regular shaped site. The enzyme on the right [B] has a misshaped active site because of denaturation from a change in the pH or the temperature.

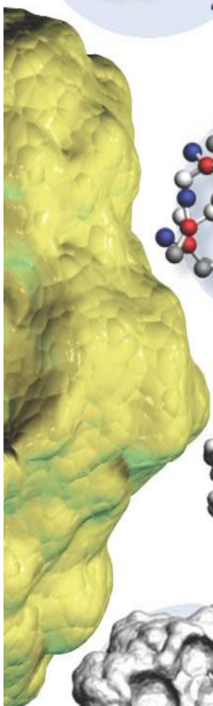


[fig1]

Different ways to look at an enzyme

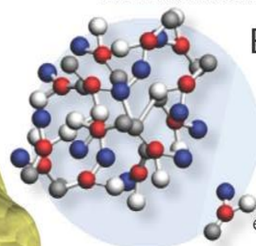
Enzymes and substrates, like all molecules, are made of atoms which consist of protons and neutrons with circulating electrons. The atoms in a molecule are held together with chemical bonds, usually by sharing electrons between them. Molecules can be shown in three different ways, shown below. Refer to the first three models, and then to our own simplified form at the bottom of the page.





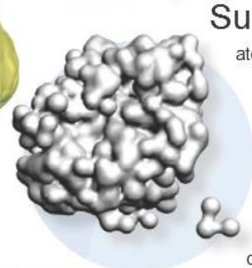
Ribbon Model:

Proteins are very large molecules made up of a series of connected amino acids. Amino acids have a common backbone with other atoms decorating the sides of the backbone to make each amino acid special. The ribbon model shows the chain of backbones and ignores the decorating atoms. But the backbone chain can have a structure itself, either a helix (like a corkscrew) or a strand of a pleated sheet (like a curtain). Each type is represented with a different color; red represents helices, blue represents pleated sheets and green represents turns at the end of the sheets. This type of model gives less specific details about the arrangement of individual atoms and chemical bonds in the molecule but displays important information regarding the basic structure of the protein, just as a skeleton tells us important information about the shape of the whole body.



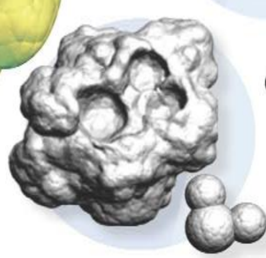
Ball and Stick Model:

This model shows the atoms as balls and the chemical bonds as sticks joining each ball (atom). Each type of atom (carbon, hydrogen, etc.) is colored differently. Each carbon atom is usually black or grey, each hydrogen atom is white, each oxygen atom is red and each nitrogen atom is blue. A problem with the ball and stick models is that it does not represent the space consumed by the circulating electrons.



Surface or Space Filling Model:

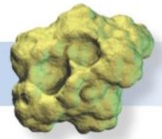
Here the atoms are represented as overlapping spheres. The diameters of the sphere are important because they correspond to their Van der Waals radius; atoms can get no closer to each other than their Van der Waals radii. This model gives a better sense of how crowded the space is within the molecule. This type of model is not very useful for probing the inner structure of a protein (because the inside is not visible, only the surface), but can do a good job in showing the shape and charge of the surface and how it might interact with another protein or with an enzyme substrate.

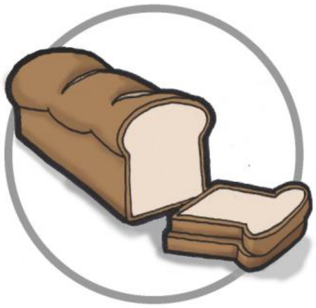


Our Model

for this learning module is a slight variation from the typical surface or space filling model. We have simplified the surface and made the active site more obvious by smoothing some of the atoms. We have also enlarged the substrate to make it easier to view. You can compare all of the models to see the similarities and differences between them all.

Fun Facts About Enzymes





[fig 2]

[fig 3]

[fig 4]

Do you know where enzymes get their name? [fig 2] Yeasts contain enzymes which convert sugar into ethanol and carbon dioxide gas. The word "enzyme" comes from the Greek words "in-zyme" which means "in leaven" or "in yeast."

Speaking of names, do you know the common suffix for enzymes? [fig3] Most enzymes start with the name of the substrate that they work with and end in –ase. For example, an enzyme that breaks up carbohydrates would be called carbohydrase. But this is not true for all enzymes. The enzyme rennin and trypsin do not follow this rule. Do you know which substrates they perform on? rennin breaks up casein inside milk and trypsin breaks up peptide bonds within proteins.

Do you know why your eyes water when you cut an onion? [fig 4] During the process of slicing up these tear- jerkers an enzyme known as allinase and another compound called isothiocyanate get together on the surface of the onion and create a type of sulfuric vapor which gets into the eyes and irritates them to the point of tears.

Questions:

1. How are amino acids the same? How are they different? *Same backbone, different "decorating" side chains.*
2. Compare in your own words the different ways of looking at a protein or enzyme. Find examples of each on the internet. *(Hint: Google the model name, such as "space-filling model.")*
3. We are warm-blooded and maintain the same temperature regardless of the external temperature. Do you know of any cold-blooded animals? What do you think happens to their enzyme activities when the weather gets cold? *Snake; they slow down*
4. Give two alternative names for molecules? *substrates and reactants*
5. How is the protein model used in this handout ("Our Model" on page 2) different from a surface model? How is it the same? *different: there are less crevices and the substrate is much bigger, same: it has a similar contour and bumps.*

Enzyme Instigator

Teacher Instructions: Animation Questions and Answers

Below is a list of the questions that occur throughout the animation. The numbers located at the beginning of the questions are the minute and seconds that the questions occur and represent a good stopping point for class discussion.

(01:54) You and your friend place a pile of logs in the middle of a field and wait for lightning to ignite the wood. Your friend gets tired of waiting and pulls a match from his pocket, setting the pile ablaze. Name the substrates, catalyst and product.
Substrates: wood logs
Catalyst: match
Product: fire

(03:00) What would happen to you if these basic body reactions did not have the help of enzymes?
If there were no digestive enzyme: malnutrition, constipation or diarrhea.
If there were no blood clotting enzymes: hemophilia.

(04:15) What is another name for a biological reactant?
Substrate

(05:30) Can any enzyme bind with any substrate? Why or why not?
No. An enzyme can only bind with a substrate that has the correct shape and fits into its active site.

(06:08) What determines if a reaction will occur?
The activation energy.

(07:00) Why is induced fit helpful for the reaction?
It holds the substrate in place until the reaction is complete and also helps push the substrates closer together.

(07:55) How do you think an enzyme found in the human body would perform at 37 degrees Celsius?
Since enzymes are specific to the body and normal body temp is 37 degrees Celsius, they would act normal within this temperature.

(08:45) What kind of problem would happen if many digestive enzymes became denatured?
Food would not be broken down and the nutrients would not be taken up by the digestive system. It could also lead to constipation.

Enzyme Instigator

Teacher Instructions:
"Jeopardase" Game

Materials

- Jeopardase board game (included in this suitcase, located within pink, transparent bag)
- 25 Jeopardase cards with points on the front and questions/answers on the back (included in this suitcase, located within the handled container labeled "Jeopardase Cards")
- Score board (not included in this suitcase. Create one on the board at the front of the class)

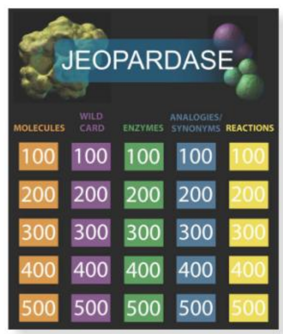
Setting up the game

1

- ❑ Remove the Jeopardase game board and cards from the suitcase.
- ❑ Hang the board on clips above an erase board, set in a chalk reservoir or simple stand on a desk at the front of the class room.

2

- ❑ Place the Jeopardase cards on the board game.
- ❑ Connect the Velcro on the back of each card to the Velcro located in the colored outlines on the board.
- ❑ Match the outline on the board with the color of the card. They should progress from "100" to "500" with "500" being at the bottom of the board.
- ❑ Your final game board should be set up like the picture to the right.



3

- ❑ Split the class up into teams of four. The students will compete in these teams throughout the duration of the game and then perform their laboratory experiments together.
- ❑ Let the teams spread out throughout the classroom so that they can easily discuss their answers.

4

- ❑ Set up a score board for the game at the front of the classroom.
- ❑ Each team should have a name (you can let them choose an appropriate name or assign them one).
- ❑ Place the name of each team at the top of a column.
- ❑ The scores will then be placed in these columns and added after each team's turn.

Team 1	Team 2	Team 3	etc.

Playing the game

The object of this game is to be the highest scoring team at the end of the game when all the cards are gone off the board.

1

- ❑ To start the game, choose a team to start by either choosing a number out of a hat, picking the closest number or what ever means possible.

2

- ❑ The first team will start off by selecting a category and point (100, 200, 300, 400 or 500) from the board game.

3

- ❑ Pull the selected card off of the board and read only the question from the back of the card.

4

- ❑ If the team gets the answer correct, give them the designated points on the score board and move on to the next team (clockwise).

5

- ❑ If the team gets the answer incorrect, allow the other teams to raise their hands and try and answer.
- ❑ If a team answers correctly, give them the points on the score board.
- ❑ If no team answers correctly, read the answer on the back of the card and discuss the question/answer so that the class understands.

6

- ❑ After the card has been either correctly answered or read allow by the teacher, continue to the following team (clockwise) from the original team that chose the card.

7

- ❑ Continue this until all the cards have been used.
- ❑ This marks the end of the game.
- ❑ Tally up the total points for each team and determine the first, second and third place winners.
- ❑ Located inside the "Teacher Instructions" booklet in the "Optional Game Rewards" tab are optional prizes for the first, second and third place winner that give them helpful hints for their laboratory experiments.
- ❑ Make a photo copy of the rewards and cut them out to hand out the individual teams.
- ❑ You can substitute these prizes for what ever suits your class.

Enzyme Instigator

Teacher Instructions:
Optional Jeopardase Game Rewards

First Place Winners
Lab 1: Milk and Rennin

Helpful hints for #2 and #5 of the "Data Analysis" of your lab:

2. The natural environment for this rennin is in the stomach of a calf, which is naturally acidic.

5. Wouldn't the reaction have to occur on its own and therefore it might never happen? What would happen to the calf if it had no nutrients from milk?

Second Place Winners
Lab 2: Gelatin and Juice

Helpful hints for #2 and #5 of the "Data Analysis" of your lab:

2. The average temperature of Hawaii (a pineapple growing region) is 23 ° C.

5. Remember from the animation that when outside of their optimal temperature, enzymes break down. What was this process called?

Third Place Winners
Lab 1: Milk and Rennin

Helpful hint for #2 of the "Data Analysis" of your lab:

2. The natural environment for this rennin is in the stomach of a calf, which is naturally acidic.

Enzyme Instigator

Teacher Instructions:
Hands-on models: Teacher Demo

These models were made for teachers to use during a classroom demonstration. Please make sure and run through the entire set instructions and practice the demonstration before performing it in front of your class. Many students learn visually and kinesthetically. This demonstration will lend itself to these types of learning styles. The students should also be encouraged to play and handle the models once the demonstration is over. Emphasize that the correct substrates will break apart. These models were produced to withstand rough handling so let the students really play with the models and do not stress about them breaking the models. The objective of this demonstration is to give students hands-on knowledge about enzymes. It will give them a better understanding about the specificity and catalytic behavior of enzymes.

Materials (located within the suitcase)

- Six substrate models (two blue, two purple and two green)
- Three substrate stands (upside-down lid of the substrate containers)
- Enzyme model (yellow)

Setting up the models

1

- ❑ Pull out all of the components for the demo: enzyme (yellow) and substrates (blue, purple and green) models. They are all located within the suitcase in individual containers labeled "Hands-on model" and there should be four containers total.
- ❑ Start the set up at the front of the classroom where the students can easily see the models.

2

- ❑ There are colored dots located on the substrates and within the active site of the enzyme. Look for the red and green dots located on the purple substrates. Once you have found these, line up both red dots and then line up both green dots. You should feel a pull from a magnetic force when you have correctly aligned these dots.
- ❑ Repeat this for the blue and green substrates.

3

- ❑ Then find the blue and orange dots on the bottoms of the substrates and also within the active site of the yellow enzyme.
- ❑ When performing the demonstration, make sure these dots also line up (orange on the substrate with orange on the enzyme, blue on the substrate with blue on the enzyme).
- ❑ Double check that you see where these line up for each substrate.

4

- ❑ Next place the 3 substrate pairs (still connected) on their bases.
- ❑ To do this, use the lid of the container that each enzyme came inside.
- ❑ Turn the lid upside down so that the label on the front of the base is right-side-up.
- ❑ Place the substrates within the foam grooves so that the substrates stand upright.
- ❑ Place all of the substrates on the bases next to the enzyme where students can easily view the names of each.

Performing the demonstration

1

- ❑ The name of each substrate is on its stand.
- ❑ The enzyme model also has a name.
- ❑ Only one substrate will fit into the enzyme.
- ❑ If the students had answered all of the questions located throughout the homework handout, they would know which substrate fits into the enzyme model.
- ❑ But do not give them this clue ahead of time because it will allow the students to take some extra initiative.

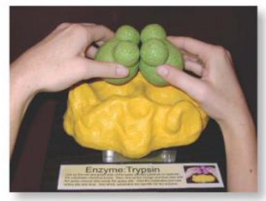
2

- ❑ Describe to the students that enzymes are very specific and remind them that only substrates with the correct shape can dock on an enzyme's active site.

3

- ❑ Next, lead a class discussion about which color /name of substrate they think will fit into the enzyme's active site and why.
- ❑ Hold up the green substrates, remind them what type of substrate they are (fats) and ask the students if they think the substrates will work with the enzyme *trypsin*.
- ❑ Repeat this for the blue and purple substrates.

4

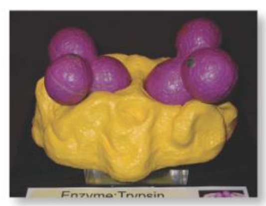


- ❑ To perform the demo, you should hold the connected substrate pair just over the enzyme's active site (nearly touching the active site).
- ❑ If you hold it too high, the substrates will bounce out of the active site.
- ❑ If you hold them too low, the substrates will not break apart.
- ❑ The colored dots on the bottom of the substrates (orange and blue) should be matched up with the colored dots inside of the active site.

5

- ❑ Start with the blue and green substrates which will not fit into the active site.
- ❑ Next, drop the substrates into the active site.
- ❑ Explain to the students that they did not fit because they are not the "specific" substrate for that enzyme.

6



- ❑ The purple substrates (peptide bonds) fit into the active site.
- ❑ When you drop the correct substrates (purple) into the active site, they should be pulled apart by a magnetic force (if it does not pull apart, give the substrates a little nudge or simply try it again).
- ❑ Explain to the students that this is because trypsin specifically breaks apart peptide bonds.

7

- ❑ Now allow the students to come up on their own or in small groups and play with the substrate and enzyme models.
- ❑ This will help the concept of “enzymes breaking apart substrates” and “specificity” stick in their minds.
- ❑ Remind the students about these two concepts.
- ❑ By holding and manipulating the models, they will be able to physically feel the magnetic pull which is representing the chemical bonds.
- ❑ Make sure that the students understand how to do the demonstration on their own.
- ❑ Re-direct them to steps 3-6 of the directions.

Enzyme Instigator

Teacher Instructions:
Lab1: Set up

Prep time: 30 minutes the day before the lab and 30 minutes the day of the lab.

MATERIALS INCLUDED inside suitcase:	MATERIALS NOT INCLUDED inside suitcase:	MATERIALS FOR SET UP:
ice cube trays	400 mL beakers	gelatin packet
strainer	test tubes	one and a half cups boiling of water
plastic knives	grease pencils	half a cup of cold water
gelatin packets	test tube racks	blue food dye
blue food dye	paper plates	ice cube trays
thermometer		one large, fresh pineapple
pipettes		strainer

THE DAY BEFORE THE LAB:

Making the gelatin:

1. Each packet of gelatin ("Knox original gelatin" located in the container labeled "lab supplies") will make enough squares for 20 groups (one square per group of four students), so depending on the amount of classes and groups performing the experiment, you might need to make more than one batch of gelatin.
2. Boil one and a half cups of water.
3. Empty a packet of the gelatin into a large bowl.
4. Pour the hot water over the gelatin.
5. Mix thoroughly for at least two minutes.
6. Add half a cup of cold water and continue mixing.
7. Add three drops of blue food coloring (located in the container "lab supplies") and mix completely.
8. Pour the entire mixture into the ice cube trays. Do not overfill each cube.
9. Let chill over night.

Making the pineapple juice:

1. Cut a large fresh pineapple (can be purchased at most grocery stores) into large chunks, leaving out the skin and core of the fruit.
2. Use a food processor to puree the cubes of pineapple.
3. Pour the puree into the strainer over an appropriately sized bowl. Use a spatula to press the puree through the strainer.
4. Cover the juice and let chill overnight.

THE DAY OF THE LAB:

1. On the day of the lab, set up three stations. One station should be stocked with enough plates (or paper towels) and plastic knives (located in the container labeled "lab supplies") so that each group can have one of each, along with the ice trays of gelatin.
2. Another station with the bowl of pineapple juice and enough one milliliter pipettes for each group.
3. The last station should have enough of the other materials for each group: three 400 mL beakers, six test tubes, one grease pencil, one thermometer and one test tube rack. Let the students know where each station is at the beginning of the class. The students also need access to ice and a microwave (to get the water to the right temperature for the experiment).

Enzyme Instigator

Teacher Instructions:
Lab 1: Gelatin and fruit enzymes

Determine the temperature at which pineapple juice (bromelain) will work best.

INTRODUCTION:

In this lab you will be investigating the enzymes found in fruits, specifically the enzyme bromelain from pineapples. Pineapples contain enzymes that actively break up other proteins, while other fruits (such as apples) do not. Enzymes that break up proteins are called proteases. Like all other enzymes, these different proteases work best within a certain temperature and pH range.

Bromelains are commonly used in cosmetics, laboratory work, and even in meat tenderizers! The protein used in this lab will be gelatin. This is a protein derived from the connective tissue of animals. Gelatin can form a water-holding matrix and when the fruit enzymes are working and breaking down the gelatin's matrix, the gelatin will go from a solid to a liquid form.

OBJECTIVES:

1) Understand the basic principles of enzyme-catalyzed reactions.

2) Determine the temperature at which different fruit enzymes will work best.

HYPOTHESIS:

You will be testing the function of the fruit enzyme bromelain through a range of temperatures. Keep in mind that pineapples are grown in very warm tropical climates. Construct a hypothesis about the temperature range in which the pineapple protease bromelain will function in the table below.

Cold 0-10 ° C y/n
Room temperature 26 ° C y/n
Hot 75 ° C y/n

Write a hypothesis about which temperature you think will work and why:

MATERIALS:

three 400 mL beakers
6 test tubes
1 mL squeeze pipette
grease pencil
small plate
plastic butter knife
test tube rack
thermometer

PROTOCOL:

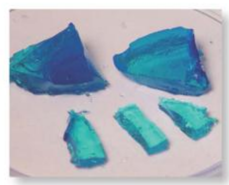
1

- ❑ Label three of your test tubes: “cold gel”, “room gel” and “hot gel”.
- ❑ The “gel” stands for the gelatin that you will be adding to these tubes.
- ❑ Next, label three test tubes: “cold pine”, “room pine” and “hot pine”.
- ❑ The “pine” stands for the pineapple juice that will be added to these tubes.

2

- ❑ Send one member of the team with the plate to gather a cube of gelatin from the ice cube trays that have been previously prepared.
- ❑ Return to the team.
- ❑ Cut the gelatin into three slices that are about ½ inch long, ¼ inch wide and 1/8 inch thick. This might take a few tries.
- ❑ Then place one slice of gelatin in each of the three “gel” test tubes.
- ❑ Let the gelatin slide down instead of shaking it down because this could break the gelatin which could mess up the lab.

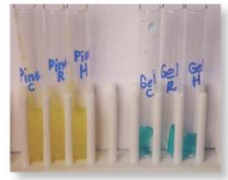
Make sure that the students cut these gelatin slices correctly. Also, make sure the students do not shake the gelatin down to the bottom because it can break the piece. They should either lightly tap the tube or allow the gelatin to make it's way down to the bottom.



3

- ☐ Have two team members go to the pineapple juice station and add two mL of pineapple juice with the squeeze pipette to each of the three "pine" test tubes.
- ☐ You should squeeze out all the air before sticking the pipette into the juice so that you can completely fill the pipette.

Make sure the students are getting the proper amount of juice inside their pipette.



4

- ☐ Label one beaker with tape and a grease pencil "ice".
- ☐ Fill it half way with ice and add enough water to fill the space around the ice.

5

- ☐ Label one beaker "room".
- ☐ Fill it with (26 ° C) room temperature water.
- ☐ Run a mixture of hot and cold water from the faucet.
- ☐ Then check the temperature with a thermometer.

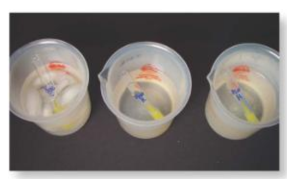
6

- ☐ Label one beaker "hot".
- ☐ Fill it with (75 ° C) hot water.
- ☐ Run hot water from the faucet.
- ☐ Then check the temperature with a thermometer.
- ☐ You might need to put it in a microwave for a minute or less.
- ☐ Continue to check the temperature with your thermometer.
- ☐ Do not leave the thermometer in the juice while the microwave is on!

7

- ☐ Place the test tubes of fruit juice in their designated bath for five minutes.

The tubes you use should be close to the height of the beakers. This will allow them to be placed in the bath, angle slightly and not sink into the water. If the tubes are getting the bath inside them, allow the students to tape the tubes to the inside of the beakers.



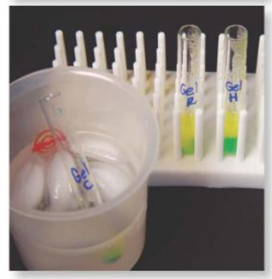
8

- ❑ After five minutes is up, take the “room” and “hot” tubes out of their baths and place them on your rack.
- ❑ Leave the “cold” tube inside the “cold” bath.
- ❑ You want the “hot” to cool back to room temp because if we added the extremely hot water to the gelatin now, the heat would break up the protein, NOT the enzyme in the juice.
- ❑ But if we bring it back to room temperature, we can evaluate the juice’s enzyme.
- ❑ Place a thermometer inside the “hot” tube and watch the temperature decrease.
- ❑ Once it hits 30 ° C, you are ready to move on to the next step.
- ❑ You can speed this process by placing it in the cold bath for a few seconds but keep the thermometer in it and pull the tube out of the ice once it reaches 40 ° C because it will continue to decrease in temperature even after you pull it out.

Make sure the students allow the “hot” tubes to cool. If they do not, the experiment will be ruined and they will need to start over. They can speed up the cooling process by placing a thermometer in the tube and placing the tube in the cold beaker. Make sure the students pull the tube out about 10 degrees before the appropriate temperature. Also make sure that the students leave the “cold” tube of juice in the “cold” bath. The “cold” tube needs to maintain it’s temperature in order for the experiment to work.

9

- ❑ Once the “hot” juice has come back down to 30 ° C, add the 2mL of fruit juice to it’s designated test tube of gelatin.
- ❑ The cold juice with the “cold gel”, the room juice with the “room gel” and the hot juice with the “hot gel”.
- ❑ Place the “cold gel” tube with juice and gelatin back in the ice bath but leave the other two out on your rack.
- ❑ Start the timer for eight minutes.



Make sure the students carefully pour the juice into the gel tubes and that they place the “cold gel” back into the cold bath.

10

- ❑ After eight minutes, evaluate the enzyme’s effective-ness.
- ❑ Stop the tube with your finger and sway the contents back and forth while looking up at a light.
- ❑ You should be able to see some difference in the gelatin between each tube.
- ❑ Record the differences in a table similar to the one in “data analysis”.

Once the laboratory is over, the students should be able to see that the juice at room temperature broke down the gelatin the best. This is because the “hot” juice’s enzymes were denatured in the heat and the “cold” juice’s enzymes were also not able to work properly because of the extreme conditions. Make sure that the students carefully plug the tube with their finger and tip the tube up to the light so that they can see the different in the gelatin slices.

DATA ANALYSIS:

Data Table

	COLD	ROOM	HOT
GELATIN RESULT	*The gelatin should still be very solid and clear blue because the cold slowed down the process too much.*	*The gelatin should be more see-through and thinner because the enzymes were not destroyed or slowed and therefore able to properly work.*	*The gelatin should still be very solid and clear blue because the heat de-natured the enzyme.*

1) At which temperature did the pineapple juice digest the gelatin the fastest?
room

2) Does your data make sense? Why or why not?
The average temperature of Hawaii (a pineapple growing region) is 23 degrees Celsius. So yes, the date made sense because the room temperature, at 26 degrees Celsius, is very close to the average temperature of the region where pineapples are grown.

3) Was your hypothesis correct? y/n

4) At which temperature did pineapple juice digest the gelatin the slowest? Why did this happen?
Both the cold and hot temperatures should barely break down the gelatin so either answer should work.

FINAL STEP:

After the entire experiment is finished and the data analysis is complete, clean up your work station, rinse your test tubes (everything can be dumped in the trash or down the sink) and return all supplies to the designated areas.

Enzyme Instigator

Teacher Instructions:
Lab2: Set up

Prep time: 30 minutes the day before the lab and 30 minutes the day of the lab.

MATERIALS INCLUDED inside suitcase:	MATERIALS NOT INCLUDED inside suitcase:	MATERIALS FOR SET UP:
powdered milk	400 mL beakers	one rennet tablet
one mL pipettes	test tubes	one tsp of powdered milk
rennet tablets	stir sticks	one and a half cups of water
pH strips	grease pencils	
pH solutions 4,6 and 8	test tube racks	

THE DAY BEFORE THE LAB:

Making the Rennin Solution:

1. Combine one tablet of rennet from the "rennet" section of the container labeled "lab supplies" with half a cup of water.
2. Stir thoroughly.
3. Can be made the night before or the same day as lab.

Making the Milk Solution:

1. Combine one tsp of powered milk (located in the container labeled "powdered milk") per one cup of water.
2. Stir thoroughly. Make sure to re stir before the lab.
3. Can be made the night before or the same day as lab.

THE DAY OF THE LAB:

1. On the day of the lab, set up three stations. One station will have a beaker of rennin solution, three beakers of 200 mL of each of the pH solutions (4, 6 and 8) and a 1 mL pipette labeled for each of the 4 beakers (you will have a beaker labeled pH 4 and a pipette with it, you will have a beaker labeled pH 6 and a pipette with it and you will have a beaker labeled pH 8 and a pipette with it). You might even consider tying a string from each pipette to its designated beaker so that students do not mix them.
2. Another station should be set up with the milk solution and a 1 mL pipette.
3. And the last station should have enough of the other materials for each group: three 400 mL beakers, seven test tubes, one grease pencil, one mL pipette, something to stir inside the test tubes, three pieces of pH paper and one test tube rack. Let the students know where each station is at the beginning of the class. Also, leave a pH color indicator out to be used by the students when comparing their tests.

Enzyme Instigator

Teacher Instructions:
Lab2: Milk and Rennin

Determine the optimal pH range for the enzyme Rennin.

INTRODUCTION:

We all know that milk will eventually curdle over several days or weeks (depending on the environment), but in the presence of an enzyme, called rennin, milk will curdle within minutes. Rennin is an enzyme produced in the stomach of calves. It breaks down proteins found in the mother's milk, in order for a baby calf to properly digest and therefore obtain nutrients. This enzyme works by breaking down a common milk protein called casein. In this lab, you will see the broken pieces of casein clump together to form milk curds. Nearly all enzymes are proteins themselves and rennin is no exception. There are a few factors that affect the efficiency of an enzyme: temperature and pH. Temperature and pH affect enzymes by influencing reaction rates and stability of the enzyme's structure. The optimal temperature range and pH range that enzymes function in are important properties. This lab will help you determine the optimal pH range for rennin.

OBJECTIVES:

1) Understand the basic principles of enzyme-catalyzed reactions.

2) Determine the pH range in which rennin will work best.

HYPOTHESIS:

You will be testing the function of the enzyme rennin through a pH range of 4, 6 and 8.
Construct a hypothesis about the pH range in which rennin will function in the table below.

Table 1. Hypothesis Formation.
Will rennin work at a very acidic pH=4? y/n
Will rennin work at a mildly acidic pH=6? y/n
Will rennin work at a mildly basic pH=8? y/n

Write your hypothesis in a sentence about which pH you think rennin will work best and why:

MATERIALS:

three beakers
seven test tubes
1 mL squeeze pipette
milk solution
rennin solution
pH solutions at values 4,6 and 8
three stir sticks
three strips of pH paper
grease pencil
one test tube rack

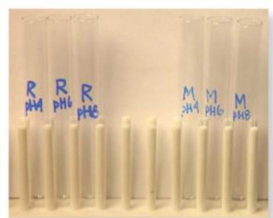
PROTOCOL:

1

- ❑ Gather all of the materials listed above except the milk, rennin and pH solutions.

2

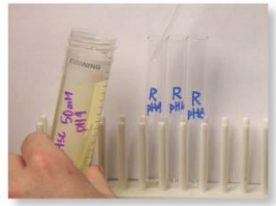
- ❑ Label three of the test tubes using a grease pencil: R pH4, R pH6 and R pH8.
- ❑ The "R" stands for the rennin that you will be adding to these tubes and the number represents the pH value that you will be testing in that tube.
- ❑ Then label three other test tubes: M4, M6 and M8.
- ❑ The "M" stands for the milk that you will be adding to these tubes and the number represents the pH value that you will be testing in that tube.
- ❑ Then label the last test tube: rennin. You'll use this tube to get all the rennin for the whole lab.



This is how the test tubes should be labeled.

3

- ❑ Have two team members bring the stand with the three "R pH" test tubes to the designated area of pre-made pH solutions.
- ❑ Then, using the one mL pipettes located with each pH value, squeeze one mL of pH 4 solution into the test tube labeled "R pH 4".



❑ You should squeeze out all the air before sticking the pipette into the solution. The pipette will not fill completely. It will only fill about half way when done properly.

❑ Continue this with the pH values 6 and 8 into its designated test tube. Do not cross contaminate the pipettes.

❑ If you use a pipette inside the solution pH 4 from the solution pH 8, you risk contaminating the pH values. Make sure to use the right pipette.

❑ When you are done, each test tube should have one mL of the designated pH solution inside them.

Make sure the students are not cross contaminating the pH solutions.

4

❑ Have one team member bring an empty test tube to the rennin solution and fill it with three mL of the rennin solution.

❑ Bring the rennin back to the group.

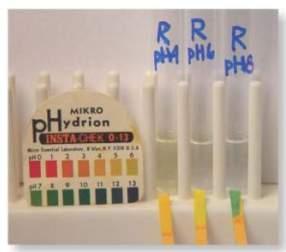
5

❑ Using a clean squeeze pipette, add one mL of rennin solution to each of the rennin labeled test tubes that you previously added different pH solutions to.

❑ Stir the new solution with a clean stir stick to assure complete mixing.

❑ Now your 3 rennin test tubes should have two mL of liquid in each of them.

6



❑ Double check the pH values of the pH solutions and rennin in the test tubes by labeling three strips 4, 6 and 8.

❑ Then use three different pipettes to take a tiny drop from the tube and place it on the designated strip. A drop of “R pH 4” should be placed on your “pH 4” strip and so on with a seperate pipette per pH tube. Compare your strip with the color pH key located on the strips container.

❑ Even though you added the rennin to each of the pH solutions, they should still maintain the original pH value.

Make sure the students are comparing the colors of their tested strips to pH indicator.

7

❑ Have two group members take the three test tubes labeled “M” to the milk station.

❑ Fill each one with two mL of the milk solution.

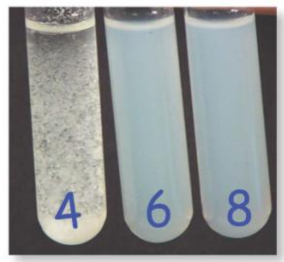
8

- ❑ Have a stop watch ready.
- ❑ Then pour the two mL of rennin and pH solutions into the designated milk solutions; R pH 4 should go into 4M, R pH 6 should go into 6M and R pH 8 should go into 8M.
- ❑ Do this quickly and set the timer for five minutes.
- ❑ Start cleaning up while you wait.

Make sure the students are being careful when pouring the rennin solution into the milk solution.

9

- ❑ After five minutes, record a description of the curdle amounts and sizes for each pH in the data analysis table.
- ❑ Stop the tube with your finger and turn it side ways while holding it up towards the light.
- ❑ Give the tube a hard shake while your finger is stopping it in order to loosen any sediment from the bottom of the tube.
- ❑ If you sway the tube around then you should be able to see the contents of the solutions easier.



The pH 4 tube should look like tiny snow flakes are floating around inside. The pH 6 and 8 tubes should be slightly milky with no visible flakes.

DATA ANALYSIS:

Data Table

Milk+rennin pH=4	*The milk should curdle into small flakes because pH 4 is close to the natural acidic environment of the stomach.*
Milk+rennin pH=6	*The milk should not curdle because pH 6 is too basic. If any curdles appear, they should be less in number and smaller in size than the pH 4 solution. The tube should have no flakes and be a milky color.*
Milk+rennin pH=8	*The milk should not curdle because pH 8 is too basic. The tube should have no flakes and be a milky color.*

1) At which pH did rennin curdle the milk the best?
The pH 4 should work the best because it is the closest to the natural acidic range of the stomach of a cow from with rennin is found.

2) Does your data make sense? Why or why not?
The natural environment for rennin is inside a calf's stomach, which is very acidic. So yes, the data makes sense because the solution curdled the best.

3) Was your hypothesis correct? y/n

4) At which pH did rennin curdle milk slowest? Why did this happen?
The other solutions should be left with little to no curdles. The rennin could not work in such basic solutions.

5) If rennin was not available for a calf, what do you think would happen?
The reaction would have to occur on its own and therefore might never happen. The calf would receive less nutrients because the milk would not be broken down into nutrient rich molecules. The calf would become malnourished and eventually die.

FINAL STEP:

After the entire experiment is finished and the data analysis is complete, clean up your work station, rinse your test tubes (everything can be dumped in the trash or down the sink) and return all supplies to the designated area.

Enzyme Instigator

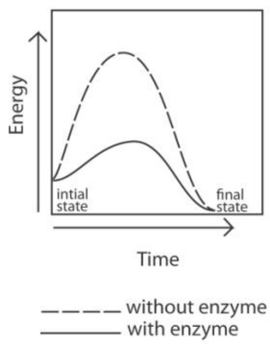
Teacher Instructions:
Pre and post quiz answers

Directions: Circle the correct answer

1. A substrate:
   - A. Speeds up a reaction
   - B. Breaks up a molecule
   - C. Is a negatively charged particle
   - D. Is the original molecule in a reaction

2. An enzyme can denature:
   - A. In extremely hot temperatures
   - B. In a very acidic environment
   - C. All of the above
   - D. None of the above

3.



According to this graph, during a reaction enzymes:
   - A. Decrease the required time
   - B. Raise the energy produced
   - C. Lower the required activation energy
   - D. Lower the initial state energy

4. In a reaction, the substrate binds to a region on an enzyme known as:
   - A. Catalyst
   - B. Active site
   - C. Docking station
   - D. Binding mark

APPENDIX D
Instructions for Production of Hands-on Models

Forming the models:
The first step is to form the enzyme model. It should be about 7 inches long, 4 inches wide and 4 inches deep. The model should have an active site, crevices that resemble the animation's enzymes and a flat underside in order to attach to a base. Start by forming the basic shape with tin foil. Then cover this tin foil with about half an inch layer of Super Sculpy. Once you have manipulated the sculpy around the model to make it look similar to the animation model, texture is ready to be added. To acquire a texture similar to the animation use the outside of a golf ball. To make the golf ball easier to use, add a handle by cutting the golf ball in half and gluing a stick to the inside of the plastic covering. Press the golf ball into the sculpy around the entire enzyme. Perfect the model until the desired effect is reached. Next, place the entire model into an oven on a nonstick cookie sheet at 275°F for fifteen minutes. Pull the model out of the oven and allow it to cool. Repeat these steps for the smaller pairs of substrates. When forming the substrates, remember to measure one set to fit perfectly into the active site but allow the other sets to be slightly larger than the enzyme's active site. There should now be one enzyme model, two substrates that pair together and fit perfectly into the active site, and two other pairs of substrates that are barely too large to fit into the active site.

Preparing the models to pour molds:
It is now time to form the molds. Using a four inch foam block that is about 3 inches larger on all sides than the enzyme model, carve out a recess in the center that will hold half the depth of the enzyme. There will be some gaps between the foam and the enzyme so fill these gaps with clay. Next, construct three inch tall walls around the perimeter of the foam block that are about an inch think. Make sure there are no holes in the seams of the walls where the join each other and where they join the foam block. Spray the entire project with a light coat of *Mann Ease Release* and let it dry for five minutes. Repeat these steps with the six substrate models.

Preparing the silicone molds:
These next steps will require very good attention to percentages and volume. Make only enough silicone mixture to thinly coat the enzyme and substrates. Weigh the empty container that you plan to mix the compound and record it. Fill the container approximately half full with the silicone base material (white goo). Weigh the container and the silicone, subtract the original weight of the container

and record the weight of just the silicone base inside. Next, add the correct amount of catalyst to the silicone base based on the manufacturer directions (example: If there were 200 grams of base and the manufacturer called for 10% catalyst, 20 grams of catalyst should be added to the silicone base). In order to precisely measure the catalyst needed, set a scale to the weight of the container + silicone base +amount of catalyst needed based on the percentage given by the manufacturer. Place the container +silicone base on one side of the scale. Now add the catalyst to the container and silicone base until the scale evens out. Mix the catalyst and silicone thoroughly so that there are no white or overly dark yellow streaks in the mixture. Be sure to scrape down the sides and the bottom until there is a uniform yellow color.

Detail Coat:
The detail coat comes next. Start by pouring a thin layer of the silicone mixture over the entire enzyme. Do not worry about drying because the silicone with adhere to itself even after parts have dried. Go slowly and make sure every detail gets covered in the silicone. Once there is a thin layer over the entire enzyme, let the silicone dry until it does not pull up when poked with a probe.

Pouring the bulk of the silicone:
After all models are dry, it is time to pour the base of the mold. Start by making enough silicone mixture (described above) to totally fill the walls of the molds. When it is thoroughly mixed, add some drops of Thixotropic compound to the mix (as per manufacturer's directions). Mix until the mixture has a butter consistency. Using a blunt object (like a spatula or cake frosting applicator), gently spread the thickened silicone into the models and bases. You want to base to be at least one inch think over the tallest part of the model. Smooth the surface flat and allow everything to dry over night. When the mold is dry, gentle pull the clay walls away first. Repeat the mold steps for the other side of the mold.

Pouring the plastic into the molds:
Set up the molds by placing the two pieces together, placing wooden sheets on either side and clamping the mold with up to four clamps. Pour the smooth cast plastic mixture based on the manufacturer's directions. Before combining the two solutions, add the desired coloring dye. Make sure to create a color that is a few shades darker than desired because the mixture will dry much lighter. Once you have reached the desired color, combine the solutions, stir thoroughly and pour into the mold through the fabricated hole. Let the molds dry as directed by the manufacturer. Once they are dry, unclamp the molds and gentle pull the two silicone pieces apart to reveal the plastic model. Repeat these steps for all the models.

Adding the magnets to the models:

This part will take understanding how the models actually work. Use a drill bit that is barely larger than the desired magnet. Drill into the following spots before adding the magnets but save the drill remnants and powder for a later step. Also, do not drill more than an eighth of an inch farther than the total height of the magnets. Stack three 10.69 lb pull magnets and add them to the center of both spheres of the active site of the enzyme (6 magnets total). Next, move direct lateral about an inch and a half and add one 10.69 lb pull magnet to both spheres of the active site (2 magnets total). To finish the enzyme, move about half an inch lateral on the smaller sphere of the enzyme and add one 2.67 lb pull magnet to the active site. Now add the magnets to the substrates. Two 2.67 lb pull magnets will be stacked and added to the connection site of both same colored substrates. The substrates that fit perfectly into the active site will have additional magnets that connect them to the active site. Add one 10.69 lb pull magnet to the center bottom of each substrate. Once all of the models have been drilled and place with the proper magnets, it is time to fill the magnets. Use the drill remnants mixed with a little clear silicone to cork the holes. Before the mixture has dried, try to texture the spot to look similar to its surroundings. After the mixture has dried, if the spot is a little dry and discolored looking, brush a little clear finger nail polish over the spot and rub it into the crevices.

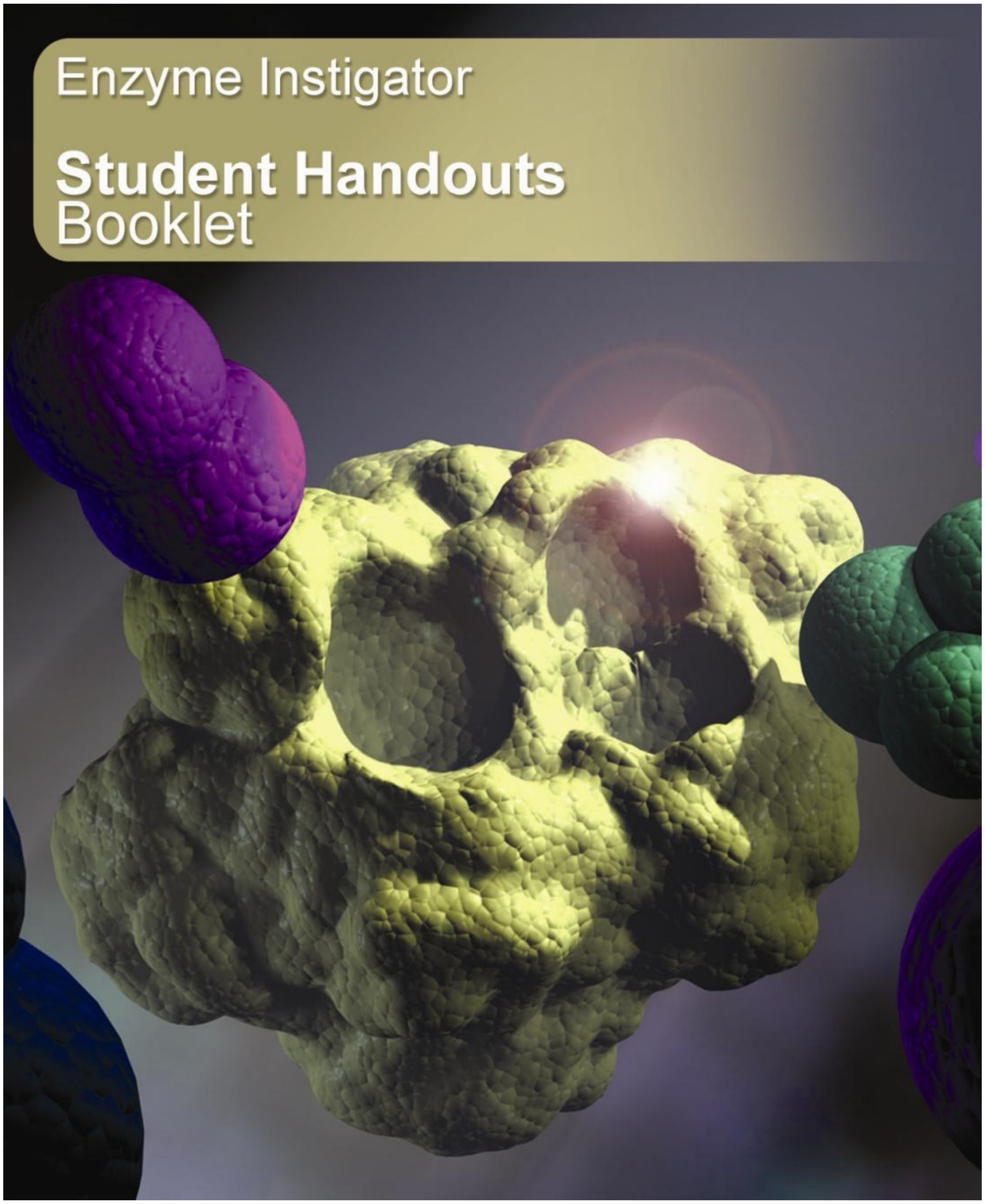
Adding the base to the enzyme model:

Cut a hard wood block to eight inches wide, ten inches long and two inches deep. Stain this wood with an ebony stain and finish with a clear polyurethane coat. Cut a one inch think piece of Plexiglas to a five inch square. Adhere the Plexiglas to the center of the wood block. Then, adhere the center bottom of the enzyme to the top of the Plexiglas block. Let dry overnight.

Adding titles to the bases:

Choose an uncommon enzyme name and the substrates that it reacts with. Then choose two other substrates that students could not easily rule out from working with the selected enzyme. Add the enzyme title to the wooden base and then add the substrate titles to the lids of their acrylic container. Make sure to place the title upside down since the lid will be upside down when serving as a base.

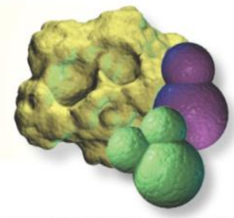
APPENDIX E
Student Handouts Booklet



Enzyme Instigator
Student Handouts
Booklet

Enzyme Instigator

Homework handout



Enzymes exist in parts of our daily lives that nobody would expect. Every time you wash your clothes, eat an ice cream cone or take an antacid, you're utilizing enzymes. Throughout this handout you'll learn how enzymes work, and some interesting facts about enzymes in your life.

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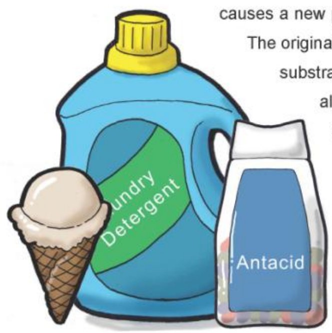
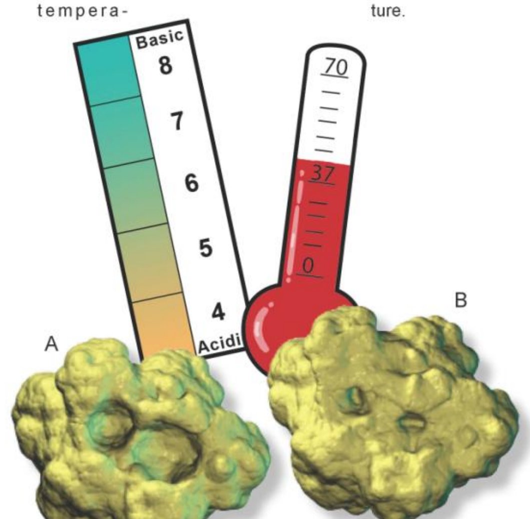


Most reactions occur very slowly and need the help of a protein called an enzyme to speed them up. Enzymes basically add some of their energy to the substrates reaction to make this happen. This energy is called activation energy. The substrates would normally require a very high amount of energy to produce a reaction on their own, but with the help of the enzyme's energy, they require much less. In order for an enzyme to add it's energy, the substrates must dock on a specially shaped spot on the enzyme's surface called the active site. This is where the reaction will be activated. But the shape of the site is very specific and will allow only a certain substrate to dock.

Slight changes in the enzyme's shape, specifically the shape of the active site, can mess up an enzyme to the point where it does not work with the substrates it was meant to work with. The two biggest things that affect the shape of an enzyme are pH level and temperature. Let's first review what "pH" means. The pH level is the measurement of the acidity of a solution which is related to the concentration of dissolved hydrogen ions (H+) within a solution.

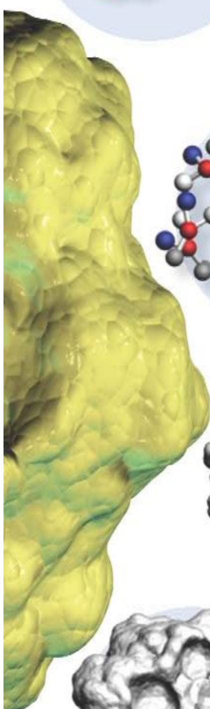
Each enzyme has a very specific pH and temperature that it needs for its activity. These are called the optimal pH and optimal temperature. If the temperature gets too high or the solution gets too acidic or basic the enzyme changes shape irreversibly, a process referred to as denaturation. In the picture below, [fig1] the yellow objects are enzymes [A and B]. The circular holes on the surface of the enzyme comprise its active site. The enzyme on the left [A] shows the regular shaped site. The enzyme on the right [B] has a misshaped active site because of denaturation from a change in the pH or the temperature.

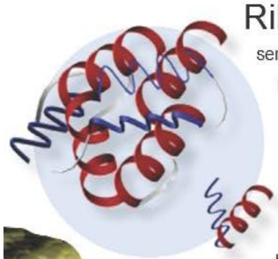


[fig1]

Different ways to look at an enzyme

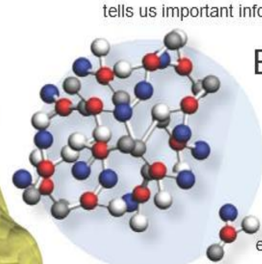
Enzymes and substrates, like all molecules, are made of atoms which consist of protons and neutrons with circulating electrons. The atoms in a molecule are held together with chemical bonds, usually by sharing electrons between them. Molecules can be shown in three different ways, shown below. Refer to the first three models, and then to our own simplified form at the bottom of the page.





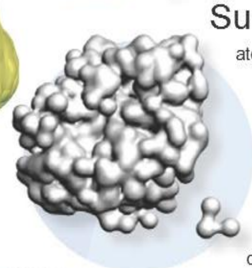
Ribbon Model:

Proteins are very large molecules made up of a series of connected amino acids. Amino acids have a common backbone with other atoms decorating the sides of the backbone to make each amino acid special. The ribbon model shows the chain of backbones and ignores the decorating atoms. But the backbone chain can have a structure itself, either a helix (like a corkscrew) or a strand of a pleated sheet (like a curtain). Each type is represented with a different color; red represents helices, blue represents pleated sheets and green represents turns at the end of the sheets. This type of model gives less specific details about the arrangement of individual atoms and chemical bonds in the molecule but displays important information regarding the basic structure of the protein, just as a skeleton tells us important information about the shape of the whole body.



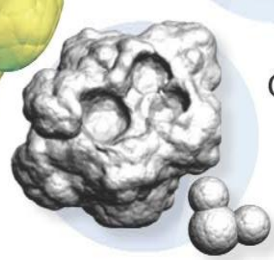
Ball and Stick Model:

This model shows the atoms as balls and the chemical bonds as sticks joining each ball (atom). Each type of atom (carbon, hydrogen, etc.) is colored differently. Each carbon atom is usually black or grey, each hydrogen atom is white, each oxygen atom is red and each nitrogen atom is blue. A problem with the ball and stick models is that it does not represent the space consumed by the circulating electrons.



Surface or Space Filling Model:

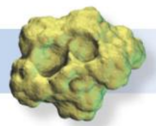
Here the atoms are represented as overlapping spheres. The diameters of the sphere are important because they correspond to their Van der Waals radius; atoms can get no closer to each other than their Van der Waals radii. This model gives a better sense of how crowded the space is within the molecule. This type of model is not very useful for probing the inner structure of a protein (because the inside is not visible, only the surface), but can do a good job in showing the shape and charge of the surface and how it might interact with another protein or with an enzyme substrate.

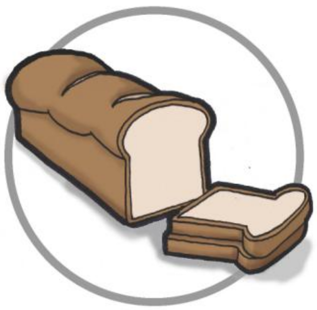


Our Model

for this learning module is a slight variation from the typical surface or space filling model. We have simplified the surface and made the active site more obvious by smoothing some of the atoms. We have also enlarged the substrate to make it easier to view. You can compare all of the models to see the similarities and differences between them all.

Fun Facts About Enzymes





[fig 2]

[fig 3]

[fig 4]

Do you know where enzymes get their name? [fig 2] Yeasts contain enzymes which convert sugar into ethanol and carbon dioxide gas. The word "enzyme" comes from the Greek words "in-zyme" which means "in leaven" or "in yeast."

Speaking of names, do you know the common suffix for enzymes? [fig3] Most enzymes start with the name of the substrate that they work with and end in –ase. For example, an enzyme that breaks up carbohydrates would be called carbohydrase. But this is not true for all enzymes. The enzyme rennin and trypsin do not follow this rule. Do you know which substrates they perform on?

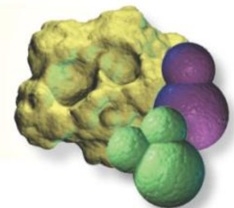
Do you know why your eyes water when you cut an onion? [fig 4] During the process of slicing up these tear- jerkers an enzyme known as allinase and another compound called isothiocyanate get together on the surface of the onion and create a type of sulfuric vapor which gets into the eyes and irritates them to the point of tears.

Questions:

1. How are amino acids the same? How are they different?
2. Compare in your own words the different ways of looking at a protein or enzyme. Find examples of each on the internet.
3. We are warm-blooded and maintain the same temperature regardless of the external temperature. Do you know of any cold-blooded animals? What do you think happens to their enzyme activities when the weather gets cold?
4. Give two alternative names for molecules?
5. How is the protein model used in this handout ("Our Model on page 2) different from a surface model? How is it the same?

Enzyme Instigator

Homework handout



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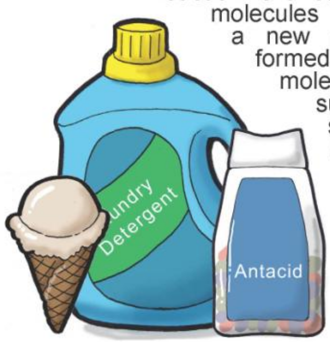

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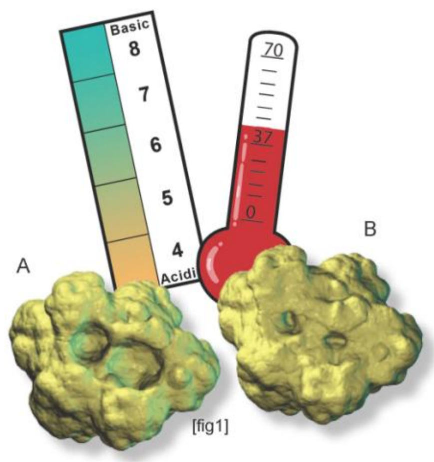

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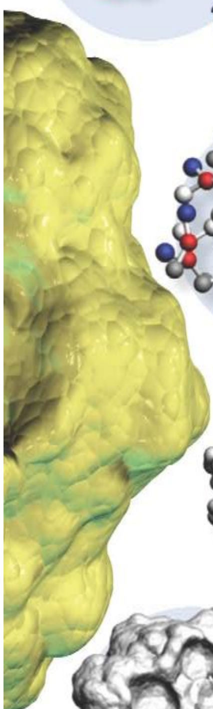

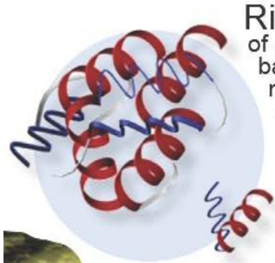

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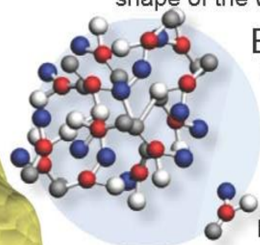

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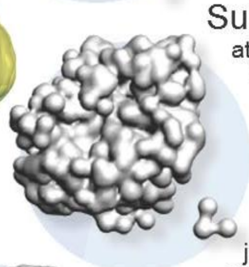

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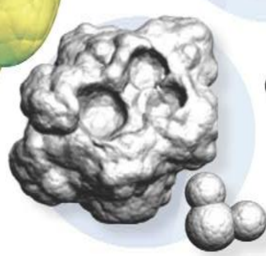

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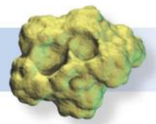
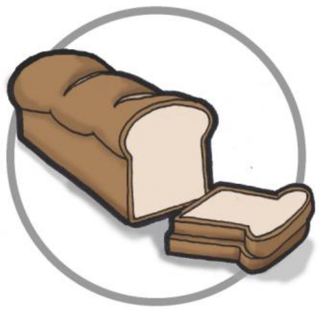
Enzyme Instigator, *Homework handout instructions*, Page 2

Fun Facts About Enzymes





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Enzyme Instigator

Teacher Instructions:
Lab1: Set up

Prep time: 30 minutes the day before the lab and 30 minutes the day of the lab.

MATERIALS INCLUDED inside suitcase:	MATERIALS NOT INCLUDED inside suitcase:	MATERIALS FOR SET UP:
ice cube trays	400 mL beakers	gelatin packet
strainer	test tubes	one and a half cups boiling of water
plastic knives	grease pencils	half a cup of cold water
gelatin packets	test tube racks	blue food dye
blue food dye	paper plates	ice cube trays
thermometer		one large, fresh pineapple
pipettes		strainer

THE DAY BEFORE THE LAB:

Making the gelatin:

1. Each packet of gelatin ("Knox original gelatin" located in the container labeled "lab supplies") will make enough squares for 20 groups (one square per group of four students), so depending on the amount of classes and groups performing the experiment, you might need to make more than one batch of gelatin.
2. Boil one and a half cups of water.
3. Empty a packet of the gelatin into a large bowl.
4. Pour the hot water over the gelatin.
5. Mix thoroughly for at least two minutes.
6. Add half a cup of cold water and continue mixing.
7. Add three drops of blue food coloring (located in the container "lab supplies") and mix completely.
8. Pour the entire mixture into the ice cube trays. Do not overfill each cube.
9. Let chill over night.

Making the pineapple juice:

1. Cut a large fresh pineapple (can be purchased at most grocery stores) into large chunks, leaving out the skin and core of the fruit.
2. Use a food processor to puree the cubes of pineapple.
3. Pour the puree into the strainer over an appropriately sized bowl. Use a spatula to press the puree through the strainer.
4. Cover the juice and let chill overnight.

THE DAY OF THE LAB:

1. On the day of the lab, set up three stations. One station should be stocked with enough plates (or paper towels) and plastic knives (located in the container labeled "lab supplies") so that each group can have one of each, along with the ice trays of gelatin.
2. Another station with the bowl of pineapple juice and enough one milliliter pipettes for each group.
3. The last station should have enough of the other materials for each group: three 400 mL beakers, six test tubes, one grease pencil, one thermometer and one test tube rack. Let the students know where each station is at the beginning of the class. The students also need access to ice and a microwave (to get the water to the right temperature for the experiment).

Teacher Instructions:
Lab 1: Gelatin and fruit enzymes
Determine the temperature at which pineapple juice (bromelain) will work best.

INTRODUCTION:

In this lab you will be investigating the enzymes found in fruits, specifically the enzyme bromelain from pineapples. Pineapples contain enzymes that actively break up other proteins, while other fruits (such as apples) do not. Enzymes that break up proteins are called proteases. Like all other enzymes, these different proteases work best within a certain temperature and pH range.

Bromelains are commonly used in cosmetics, laboratory work, and even in meat tenderizers! The protein used in this lab will be gelatin. This is a protein derived from the connective tissue of animals. Gelatin can form a water-holding matrix and when the fruit enzymes are working and breaking down the gelatin's matrix, the gelatin will go from a solid to a liquid form.

OBJECTIVES:

1) Understand the basic principles of enzyme-catalyzed reactions.

2) Determine the temperature at which different fruit enzymes will work best.

HYPOTHESIS:

You will be testing the function of the fruit enzyme bromelain through a range of temperatures. Keep in mind that pineapples are grown in very warm tropical climates. Construct a hypothesis about the temperature range in which the pineapple protease bromelain will function in the table below.

Cold 0-10 ° C y/n
Room temperature 26 ° C y/n
Hot 75 ° C y/n

Write a hypothesis about which temperature you think will work and why:

MATERIALS:

three 400 mL beakers
6 test tubes
1 mL squeeze pipette
grease pencil
small plate
plastic butter knife
test tube rack
thermometer

PROTOCOL:

1

- ❑ Label three of your test tubes: "cold gel", "room gel" and "hot gel".
- ❑ The "gel" stands for the gelatin that you will be adding to these tubes.
- ❑ Next, label three test tubes: "cold pine", "room pine" and "hot pine".
- ❑ The "pine" stands for the pineapple juice that will be added to these tubes.

2

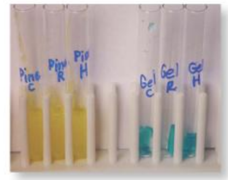
- ❑ Send one member of the team with the plate to gather a cube of gelatin from the ice cube trays that have been previously prepared.
- ❑ Return to the team.
- ❑ Cut the gelatin into three slices that are about ½ inch long, ¼ inch wide and 1/8 inch thick. This might take a few tries.
- ❑ Then place one slice of gelatin in each of the three "gel" test tubes.
- ❑ Let the gelatin slide down instead of shaking it down because this could break the gelatin which could mess up the lab.

Make sure that the students cut these gelatin slices correctly. Also, make sure the students do not shake the gelatin down to the bottom because it can break the piece. They should either lightly tap the tube or allow the gelatin to make it's way down to the bottom.

3

- ❑ Have two team members go to the pineapple juice station and add two mL of pineapple juice with the squeeze pipette to each of the three “pine” test tubes.
- ❑ You should squeeze out all the air before sticking the pipette into the juice so that you can completely fill the pipette.

Make sure the students are getting the proper amount of juice inside their pipette.



4

- ❑ Label one beaker with tape and a grease pencil “ice”.
- ❑ Fill it half way with ice and add enough water to fill the space around the ice.

5

- ❑ Label one beaker “room”.
- ❑ Fill it with (26 ° C) room temperature water.
- ❑ Run a mixture of hot and cold water from the faucet.
- ❑ Then check the temperature with a thermometer.

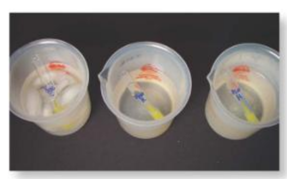
6

- ❑ Label one beaker “hot”.
- ❑ Fill it with (75 ° C) hot water.
- ❑ Run hot water from the faucet.
- ❑ Then check the temperature with a thermometer.
- ❑ You might need to put it in a microwave for a minute or less.
- ❑ Continue to check the temperature with your thermometer.
- ❑ Do not leave the thermometer in the juice while the microwave is on!

7

- ❑ Place the test tubes of fruit juice in their designated bath for five minutes.

The tubes you use should be close to the height of the beakers. This will allow them to be placed in the bath, angle slightly and not sink into the water. If the tubes are getting the bath inside them, allow the students to tape the tubes to the inside of the beakers.



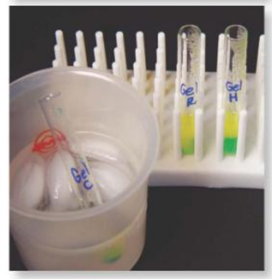
8

- ❑ After five minutes is up, take the “room” and “hot” tubes out of their baths and place them on your rack.
- ❑ Leave the “cold” tube inside the “cold” bath.
- ❑ You want the “hot” to cool back to room temp because if we added the extremely hot water to the gelatin now, the heat would break up the protein, NOT the enzyme in the juice.
- ❑ But if we bring it back to room temperature, we can evaluate the juice’s enzyme.
- ❑ Place a thermometer inside the “hot” tube and watch the temperature decrease.
- ❑ Once it hits 30 ° C, you are ready to move on to the next step.
- ❑ You can speed this process by placing it in the cold bath for a few seconds but keep the thermometer in it and pull the tube out of the ice once it reaches 40 ° C because it will continue to decrease in temperature even after you pull it out.

Make sure the students allow the “hot” tubes to cool. If they do not, the experiment will be ruined and they will need to start over. They can speed up the cooling process by placing a thermometer in the tube and placing the tube in the cold beaker. Make sure the students pull the tube out about 10 degrees before the appropriate temperature. Also make sure that the students leave the “cold” tube of juice in the “cold” bath. The “cold” tube needs to maintain it’s temperature in order for the experiment to work.

9

- ❑ Once the “hot” juice has come back down to 30 ° C, add the 2mL of fruit juice to it’s designated test tube of gelatin.
- ❑ The cold juice with the “cold gel”, the room juice with the “room gel” and the hot juice with the “hot gel”.
- ❑ Place the “cold gel” tube with juice and gelatin back in the ice bath but leave the other two out on your rack.
- ❑ Start the timer for eight minutes.



Make sure the students carefully pour the juice into the gel tubes and that they place the “cold gel” back into the cold bath.

10

- ❑ After eight minutes, evaluate the enzyme’s effectiveness.
- ❑ Stop the tube with your finger and sway the contents back and forth while looking up at a light.
- ❑ You should be able to see some difference in the gelatin between each tube.
- ❑ Record the differences in a table similar to the one in “data analysis”.

Once the laboratory is over, the students should be able to see that the juice at room temperature broke down the gelatin the best. This is because the “hot” juice’s enzymes were denatured in the heat and the “cold” juice’s enzymes were also not able to work properly because of the extreme conditions. Make sure that the students carefully plug the tube with their finger and tip the tube up to the light so that they can see the different in the gelatin slices.

DATA ANALYSIS:

Data Table

	COLD	ROOM	HOT
GELATIN RESULT	*The gelatin should still be very solid and clear blue because the cold slowed down the process too much.*	*The gelatin should be more see-through and thinner because the enzymes were not destroyed or slowed and therefore able to properly work.*	*The gelatin should still be very solid and clear blue because the heat de-natured the enzyme.*

1) At which temperature did the pineapple juice digest the gelatin the fastest?
room

2) Does your data make sense? Why or why not?
The average temperature of Hawaii (a pineapple growing region) is 23 degrees Celsius. So yes, the date made sense because the room temperature, at 26 degrees Celsius, is very close to the average temperature of the region where pineapples are grown.

3) Was your hypothesis correct? y/n

4) At which temperature did pineapple juice digest the gelatin the slowest? Why did this happen?
Both the cold and hot temperatures should barely break down the gelatin so either answer should work.

FINAL STEP:

After the entire experiment is finished and the data analysis is complete, clean up your work station, rinse your test tubes (everything can be dumped in the trash or down the sink) and return all supplies to the designated areas.

Enzyme Instigator

Lab 1: Gelatin and fruit enzymes

Determine the temperature at which pineapple juice (bromelain) will work best.

INTRODUCTION:

In this lab you will be investigating the enzymes found in fruits, specifically the enzyme bromelain from pineapples. Pineapples contain enzymes that actively break up other proteins, while other fruits (such as apples) do not. Enzymes that break up proteins are called proteases. Like all other enzymes, these different proteases work best within a certain temperature and pH range.

Bromelains are commonly used in cosmetics, laboratory work, and even in meat tenderizers! The protein used in this lab will be gelatin. This is a protein derived from the connective tissue of animals. Gelatin can form a water-holding matrix and when the fruit enzymes are working and breaking down the gelatin's matrix, the gelatin will go from a solid to a liquid form.

OBJECTIVES:

1) Understand the basic principles of enzyme-catalyzed reactions.

2) Determine the temperature at which different fruit enzymes will work best.

HYPOTHESIS:

You will be testing the function of the fruit enzyme bromelain through a range of temperatures. Keep in mind that pineapples are grown in very warm tropical climates. Construct a hypothesis about the temperature range in which the pineapple protease bromelain will function in the table below.

Cold 0-10 ° C y/n
Room temperature 26 ° C y/n
Hot 75 ° C y/n

Write a hypothesis about which temperature you think will work and why:

MATERIALS:

three 400 mL beakers
6 test tubes
1 mL squeeze pipette
grease pencil
small plate
plastic butter knife
test tube rack
thermometer

PROTOCOL:

1

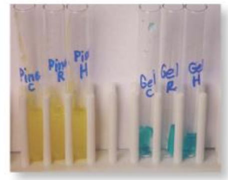
- ❑ Label three of your test tubes: “cold gel”, “room gel” and “hot gel”.
- ❑ The “gel” stands for the gelatin that you will be adding to these tubes.
- ❑ Next, label three test tubes: “cold pine”, “room pine” and “hot pine”.
- ❑ The “pine” stands for the pineapple juice that will be added to these tubes.

2

- ❑ Send one member of the team with the plate to gather a cube of gelatin from the ice cube trays that have been previously prepared.
- ❑ Return to the team.
- ❑ Cut the gelatin into three slices that are about ½ inch long, ¼ inch wide and 1/8 inch thick. This might take a few tries.
- ❑ Then place one slice of gelatin in each of the three “gel” test tubes.
- ❑ Let the gelatin slide down instead of shaking it down because this could break the gelatin which could mess up the lab.

3

- ❑ Have two team members go to the pineapple juice station and add two mL of pineapple juice with the squeeze pipette to each of the three "pine" test tubes.
- ❑ You should squeeze out all the air before sticking the pipette into the juice so that you can completely fill the pipette.



4

- ❑ Label one beaker with tape and a grease pencil "ice".
- ❑ Fill it half way with ice and add enough water to fill the space around the ice.

5

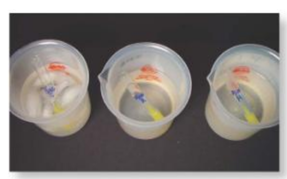
- ❑ Label one beaker "room".
- ❑ Fill it with (26 ° C) room temperature water.
- ❑ Run a mixture of hot and cold water from the faucet.
- ❑ Then check the temperature with a thermometer.

6

- ❑ Label one beaker "hot".
- ❑ Fill it with (75 ° C) hot water.
- ❑ Run hot water from the faucet.
- ❑ Then check the temperature with a thermometer.
- ❑ You might need to put it in a microwave for a minute or less.
- ❑ Continue to check the temperature with your thermometer.
- ❑ Do not leave the thermometer in the juice while the microwave is on!

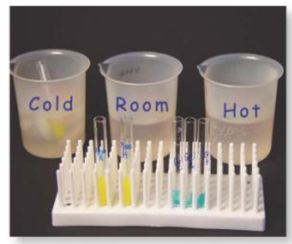
7

- ❑ Place the test tubes of fruit juice in their designated bath for five minutes.



8

- ❑ After five minutes is up, take the “room” and “hot” tubes out of their baths and place them on your rack.
- ❑ Leave the “cold” tube inside the “cold” bath.
- ❑ You want the “hot” to cool back to room temp because if we added the extremely hot water to the gelatin now, the heat would break up the protein, NOT the enzyme in the juice.
- ❑ But if we bring it back to room temperature, we can evaluate the juice’s enzyme.
- ❑ Place a thermometer inside the “hot” tube and watch the temperature decrease.
- ❑ Once it hits 30 ° C, you are ready to move on to the next step.
- ❑ You can speed this process by placing it in the cold bath for a few seconds but keep the thermometer in it and pull the tube out of the ice once it reaches 40 ° C because it will continue to decrease in temperature even after you pull it out.



9

- ❑ Once the “hot” juice has come back down to 30 ° C, add the 2mL of fruit juice to it’s designated test tube of gelatin.
- ❑ The cold juice with the “cold gel”, the room juice with the “room gel” and the hot juice with the “hot gel”.
- ❑ Place the “cold gel” tube with juice and gelatin back in the ice bath but leave the other two out on your rack.
- ❑ Start the timer for eight minutes.

10

- ❑ After eight minutes, evaluate the enzyme’s effectiveness.
- ❑ Stop the tube with your finger and sway the contents back and forth while looking up at a light.
- ❑ You should be able to see some difference in the gelatin between each tube.
- ❑ Record the differences in a table similar to the one in “data analysis”.

DATA ANALYSIS:

Data Table

	COLD	ROOM	HOT
GELATIN RESULT			

1) At which temperature did the pineapple juice digest the gelatin the fastest?

2) Does your data make sense? Why or why not?

3) Was your hypothesis correct? y/n

4) At which temperature did pineapple juice digest the gelatin the slowest? Why did this happen?

FINAL STEP:

After the entire experiment is finished and the data analysis is complete, clean up your work station, rinse your test tubes (everything can be dumped in the trash or down the sink) and return all supplies to the designated areas.

Enzyme Instigator

Lab2: Milk and Rennin

Determine the optimal pH range for the enzyme Rennin.

INTRODUCTION:

We all know that milk will eventually curdle over several days or weeks (depending on the environment), but in the presence of an enzyme, called rennin, milk will curdle within minutes. Rennin is an enzyme produced in the stomach of calves. It breaks down proteins found in the mother's milk, in order for a baby calf to properly digest and therefore obtain nutrients. This enzyme works by breaking down a common milk protein called casein. In this lab, you will see the broken pieces of casein clump together to form milk curds. Nearly all enzymes are proteins themselves and rennin is no exception. There are a few factors that affect the efficiency of an enzyme: temperature and pH. Temperature and pH affect enzymes by influencing reaction rates and stability of the enzyme's structure. The optimal temperature range and pH range that enzymes function in are important properties. This lab will help you determine the optimal pH range for rennin.

OBJECTIVES:

1) Understand the basic principles of enzyme-catalyzed reactions.

2) Determine the pH range in which rennin will work best.

HYPOTHESIS:

You will be testing the function of the enzyme rennin through a pH range of 4, 6 and 8.
Construct a hypothesis about the pH range in which rennin will function in the table below.

Table 1. Hypothesis Formation.
Will rennin work at a very acidic pH=4? y/n
Will rennin work at a mildly acidic pH=6? y/n
Will rennin work at a mildly basic pH=8? y/n

Write your hypothesis in a sentence about which pH you think rennin will work best and why:

MATERIALS:

three beakers
seven test tubes
1 mL squeeze pipette
milk solution
rennin solution
pH solutions at values 4,6 and 8
three stir sticks
three strips of pH paper
grease pencil
one test tube rack

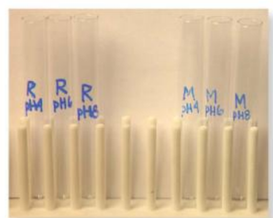
PROTOCOL:

1

- ❑ Gather all of the materials listed above except the milk, rennin and pH solutions.

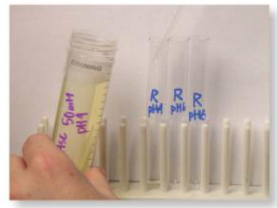
2

- ❑ Label three of the test tubes using a grease pencil: R pH4, R pH6 and R pH8.
- ❑ The "R" stands for the rennin that you will be adding to these tubes and the number represents the pH value that you will be testing in that tube.
- ❑ Then label three other test tubes: M4, M6 and M8.
- ❑ The "M" stands for the milk that you will be adding to these tubes and the number represents the pH value that you will be testing in that tube.
- ❑ Then label the last test tube: rennin. You'll use this tube to get all the rennin for the whole lab.



3

- ❑ Have two team members bring the stand with the three "R pH" test tubes to the designated area of pre-made pH solutions.
- ❑ Then, using the one mL pipettes located with each pH value, squeeze one mL of pH 4 solution into the test tube labeled "R pH 4".



- ❑ You should squeeze out all the air before sticking the pipette into the solution. The pipette will not fill completely. It will only fill about half way when done properly.
- ❑ Continue this with the pH values 6 and 8 into its designated test tube. Do not cross contaminate the pipettes.
- ❑ If you use a pipette inside the solution pH 4 from the solution pH 8, you risk contaminating the pH values. Make sure to use the right pipette.
- ❑ When you are done, each test tube should have one mL of the designated pH solution inside them.

4

- ❑ Have one team member bring an empty test tube to the rennin solution and fill it with three mL of the rennin solution.
- ❑ Bring the rennin back to the group.

5

- ❑ Using a clean squeeze pipette, add one mL of rennin solution to each of the rennin labeled test tubes that you previously added different pH solutions to.
- ❑ Stir the new solution with a clean stir stick to assure complete mixing.
- ❑ Now your 3 rennin test tubes should have two mL of liquid in each of them.

6

- ❑ Double check the pH values of the pH solutions and rennin in the test tubes by labeling three strips 4, 6 and 8.
- ❑ Then use three different pipettes to take a tiny drop from the tube and place it on the designated strip. A drop of “R pH 4” should be placed on your “pH 4” strip and so on with a seperate pipette per pH tube. Compare your strip with the color pH key located on the strips container.
- ❑ Even though you added the rennin to each of the pH solutions, they should still maintain the original pH value.

7

- ❑ Have two group members take the three test tubes labeled “M” to the milk station.
- ❑ Fill each one with two mL of the milk solution.

8

- ❑ Have a stop watch ready.
- ❑ Then pour the two mL of rennin and pH solutions into the designated milk solutions; R pH 4 should go into 4M, R pH 6 should go into 6M and R pH 8 should go into 8M.
- ❑ Do this quickly and set the timer for five minutes.
- ❑ Start cleaning up while you wait.

9

- ❑ After five minutes, record a description of the curdle amounts and sizes for each pH in the data analysis table.
- ❑ Stop the tube with your finger and turn it side ways while holding it up towards the light.
- ❑ Give the tube a hard shake while your finger is stopping it in order to loosen any sediment from the bottom of the tube.
- ❑ If you sway the tube around then you should be able to see the contents of the solutions easier.

DATA ANALYSIS:

Data Table

Milk+rennin pH=4	
Milk+rennin pH=6	
Milk+rennin pH=8	

1) At which pH did rennin curdle the milk the best?

2) Does your data make sense? Why or why not?

3) Was your hypothesis correct? y/n

4) At which pH did rennin curdle milk slowest? Why did this happen?

5) If rennin was not available for a calf, what do you think would happen?

FINAL STEP:

After the entire experiment is finished and the data analysis is complete, clean up your work station, rinse your test tubes (everything can be dumped in the trash or down the sink) and return all supplies to the designated area.

Enzyme Instigator

Lab2: Milk and Rennin

Determine the optimal pH range for the enzyme Rennin.

INTRODUCTION:

We all know that milk will eventually curdle over several days or weeks (depending on the environment), but in the presence of an enzyme, called rennin, milk will curdle within minutes. Rennin is an enzyme produced in the stomach of calves. It breaks down proteins found in the mother's milk, in order for a baby calf to properly digest and therefore obtain nutrients. This enzyme works by breaking down a common milk protein called casein. In this lab, you will see the broken pieces of casein clump together to form milk curds. Nearly all enzymes are proteins themselves and rennin is no exception. There are a few factors that affect the efficiency of an enzyme: temperature and pH. Temperature and pH affect enzymes by influencing reaction rates and stability of the enzyme's structure. The optimal temperature range and pH range that enzymes function in are important properties. This lab will help you determine the optimal pH range for rennin.

OBJECTIVES:

1) Understand the basic principles of enzyme-catalyzed reactions.

2) Determine the pH range in which rennin will work best.

HYPOTHESIS:

You will be testing the function of the enzyme rennin through a pH range of 4, 6 and 8. Construct a hypothesis about the pH range in which rennin will function in the table below.

Table 1. Hypothesis Formation.
Will rennin work at a very acidic pH=4? y/n
Will rennin work at a mildly acidic pH=6? y/n
Will rennin work at a mildly basic pH=8? y/n

Write your hypothesis in a sentence about which pH you think rennin will work best and why:

MATERIALS:

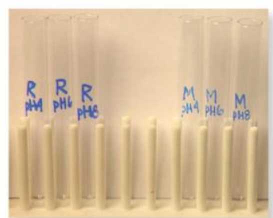
three beakers
seven test tubes
1 mL squeeze pipette
milk solution
rennin solution
pH solutions at values 4,6 and 8
three stir sticks
three strips of pH paper
grease pencil
one test tube rack

PROTOCOL:

1

- ❑ Gather all of the materials listed above except the milk,
  rennin and pH solutions.

2

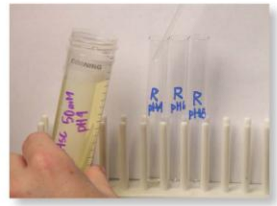


- ❑ Label three of the test tubes using a grease pencil: R pH4, R pH6 and R pH8.
- ❑ The "R" stands for the rennin that you will be adding to these tubes and the number represents the pH value that you will be testing in that tube.
- ❑ Then label three other test tubes: M4, M6 and M8.
- ❑ The "M" stands for the milk that you will be adding to these tubes and the number represents the pH value that you will be testing in that tube.
- ❑ Then label the last test tube: rennin. You'll use this tube to get all the rennin for the whole lab.

3

- ❑ Have two team members bring the stand with the three "R pH" test tubes to the designated area of pre-made pH solutions.
- ❑ Then, using the one mL pipettes located with each pH value, squeeze one mL of pH 4 solution into the test tube labeled "R pH 4".

- ❑ You should squeeze out all the air before sticking the pipette into the solution. The pipette will not fill completely. It will only fill about half way when done properly.



- ❑ Continue this with the pH values 6 and 8 into its designated test tube. Do not cross contaminate the pipettes.
- ❑ If you use a pipette inside the solution pH 4 from the solution pH 8, you risk contaminating the pH values. Make sure to use the right pipette.
- ❑ When you are done, each test tube should have one mL of the designated pH solution inside them.

4

- ❑ Have one team member bring an empty test tube to the rennin solution and fill it with three mL of the rennin solution.
- ❑ Bring the rennin back to the group.

5

- ❑ Using a clean squeeze pipette, add one mL of rennin solution to each of the rennin labeled test tubes that you previously added different pH solutions to.
- ❑ Stir the new solution with a clean stir stick to assure complete mixing.
- ❑ Now your 3 rennin test tubes should have two mL of liquid in each of them.

6

- ❑ Double check the pH values of the pH solutions and rennin in the test tubes by labeling three strips 4, 6 and 8.
- ❑ Then use three different pipettes to take a tiny drop from the tube and place it on the designated strip. A drop of “R pH 4” should be placed on your “pH 4” strip and so on with a seperate pipette per pH tube. Compare your strip with the color pH key located on the strips container.
- ❑ Even though you added the rennin to each of the pH solutions, they should still maintain the original pH value.

7

- ❑ Have two group members take the three test tubes labeled “M” to the milk station.
- ❑ Fill each one with two mL of the milk solution.

8

- ❑ Have a stop watch ready.
- ❑ Then pour the two mL of rennin and pH solutions into the designated milk solutions; R pH 4 should go into 4M, R pH 6 should go into 6M and R pH 8 should go into 8M.
- ❑ Do this quickly and set the timer for five minutes.
- ❑ Start cleaning up while you wait.

9

- ❑ After five minutes, record a description of the curdle amounts and sizes for each pH in the data analysis table.
- ❑ Stop the tube with your finger and turn it side ways while holding it up towards the light.
- ❑ Give the tube a hard shake while your finger is stopping it in order to loosen any sediment from the bottom of the tube.
- ❑ If you sway the tube around then you should be able to see the contents of the solutions easier.

DATA ANALYSIS:

Data Table

Milk+rennin pH=4	
Milk+rennin pH=6	
Milk+rennin pH=8	

1) At which pH did rennin curdle the milk the best?

2) Does your data make sense? Why or why not?

3) Was your hypothesis correct? y/n

4) At which pH did rennin curdle milk slowest? Why did this happen?

5) If rennin was not available for a calf, what do you think would happen?

FINAL STEP:

After the entire experiment is finished and the data analysis is complete, clean up your work station, rinse your test tubes (everything can be dumped in the trash or down the sink) and return all supplies to the designated area.

Enzyme Instigator

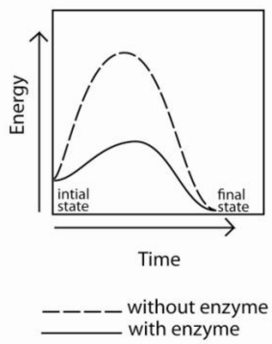
Pre-quiz

Directions: Circle the correct answer

1. A substrate:
   A. Speeds up a reaction
   B. Breaks up a molecule
   C. Is a negatively charged particle
   D. Is the original molecule in a reaction

2. An enzyme can denature:
   A. In extremely hot temperatures
   B. In a very acidic environment
   C. All of the above
   D. None of the above

3.



According to this graph, during a reaction enzymes:
   A. Decrease the required time
   B. Raise the energy produced
   C. Lower the required activation energy
   D. Lower the initial state energy

4. In a reaction, the substrate binds to a region on an enzyme known as:
   A. Catalyst
   B. Active site
   C. Docking station
   D. Binding mark

Enzyme Instigator

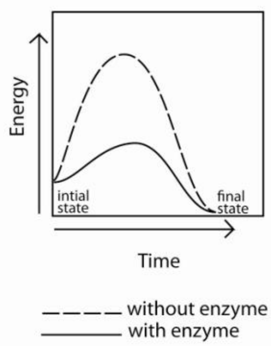
Post-quiz

Directions: Circle the correct answer

1. A substrate:
   A. Speeds up a reaction
   B. Breaks up a molecule
   C. Is a negatively charged particle
   D. Is the original molecule in a reaction

2. An enzyme can denature:
   A. In extremely hot temperatures
   B. In a very acidic environment
   C. All of the above
   D. None of the above

3.



According to this graph, during a reaction enzymes:
   A. Decrease the required time
   B. Raise the energy produced
   C. Lower the required activation energy
   D. Lower the initial state energy

4. In a reaction, the substrate binds to a region on an enzyme known as:
   A. Catalyst
   B. Active site
   C. Docking station
   D. Binding mark

Enzyme Instigator

Glossary

Activation Energy: the amount of energy necessary to activate the start of a reaction

Active Site: the specifically shaped spot on an enzyme where the substrates dock

Amino Acid: building blocks of proteins

Antacid: a substance that neutralizes stomach acidity

Atom: the smallest particle that comprises a chemical element; consists of an electron cloud, protons and neutrons

Ball and stick model: a 3D model that describes the structure of a chemical; utilizes spheres to represent atoms and sticks to represent chemical bonds

Carbon: chemical element with the symbol C; example is "graphite"

Carbon dioxide: chemical compound composed of one carbon atom and two oxygen atoms

Charge: refers to the positive or negative electromagnetic interaction of a molecule

Chemical bond: the attraction between atoms

Chemical element: a type of atom that is distinguished by its atomic number and is located on the periodic table

Compound: a combination of two or more chemical elements

Denaturation: the process where an enzyme loses its shape (often because of an undesirable temperature or pH range)

Electron: a subatomic particle that has a negative charge

Enzyme: a catalyst that helps a reaction between molecules/substrates begin

Ethanol: a flammable, colorless compound that is commonly known as a type of alcohol

Hydrogen: chemical element with the symbol H

Molecule: any group of at least two atoms that are held together by a chemical bond

Neutron: a subatomic particle that has no charge and is slightly larger in size than a proton

Optimal pH: the pH level at which an enzyme will react the best

Optimal temperature: the temperature at which an enzyme will react the best

Oxygen: chemical element with the symbol O

pH: the measurement of the acidity of a solution which is related to the concentration of dissolved hydrogen ions (H+) within a solution

Product: the new molecules formed after a reaction

Protein: organic compound made of amino acids

Proton: a subatomic particle with a positive charge

Reaction: when molecules collide in space, change their chemical bonds and form products

Ribbon model: 3d model that describes the structure of a chemical; utilizes long ribbon shaped elements to describe amino acid backbones

Specificity: referring to an enzymes active site; the site is shape specific

Subatomic particle: a particle smaller than an atom; includes protons, neutrons and electrons.

Substrates: a molecule that an enzyme reacts upon

Surface/Space filling model: 3D model that describes the structure of a chemical; utilizes spheres to represent atoms and sticks to represent chemical bonds.

Van der Waals radius: the radius of an atom determined from measurements of space between pairs of unbonded atoms

APPENDIX F
Evaluation Survey

Enzyme Instigator: A Portable Suitcase Exhibit for the Biology Classroom

Are you a teacher? ______
If so, what grade and subject do you teach? ______
If you are not a teacher, what is your title? ______

Instructions:
Please check the box that corresponds to your level of agreement with the statement to the left (SA=strongly agree, A=agree, N=neutral, D-disagree, SD=strongly disagree). Please feel free to provide additional comments in the spaces provided.

Teacher Instructions Booklet	**SA**	**A**	**N**	**D**	**SD**
1. The Teacher Instructions Booklet was designed in a clear and easy to understand format. Comments:	☐	☐	☐	☐	☐

Homework Handout	**SA**	**A**	**N**	**D**	**SD**
2. The *Homework handout* included helpful information to engage students in the complex concepts of enzymes. Comments:	☐	☐	☐	☐	☐
3. The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading. Comments:	☐	☐	☐	☐	☐

Animation Titled "Enzyme Instigator"	**SA**	**A**	**N**	**D**	**SD**
4. The instructions for playing the animation were clear and helpful. Comments:	☐	☐	☐	☐	☐
5. The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions. Comments:	☐	☐	☐	☐	☐
6. The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion. Comments:	☐	☐	☐	☐	☐
7. The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics. Comments:	☐	☐	☐	☐	☐

	SA	A	N	D	SD
8. The animations clearly described many of the complex concepts of enzymes. Comments:	☐	☐	☐	☐	☐
9. The animation would appeal to students. Comments:	☐	☐	☐	☐	☐

Jeopardase Game

	SA	A	N	D	SD
10. The teacher instructions on the Jeopardase board game clearly described the full setup of the game. Comments:	☐	☐	☐	☐	☐
11. The question board was easy to display and use during the progression of the game. Comments:	☐	☐	☐	☐	☐
12. The game created a fun atmosphere that would spark friendly competition between my students. Comments:	☐	☐	☐	☐	☐

Hands-On Model Demonstration

	SA	A	N	D	SD
13. The teacher instructions on the hands-on model demonstration were clear and helpful. Comments:	☐	☐	☐	☐	☐

Laboratory Experiments

	SA	A	N	D	SD
14. The teacher instructions of the laboratory experiments were clear and helpful. Comments:	☐	☐	☐	☐	☐
15. The laboratory experiments were easy to understand and follow. Comments:	☐	☐	☐	☐	☐
16. The labs were good examples of optimal temperature and pH of enzymes. Comments:	☐	☐	☐	☐	☐
17.The photographs throughout the laboratories helped reinforce the procedures of the experiments. Comments:	☐	☐	☐	☐	☐

Suitcase	**SA**	**A**	**N**	**D**	**SD**
18. The transportation instructions located on the outside of the suitcase were easy to understand. Comments:	□	□	□	□	□
19. The actual suitcase was easy to transport. Comments:	□	□	□	□	□
20. The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase. Comments:	□	□	□	□	□
21. The components of this suitcase will be easy to incorporate into my current curriculum of enzymes. Comments:	□	□	□	□	□
22. The components of this suitcase will enhance my current curriculum of enzymes. Comments:	□	□	□	□	□
23. The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS. Comments:	□	□	□	□	□
24. I would recommend this suitcase to other science teachers. Comments:	□	□	□	□	□

Additional Questions

25. Which component of the suitcase do you think was most effective?

□Homework Handout
□3D animation
□Jeopardase board game
□Hands-on-models
□Laboratory experiments

Comments:

26. Which component of the suitcase do you think was least effective?
□Homework Handout
□3D animation
□Jeopardase board game
□Hands-on-models
□Laboratory experiments

Comments:

27. What type of machine do you currently have access to play movies and animations in your class room?
□PC computer with a projector
□MAC computer with a projector
□TV with DVD player
□I do not have access to any machine for this purpose

Comments:

28. Check the boxes next to the components that you currently have for teaching students about enzymes:
□Homework with only text
□Homework with color illustrations
□3D animation (s)
□Board game (s)
□Hands-on-model (s)
□Laboratory experiment (s)

Comments:

Thank you for your time and participation!

APPENDIX G
Completed Evaluations

Enzyme Instigator: A Portable Suitcase Exhibit for the Biology Classroom

Are you a teacher? Yes
If so, what grade and subject do you teach? 9-12 Biology & PreAP Biology
If you are not a teacher, what is your title? ____________________

Instructions:
Please check the box that corresponds to your level of agreement with the statement to the left (SA=strongly agree, A=agree, N=neutral, D-disagree, SD=strongly disagree). Please feel free to provide additional comments in the spaces provided.

Teacher Instructions Booklet	SA	A	N	D	SD
1. The Teacher Instructions Booklet was designed in a clear and easy to understand format. Comments:	☑	☐	☐	☐	☐

Homework Handout	SA	A	N	D	SD
2. The *Homework handout* included helpful information to engage students in the complex concepts of enzymes. Comments: I would like at least 5 questions on the HW assignments or perhaps 2 different HW assignments.	☐	☑	☐	☐	☐
3. The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading. Comments: Thanks for including answer key	☑	☐	☐	☐	☐

Animation Titled "Enzyme Instigator"	SA	A	N	D	SD
4. The instructions for playing the animation were clear and helpful. Comments:	☑	☐	☐	☐	☐
5. The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions. Comments: Very appropriate for all levels (high & low levels of learners)	☑	☐	☐	☐	☐
6. The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion. Comments:	☑	☐	☐	☐	☐
7. The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics. Comments:	☑	☐	☐	☐	☐

	SA	A	N	D	SD
8. The animations clearly described many of the complex concepts of enzymes. Comments:	☑	☐	☐	☐	☐
9. The animation would appeal to students. Comments:	☑	☐	☐	☐	☐

Jeopardase Game

	SA	A	N	D	SD
10. The teacher instructions on the Jeopardase board game clearly described the full setup of the game. Comments:	☑	☐	☐	☐	☐
11. The question board was easy to display and use during the progression of the game. Comments:	☑	☐	☐	☐	☐
12. The game created a fun atmosphere that would spark friendly competition between my students. Comments:	☑	☐	☐	☐	☐

Hands-On Model Demonstration

	SA	A	N	D	SD
13. The teacher instructions on the hands-on model demonstration were clear and helpful. Comments:	☑	☐	☐	☐	☐

Laboratory Experiments

	SA	A	N	D	SD
14. The teacher instructions of the laboratory experiments were clear and helpful. Comments: Yes, Check off box are neat...	☑	☐	☐	☐	☐
15. The laboratory experiments were easy to understand and follow. Comments: ~~Add~~ In directions, have students to label pH strips. Also use pipet to put pH solution on pH strips. Include in directions	☑	☐	☐	☐	☐
16. The labs were good examples of optimal temperature and pH of enzymes. Comments:	☑	☐	☐	☐	☐
17. The photographs throughout the laboratories helped reinforce the procedures of the experiments. Comments:	☑	☐	☐	☐	☐

Suitcase	**SA**	**A**	**N**	**D**	**SD**
18. The transportation instructions located on the outside of the suitcase were easy to understand. Comments:	☑	☐	☐	☐	☐
19. The actual suitcase was easy to transport. Comments: Most definitely	☑	☐	☐	☐	☐
20. The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase. Comments:	☑	☐	☐	☐	☐
21. The components of this suitcase will be easy to incorporate into my current curriculum of enzymes. Comments:	☑	☐	☐	☐	☐
22. The components of this suitcase will enhance my current curriculum of enzymes. Comments:	☑	☐	☐	☐	☐
23. The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS. Comments:	☑	☐	☐	☐	☐
24. I would recommend this suitcase to other science teachers. Comments:	☑	☐	☐	☐	☐

Additional Questions

25. Which component of the suitcase do you think was most effective?

☐Homework Handout
☐3D animation
☐Jeopardase board game
☐Hands-on-models
☐Laboratory experiments

Comments:

All activities will prove to be effective.
Additional thought * Have Jeopardase game as a powerpoint presentation to use on overhead & smartboard

26. Which component of the suitcase do you think was least effective?
☐Homework Handout
☐3D animation
☐Jeopardase board game
☐Hands-on-models
☐Laboratory experiments

Comments: NA

27. What type of machine do you currently have access to play movies and animations in your class room?
☑PC computer with a projector
☐MAC computer with a projector
☐TV with DVD player
☐I do not have access to any machine for this purpose

Comments:

28. Check the boxes next to the components that you currently have for teaching students about enzymes:
☑Homework with only text
☐Homework with color illustrations
☐3D animation (s)
☐Board game (s)
☐Hands-on-model (s)
☑Laboratory experiment (s)

Comments:

Thank you for your time and participation!

Enzyme Instigator: A Portable Suitcase Exhibit for the Biology Classroom

Are you a teacher? yes

If so, what grade and subject do you teach? Biology, Pre-AP Bio, AP Bio

If you are not a teacher, what is your title?

Instructions:
Please check the box that corresponds to your level of agreement with the statement to the left (SA=strongly agree, A=agree, N=neutral, D-disagree, SD=strongly disagree). Please feel free to provide additional comments in the spaces provided.

Teacher Instructions Booklet

	SA	A	N	D	SD
1. The Teacher Instructions Booklet was designed in a clear and easy to understand format.	☑	☐	☐	☐	☐

Comments: Love the tabs!

Homework Handout

	SA	A	N	D	SD
2. The *Homework handout* included helpful information to engage students in the complex concepts of enzymes.	☐	☐	☑	☐	☐

Comments: I think maybe the "different ways to look at an enzyme" page is irrelevant to the material that students need to know & I think it might be to complicated for them (would cause them to disengage).

also I might add more questions

	SA	A	N	D	SD
3. The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading.	☐	☑	☐	☐	☐

Comments:

Animation Titled "Enzyme Instigator"

	SA	A	N	D	SD
4. The instructions for playing the animation were clear and helpful. Comments:	☑	☐	☐	☐	☐
5. The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions. Comments:	☑	☐	☐	☐	☐
6. The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion. Comments:	☐	☑	☐	☐	☐
7. The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics. Comments:	☐	☑	☐	☐	☐

	SA	A	N	D	SD
8. The animations clearly described many of the complex concepts of enzymes. Comments:	☐	☑	☐	☐	☐
9. The animation would appeal to students. Comments:	☐	☑	☐	☐	☐

Jeopardase Game

	SA	A	N	D	SD
10. The teacher instructions on the Jeopardase board game clearly described the full setup of the game. Comments:	☐	☑	☐	☐	☐
11. The question board was easy to display and use during the progression of the game. Comments: It would be helpful to have this on a PowerPoint presentation to present to the class.	☐	☑	☐	☐	☐
12. The game created a fun atmosphere that would spark friendly competition between my students. Comments:	☐	☑	☐	☐	☐

Hands-On Model Demonstration

	SA	A	N	D	SD
13. The teacher instructions on the hands-on model demonstration were clear and helpful. Comments: Love it! It would be great if there were even more substrates to test & many enzymes that several students could find the right substrates to.	☑	☐	☐	☐	☐

Laboratory Experiments

	SA	A	N	D	SD
14. The teacher instructions of the laboratory experiments were clear and helpful. Comments:	☐	☑	☐	☐	☐
15. The laboratory experiments were easy to understand and follow. Comments:	☐	☑	☐	☐	☐
16. The labs were good examples of optimal temperature and pH of enzymes. Comments:	☐	☑	☐	☐	☐
17. The photographs throughout the laboratories helped reinforce the procedures of the experiments. Comments: Yes! The photographs are extremely helpful.	☑	☑	☐	☐	☐

Suitcase	SA	A	N	D	SD
18. The transportation instructions located on the outside of the suitcase were easy to understand. Comments:	☐	☐	☑	☐	☐
19. The actual suitcase was easy to transport. Comments:	☐	☐	☑	☐	☐
20. The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase. Comments:	☐	☑	☐	☐	☐
21. The components of this suitcase will be easy to incorporate into my current curriculum of enzymes. Comments:	☑	☐	☐	☐	☐
22. The components of this suitcase will enhance my current curriculum of enzymes. Comments:	☑	☐	☐	☐	☐
23. The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS. Comments:	☑	☐	☐	☐	☐
24. I would recommend this suitcase to other science teachers. Comments:	☑	☐	☐	☐	☐

Additional Questions

25. Which component of the suitcase do you think was most effective?

☐ Homework Handout
☑ 3D animation
☐ Jeopardase board game
☑ Hands-on-models
☑ Laboratory experiments

Comments:

26. Which component of the suitcase do you think was least effective?
    - ☑Homework Handout
    - ☐3D animation
    - ☐Jeopardase board game
    - ☐Hands-on-models
    - ☐Laboratory experiments

    Comments:

27. What type of machine do you currently have access to play movies and animations in your class room?
    - ☑PC computer with a projector
    - ☐MAC computer with a projector
    - ☐TV with DVD player
    - ☐I do not have access to any machine for this purpose

    Comments:

28. Check the boxes next to the components that you currently have for teaching students about enzymes:
    - ☐Homework with only text
    - ☑Homework with ~~color~~ illustrations
    - ☐3D animation (s)
    - ☐Board game (s)
    - ☐Hands-on-model (s)
    - ☑Laboratory experiment (s) Toothpickase Lab (w/toothpicks & fingers)

    Comments:

Thank you for your time and participation!

Loved your participation. This is 100x better than what I have in my classroom now. Please build more. ☺

Enzyme Instigator: A Portable Suitcase Exhibit for the Biology Classroom

Are you a teacher? Yes
If so, what grade and subject do you teach? Biology, Biology Pre-AP
If you are not a teacher, what is your title?

Instructions:
Please check the box that corresponds to your level of agreement with the statement to the left (SA=strongly agree, A=agree, N=neutral, D-disagree, SD=strongly disagree). Please feel free to provide additional comments in the spaces provided.

Teacher Instructions Booklet	**SA**	**A**	**N**	**D**	**SD**
1. The Teacher Instructions Booklet was designed in a clear and easy to understand format. Comments:	☒	☐	☐	☐	☐

Homework Handout	**SA**	**A**	**N**	**D**	**SD**
2. The *Homework handout* included helpful information to engage students in the complex concepts of enzymes. Comments:	☐	☒	☐	☐	☐
3. The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading. Comments:	☐	☒	☐	☐	☐

Animation Titled "Enzyme Instigator"	**SA**	**A**	**N**	**D**	**SD**
4. The instructions for playing the animation were clear and helpful. Comments:	☐	☒	☐	☐	☐
5. The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions. Comments:	☒	☐	☐	☐	☐
6. The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion. Comments:	☒	☐	☐	☐	☐
7. The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics. Comments:	☒	☐	☐	☐	☐

	SA	A	N	D	SD
8. The animations clearly described many of the complex concepts of enzymes.	☒	☐	☐	☐	☐

Comments: will be helpful to include lock-and key analogy. Also, in chemistry the students

	SA	A	N	D	SD
9. The animation would appeal to students.	☒	☐	☐	☐	☐

Comments: deals with reactants → products concepts. The term substrate has to be introduced in relation with reactants

Jeopardase Game

	SA	A	N	D	SD
10. The teacher instructions on the Jeopardase board game clearly described the full setup of the game.	☒	☐	☐	☐	☐
11. The question board was easy to display and use during the progression of the game.	☒	☐	☐	☐	☐
12. The game created a fun atmosphere that would spark friendly competition between my students.	☒	☐	☐	☐	☐

Comments (10):

Comments (11):

Comments (12):

Hands-On Model Demonstration

	SA	A	N	D	SD
13. The teacher instructions on the hands-on model demonstration were clear and helpful.	☐	☒	☐	☐	☐

Comments: Could be helpful also to demonstrate enzyme-assisted synthesis reaction

Laboratory Experiments

	SA	A	N	D	SD
14. The teacher instructions of the laboratory experiments were clear and helpful.	☐	☒	☐	☐	☐

Comments: Some improvements should be made

	SA	A	N	D	SD
15. The laboratory experiments were easy to understand and follow.	☒	☐	☐	☐	☐

Comments:

	SA	A	N	D	SD
16. The labs were good examples of optimal temperature and pH of enzymes.	☐	☒	☐	☐	☐

Comments: pH lab did not work out

	SA	A	N	D	SD
17. The photographs throughout the laboratories helped reinforce the procedures of the experiments.	☒	☐	☐	☐	☐

Comments:

Suitcase	**SA**	**A**	**N**	**D**	**SD**
18. The transportation instructions located on the outside of the suitcase were easy to understand. Comments:	☒	☐	☐	☐	☐
19. The actual suitcase was easy to transport. Comments:	☐	☒	☐	☐	☐
20. The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase. Comments:	☐	☒	☐	☐	☐
21. The components of this suitcase will be easy to incorporate into my current curriculum of enzymes. Comments:	☐	☒	☐	☐	☐
22. The components of this suitcase will enhance my current curriculum of enzymes. Comments:	☐	☒	☐	☐	☐
23. The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS. Comments:	☐	☒	☐	☐	☐
24. I would recommend this suitcase to other science teachers. Comments:	☐	☒	☐	☐	☐

Additional Questions

25. Which component of the suitcase do you think was most effective?

- ☐ Homework Handout
- ☒ 3D animation
- ☐ Jeopardase board game
- ☒ Hands-on-models
- ☐ Laboratory experiments

Comments:

26. Which component of the suitcase do you think was least effective?
- ☐Homework Handout
- ☐3D animation
- ☐Jeopardase board game
- ☐Hands-on-models
- ☐Laboratory experiments

Comments:

27. What type of machine do you currently have access to play movies and animations in your class room?
- ☒PC computer with a projector
- ☐MAC computer with a projector
- ☐TV with DVD player
- ☐I do not have access to any machine for this purpose

Comments:

28. Check the boxes next to the components that you currently have for teaching students about enzymes:
- ☐Homework with only text
- ☐Homework with color illustrations
- ☒3D animation (s)
- ☐Board game (s)
- ☐Hands-on-model (s)
- ☒Laboratory experiment (s)

Comments:

Thank you for your time and participation!

Enzyme Instigator: A Portable Suitcase Exhibit for the Biology Classroom

Are you a teacher? Yes
If so, what grade and subject do you teach? 9-12
If you are not a teacher, what is your title?

Instructions:
Please check the box that corresponds to your level of agreement with the statement to the left (SA=strongly agree, A=agree, N=neutral, D-disagree, SD=strongly disagree). Please feel free to provide additional comments in the spaces provided.

Teacher Instructions Booklet	SA	A	N	D	SD
1. The Teacher Instructions Booklet was designed in a clear and easy to understand format.	☐	☑	☐	☐	☐

Comments:
tabbed format is wonderful!

Homework Handout	SA	A	N	D	SD
2. The *Homework handout* included helpful information to engage students in the complex concepts of enzymes.	☐	☑	☐	☐	☐

Comments:
Check "energy" comment - pg 12

	SA	A	N	D	SD
3. The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading.	☐	☑	☐	☐	☐

Comments:

Animation Titled "Enzyme Instigator"	SA	A	N	D	SD
4. The instructions for playing the animation were clear and helpful.	☐	☑	☐	☐	☐

Comments:

	SA	A	N	D	SD
5. The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions.	☐	☐	☐	☐	☐

Comments: Question 8 probably needs to be 2 part. One part needs to address the content of the video + then the application question. Question 7 needs reference to normal body temp = 37°C

	SA	A	N	D	SD
6. The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion.	☐	☑	☐	☐	☐

Comments:

	SA	A	N	D	SD
7. The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics.	☐	☐	☐	☐	☐

Comments:

Concerned about lock + key analogy since its antiquated.

	SA	A	N	D	SD
8. The animations clearly described many of the complex concepts of enzymes.	☐	☑	☐	☐	☐
9. The animation would appeal to students.	☐	☐	☐	☐	☐

Comments (8): Need to connect substrate to reactant. Use the word reactant before substrate.

Comments (9):

Jeopardase Game

	SA	A	N	D	SD
10. The teacher instructions on the Jeopardase board game clearly described the full setup of the game.	☐	☑	☐	☐	☐
11. The question board was easy to display and use during the progression of the game.	☐	☑	☐	☐	☐
12. The game created a fun atmosphere that would spark friendly competition between my students.	☐	☐	☐	☐	☐

Comments (10):

Comments (11):
The questions should stand alone to measure transferability of info.

Comments (12):

Hands-On Model Demonstration

	SA	A	N	D	SD
13. The teacher instructions on the hands-on model demonstration were clear and helpful.	☑	☐	☐	☐	☐

Comments: Amazing

Laboratory Experiments

	SA	A	N	D	SD
14. The teacher instructions of the laboratory experiments were clear and helpful.	☐	☐	☐	☐	☐
15. The laboratory experiments were easy to understand and follow.	☐	☐	☐	☐	☐
16. The labs were good examples of optimal temperature and pH of enzymes.	☐	☐	☐	☐	☐
17. The photographs throughout the laboratories helped reinforce the procedures of the experiments.	☐	☐	☐	☐	☐

Comments (14):

Comments (15):

Comments (16):

Comments (17):

Suitcase

	SA	A	N	D	SD
18. The transportation instructions located on the outside of the suitcase were easy to understand. Comments:	☐	☐	☐	☐	☐
19. The actual suitcase was easy to transport. Comments:	☐	☐	☐	☐	☐
20. The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase. Comments:	☐	☐	☐	☐	☐
21. The components of this suitcase will be easy to incorporate into my current curriculum of enzymes. Comments:	☐	☐	☐	☐	☐
22. The components of this suitcase will enhance my current curriculum of enzymes. Comments:	☐	☐	☐	☐	☐
23. The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS. Comments:	☐	☐	☐	☐	☐
24. I would recommend this suitcase to other science teachers. Comments:	☐	☐	☐	☐	☐

Additional Questions

25. Which component of the suitcase do you think was most effective?

☐Homework Handout
☐3D animation
☐Jeopardase board game
☐Hands-on-models
☐Laboratory experiments

Comments:

26. Which component of the suitcase do you think was least effective?
    - ☐Homework Handout
    - ☐3D animation
    - ☐Jeopardase board game
    - ☐Hands-on-models
    - ☐Laboratory experiments

    Comments:

27. What type of machine do you currently have access to play movies and animations in your class room?
    - ☐PC computer with a projector
    - ☐MAC computer with a projector
    - ☐TV with DVD player
    - ☐I do not have access to any machine for this purpose

    Comments:

28. Check the boxes next to the components that you currently have for teaching students about enzymes:
    - ☐Homework with only text
    - ☐Homework with color illustrations
    - ☐3D animation (s)
    - ☐Board game (s)
    - ☐Hands-on-model (s)
    - ☐Laboratory experiment (s)

    Comments:

Thank you for your time and participation!

Enzyme Instigator: A Portable Suitcase Exhibit for the Biology Classroom

Are you a teacher? yes

If so, what grade and subject do you teach? 9th; Biology, Pre-AP Biology; IPC

If you are not a teacher, what is your title?

Instructions:
Please check the box that corresponds to your level of agreement with the statement to the left (SA=strongly agree, A=agree, N=neutral, D-disagree, SD=strongly disagree). Please feel free to provide additional comments in the spaces provided.

Teacher Instructions Booklet

	SA	A	N	D	SD
1. The Teacher Instructions Booklet was designed in a clear and easy to understand format. Comments:	☑	☐	☐	☐	☐

Homework Handout

	SA	A	N	D	SD
2. The *Homework handout* included helpful information to engage students in the complex concepts of enzymes. Comments:	☐	☐	☐	☐	☐
3. The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading. Comments:	☑	☐	☐	☐	☐

Animation Titled "Enzyme Instigator"

	SA	A	N	D	SD
4. The instructions for playing the animation were clear and helpful. Comments:	☑	☐	☐	☐	☐
5. The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions. Comments:	☑	☐	☐	☐	☐
6. The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion. Comments:	☑	☐	☐	☐	☐
7. The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics. Comments:	☑	☐	☐	☐	☐

	SA	A	N	D	SD
8. The animations clearly described many of the complex concepts of enzymes. Comments: Need to specify "lock and key" model; include "enzyme-substrate" complex	☐	☑	☐	☐	☐
9. The animation would appeal to students. Comments:	☑	☐	☐	☐	☐

Jeopardase Game

	SA	A	N	D	SD
10. The teacher instructions on the Jeopardase board game clearly described the full setup of the game. Comments:	☑	☐	☐	☐	☐
11. The question board was easy to display and use during the progression of the game. Comments: create a powerpoint presentation for use on computer or smart board.	☑	☐	☐	☐	☐
12. The game created a fun atmosphere that would spark friendly competition between my students. Comments:	☑	☐	☐	☐	☐

Hands-On Model Demonstration

	SA	A	N	D	SD
13. The teacher instructions on the hands-on model demonstration were clear and helpful. Comments:	☑	☐	☐	☐	☐

Laboratory Experiments

	SA	A	N	D	SD
14. The teacher instructions of the laboratory experiments were clear and helpful. Comments:	☑	☐	☐	☐	☐
15. The laboratory experiments were easy to understand and follow. Comments: ~~add~~	☑	☐	☐	☐	☐
16. The labs were good examples of optimal temperature and pH of enzymes. Comments:	☑	☐	☐	☐	☐
17. The photographs throughout the laboratories helped reinforce the procedures of the experiments. Comments:	☑	☐	☐	☐	☐

Suitcase	**SA**	**A**	**N**	**D**	**SD**
18. The transportation instructions located on the outside of the suitcase were easy to understand. Comments:	☐	☑	☐	☐	☐
19. The actual suitcase was easy to transport. Comments: The suitcase would not fit into a compact car and needs more than one person to transport.	☑	☐	☑	☐	☐
20. The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase. Comments:	☑	☐	☐	☐	☐
21. The components of this suitcase will be easy to incorporate into my current curriculum of enzymes. Comments:	☐	☑	☐	☐	☐
22. The components of this suitcase will enhance my current curriculum of enzymes. Comments:	☐	☑	☐	☐	☐
23. The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS. Comments:	☐	☑	☐	☐	☐
24. I would recommend this suitcase to other science teachers. Comments:	☐	☑	☐	☐	☐

Additional Questions

25. Which component of the suitcase do you think was most effective?
   - ☐ Homework Handout
   - ☐ 3D animation
   - ☐ Jeopardase board game
   - ☐ Hands-on-models
   - ☑ Laboratory experiments

   Comments:

26. Which component of the suitcase do you think was least effective?
   ☑Homework Handout
   ☐3D animation
   ☐Jeopardase board game
   ☐Hands-on-models
   ☐Laboratory experiments

   Comments:

27. What type of machine do you currently have access to play movies and animations in your class room?
   ☑PC computer with a projector
   ☐MAC computer with a projector
   ☑TV with DVD player
   ☐I do not have access to any machine for this purpose

   Comments:

28. Check the boxes next to the components that you currently have for teaching students about enzymes:
   ☑Homework with only text
   ☐Homework with color illustrations
   ☐3D animation (s)
   ☐Board game (s)
   ☐Hands-on-model (s)
   ☑Laboratory experiment (s)

   Comments:

Thank you for your time and participation!

Enzyme Instigator: A Portable Suitcase Exhibit for the Biology Classroom

Are you a teacher? Yes
If so, what grade and subject do you teach? Biology, IPC, Pre-AP
If you are not a teacher, what is your title?

Instructions:
Please check the box that corresponds to your level of agreement with the statement to the left (SA=strongly agree, A=agree, N=neutral, D-disagree, SD=strongly disagree). Please feel free to provide additional comments in the spaces provided.

Teacher Instructions Booklet	**SA**	**A**	**N**	**D**	**SD**
1. The Teacher Instructions Booklet was designed in a clear and easy to understand format. Comments: NICE	☐	☒	☐	☐	☐

Homework Handout	**SA**	**A**	**N**	**D**	**SD**
2. The *Homework handout* included helpful information to engage students in the complex concepts of enzymes. Comments: NICE	☒	☐	☐	☐	☐
3. The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading. Comments:	☐	☒	☐	☐	☐

Animation Titled "Enzyme Instigator"	**SA**	**A**	**N**	**D**	**SD**
4. The instructions for playing the animation were clear and helpful. Comments: GREAT	☐	☒	☐	☐	☐
5. The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions. Comments:	☐	☒	☐	☐	☐
6. The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion. Comments:	☐	☒	☐	☐	☐
7. The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics. Comments: GOOD!	☒	☐	☐	☐	☐

	SA	A	N	D	SD
8. The animations clearly described many of the complex concepts of enzymes. Comments:	☒	☐	☐	☐	☐
9. The animation would appeal to students. Comments: I Believe THEY WOULD FIND IT FUNNY	☐	☒	☐	☐	☐

Jeopardase Game

	SA	A	N	D	SD
10. The teacher instructions on the Jeopardase board game clearly described the full setup of the game. Comments:	☐	☒	☐	☐	☐
11. The question board was easy to display and use during the progression of the game. Comments:	☐	☒	☐	☐	☐
12. The game created a fun atmosphere that would spark friendly competition between my students. Comments:	☐	☒	☐	☐	☐

Hands-On Model Demonstration

	SA	A	N	D	SD
13. The teacher instructions on the hands-on model demonstration were clear and helpful. Comments:	☒	☐	☐	☐	☐

Laboratory Experiments

	SA	A	N	D	SD
14. The teacher instructions of the laboratory experiments were clear and helpful. Comments:	☐	☒	☐	☐	☐
15. The laboratory experiments were easy to understand and follow. Comments:	☐	☒	☐	☐	☐
16. The labs were good examples of optimal temperature and pH of enzymes. Comments:	☐	☒	☐	☐	☐
17.The photographs throughout the laboratories helped reinforce the procedures of the experiments. Comments:	☐	☒	☐	☐	☐

Suitcase

	SA	A	N	D	SD
18. The transportation instructions located on the outside of the suitcase were easy to understand. Comments:	☐	☒	☐	☐	☐
19. The actual suitcase was easy to transport. Comments:	☐	☒	☐	☐	☐
20. The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase. Comments:	☐	☒	☐	☐	☐
21. The components of this suitcase will be easy to incorporate into my current curriculum of enzymes. Comments: Nice	☐	☒	☐	☐	☐
22. The components of this suitcase will enhance my current curriculum of enzymes. Comments: NICE	☐	☒	☐	☐	☐
23. The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS. Comments:	☐	☒	☐	☐	☐
24. I would recommend this suitcase to other science teachers. Comments:	☐	☒	☐	☐	☐

Additional Questions

25. Which component of the suitcase do you think was most effective?

☐ Homework Handout
☐ 3D animation
☐ Jeopardase board game
☐ Hands-on-models
☒ Laboratory experiments

Comments:

26. Which component of the suitcase do you think was least effective?
    - ☐Homework Handout
    - ☐3D animation
    - ☐Jeopardase board game
    - ☐Hands-on-models
    - ☐Laboratory experiments

    Comments: None

27. What type of machine do you currently have access to play movies and animations in your class room?
    - ☑PC computer with a projector
    - ☑MAC computer with a projector
    - ☑TV with DVD player
    - ☐I do not have access to any machine for this purpose

    Comments:

28. Check the boxes next to the components that you currently have for teaching students about enzymes:
    - ☑Homework with only text
    - ☐Homework with color illustrations
    - ☐3D animation (s)
    - ☐Board game (s)
    - ☐Hands-on-model (s)
    - ☑Laboratory experiment (s)

    Comments:

Thank you for your time and participation!

Enzyme Instigator: A Portable Suitcase Exhibit for the Biology Classroom

Are you a teacher? yes

If so, what grade and subject do you teach? 9th Biology

If you are not a teacher, what is your title?

Instructions:
Please check the box that corresponds to your level of agreement with the statement to the left (SA=strongly agree, A=agree, N=neutral, D-disagree, SD=strongly disagree). Please feel free to provide additional comments in the spaces provided.

Teacher Instructions Booklet

	SA	A	N	D	SD
1. The Teacher Instructions Booklet was designed in a clear and easy to understand format. Comments:	☑	☑	☐	☐	☐

Homework Handout

	SA	A	N	D	SD
2. The *Homework handout* included helpful information to engage students in the complex concepts of enzymes. Comments:	☑	☐	☐	☐	☐
3. The Teachers Instructions of the *Homework Handout* has the answers laid out for easy grading. Comments:	☑	☐	☐	☐	☐

Animation Titled "Enzyme Instigator"

	SA	A	N	D	SD
4. The instructions for playing the animation were clear and helpful. Comments:	☑	☐	☐	☐	☐
5. The questions throughout the animation were relevant to the video and were placed at appropriate intervals for class discussions. Comments:	☑	☐	☐	☐	☐
6. The *Animation Questions and Answers* located within the Teacher Instructions Booklet were easy to follow and provided useful information with which to lead a class discussion. Comments:	☑	☐	☐	☐	☐
7. The cartoon analogies about "forming a basketball team" and "starting a car in extreme temperatures" were an effective way to portray these topics. Comments:	☑	☐	☐	☐	☐

	SA	A	N	D	SD
8. The animations clearly described many of the complex concepts of enzymes. Comments:	☑	☐	☐	☐	☐
9. The animation would appeal to students. Comments:	☑	☐	☐	☐	☐

Jeopardase Game

	SA	A	N	D	SD
10. The teacher instructions on the Jeopardase board game clearly described the full setup of the game. Comments:	☑	☐	☐	☐	☐
11. The question board was easy to display and use during the progression of the game. Comments:	☑	☐	☐	☐	☐
12. The game created a fun atmosphere that would spark friendly competition between my students. Comments: CD / power point for the game.	☑	☐	☐	☐	☐

Hands-On Model Demonstration

	SA	A	N	D	SD
13. The teacher instructions on the hands-on model demonstration were clear and helpful. Comments: . Have smaller handson models for the students (7 or 8) so the teacher can put the students in groups and share the info with them while the touch it.	☑	☐	☐	☐	☐

Laboratory Experiments

	SA	A	N	D	SD
14. The teacher instructions of the laboratory experiments were clear and helpful. Comments:	☑	☐	☐	☐	☐
15. The laboratory experiments were easy to understand and follow. Comments:	☑	☐	☐	☐	☐
16. The labs were good examples of optimal temperature and pH of enzymes. Comments:	☑	☐	☐	☐	☐
17. The photographs throughout the laboratories helped reinforce the procedures of the experiments. Comments:	☑	☐	☐	☐	☐

Suitcase

Item	SA	A	N	D	SD
18. The transportation instructions located on the outside of the suitcase were easy to understand. Comments:	☑	☐	☐	☐	☐
19. The actual suitcase was easy to transport. Comments:	☑	☐	☐	☐	☐
20. The photograph of the packed suitcase located within the *Teacher Instructions Booklet* gave quick and easy reference for the components of the suitcase. Comments:	☑	☐	☐	☐	☐
21. The components of this suitcase will be easy to incorporate into my current curriculum of enzymes. Comments:	☑	☐	☐	☐	☐
22. The components of this suitcase will enhance my current curriculum of enzymes. Comments:	☑	☐	☐	☐	☐
23. The contents of this suitcase reinforce the concepts about enzymes that I must teach my students for standardized tests including the TAKS. Comments:	☑	☐	☐	☐	☐
24. I would recommend this suitcase to other science teachers. Comments: Needs a lock	☑	☐	☐	☐	☐

Additional Questions

25. Which component of the suitcase do you think was most effective?
    - ☐ Homework Handout
    - ☑ 3D animation
    - ☐ Jeopardase board game
    - ☐ Hands-on-models
    - ☐ Laboratory experiments

   I think all of them were effective.

   Comments:

   ~~Need a lock~~

26. Which component of the suitcase do you think was least effective?
    - ☐Homework Handout
    - ☐3D animation
    - ☐Jeopardase board game
    - ☐Hands-on-models
    - ☐Laboratory experiments

    Comments:

27. What type of machine do you currently have access to play movies and animations in your class room?
    - ☑PC computer with a projector
    - ☐MAC computer with a projector
    - ☑TV with DVD player
    - ☐I do not have access to any machine for this purpose

    Comments:

28. Check the boxes next to the components that you currently have for teaching students about enzymes:
    - ☑Homework with only text
    - ☐Homework with color illustrations
    - ☐3D animation (s)
    - ☐Board game (s)
    - ☑Hands-on-model (s) tha they need to create
    - ☑Laboratory experiment (s)

    Comments:

Thank you for your time and participation!

APPENDIX H
Re-stocking Form

Restocking Form

- ☐ Teacher Instructions Booklet
- ☐ Student Handouts Booklet
- ☐ PDF documents CD
- ☐ Animations CD
- ☐ Jeopardase game cards (25 total)
- ☐ Jeopardase game board
- ☐ Hands-on models:
    - ☐ Enzyme
    - ☐ Fat substrate (2 blue models and the blue container/base)
    - ☐ Carbohydrate substrate (2 green models and the green container/base)
    - ☐ Protein substrate with peptide bonds (2 purple models and the purple container/base)
- ☐ pH solutions (1 liter each): If any of the solutions have turned to a rusty color, have the solutions re-made. They should last for at least one month each.
    - ☐ 4
    - ☐ 6
    - ☐ 8
- ☐ Strainer
- ☐ Ice cube trays (2)
- ☐ Lab supplies:
    - ☐ Thermometers (5)
    - ☐ Rennet tablets (between 3-5)
    - ☐ Gelatin packets (between 3-5)
    - ☐ pH strips (there should be 2-4 tubes of strips, double check that each tube has at least 40 strips)
    - ☐ Plastic knives (3-5, these might need to be restocked with every use)
    - ☐ Blue food dye (one tube)
- ☐ Pipettes (1 mL)(there should at least 50 pipettes, the container should be a least half way full)
- ☐ Powdered milk (the container should be at least half way full)

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AUTHOR: Neil Campbell, Jane Reece	AUTHOR:
ISBN: 0-8053-7146-X	ISBN: CUSTOMER ID 2028952 REQUEST ID 139045
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>
> Brenda Harrison McArthur
> Biomedical Communication Department
> University of Texas Southwestern Medical Center at Dallas, Texas

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