

5 Es Science Lesson Plan Template

Instructor: Inga Pinnix		Course: BSC 2010C – Dual Enrollment Biology	
Date(s): Dec. 1-9		Essential Question/Learning Outcome: The student should understand biotechnology procedures and how they are applied to research.	
NGSSS Benchmarks: N/A			
Instructional Activities*** ALL 5 Es WILL NOT BE DONE IN ONE CLASS PERIOD.		Assessment Tool:	
Date	Engage:	Assessment Tool:	
Dec. 1	Video clip of Dolly the sheep and of genetically modified foods. Crime scene reading passage	Informal: Oral questions about video clips; GIST reading slip	
Dec. 5 & 7	Explore (Investigation): 1. DNA Scissors – Restriction Enzyme Digest Simulation 2. Pipetting by Design	Assessment Tool: Correct construction of enzymatic digest products; Production of correct pipetting designs	
Dec. 1-9	Explain: 1. Advanced Notes Organizer for Chapter 12 2. Lecture/discussion – Chapter 12: DNA Technology and Genomics 3. Interactive Exercises on Biotechnology	Assessment Tool: Completion of Organizer and correct answers on Interactive exercises; mini-quiz following lecture discussion	
Dec.9	Extend: 1. Restriction enzyme digestion lab 2. DNA agarose gel electrophoresis lab 3. “Who’s the Father” and “Virus Epidemiology” scenarios 4. Excerpts from translational research 5. Class discussion on the ethics of biotechnology applications	Assessment Tool: Lab reports; correct answers to scenarios; participation in discussion	
Evaluate (Method): 1. Lab reports 2. Mini-quiz on chapter lecture discussion 3. Interactive exercises 4. Completion of DNA Scissors and Pipetting by Design 5. Performance on chapter test			
Vocabulary: See attached list		Materials Needed: Handouts: Advanced Notes Organizer, DNA Scissors, Interactive exercises; lab packets; scenarios; mini-quiz Labs: UF equipment lockers for pipetting and gel labs	
Homework: Advanced Notes Organizer; Lab reports			

***Teacher should be able to identify where students are reading, writing, listening, and speaking within this lesson plan.

5 Es Science Lesson Plan Template

Instructor: Inga Pinnix		Course: BSC 2010C – Dual Enrollment Biology	
Date(s): Late September 2011		Essential Question/Learning Outcome: How do cellular organelles interact and how does the cell contribute to organism function?	
NGSSS Benchmarks: N/A			
Instructional Activities*** ALL 5 Es WILL NOT BE DONE IN ONE CLASS PERIOD.		Assessment Tool:	
Date Day 1	Engage: Interpret the analogy of the cell as a factory.	Assessment Tool: Informal: Correct assignment of structures to functions.	
Day 2	Explore (Investigation): <ol style="list-style-type: none"> 1. Microscope Lab of Cells – Students will look at prokaryotic and eukaryotic cells and tissues and prepare drawings. They will answer questions about microscopic observations. 2. Stem Cell Activity – Science Take-Out 	Assessment Tool: Lab report of cell drawings and correct answers to lab questions; answers to Stem Cell Activity questions	
Days 1 & 2	Explain: <ol style="list-style-type: none"> 1. Advanced Notes Organizer for Chapter 6 2. Lecture/discussion – Chapter 6: A Tour of the Cell 3. Interactive Exercises on Cellular Function 	Assessment Tool: Completion of Organizer and correct answers on Interactive exercises; exit slips following lecture/discussion	
Days 3 & 4	Extend: <ol style="list-style-type: none"> 1. Student summary on Stem Cell article 2. Lecture excerpts from Bench to Bedside presenters 3. Create a Stem Cell Line – Utah Genetics website 4. Extraordinary Measures movie viewing 	Assessment Tool: Check of student summaries; completion of Internet assignment; exit slip following lecture excerpts; worksheet for movie	
Evaluate (Method): <ol style="list-style-type: none"> 1. Lab report 2. Exit slips 3. Interactive exercises 4. Answers for Science Take-Out activity 5. Check of movie worksheet 6. Performance on chapter test 			
Vocabulary: See attached list		Materials Needed: Handouts: Advanced Notes Organizer, Movie worksheet, exit slips, Microscope Lab packet, Interactive exercises; instructions for Internet activity; stem cell article Labs: Microscopes, slides, Stem Cell kits (1 per pair of students) Extraordinary Measures movie	
Homework: Advanced Notes Organizer; Create a Stem Cell; article summary			

***Teacher should be able to identify where students are reading, writing, listening, and speaking within this lesson plan.

Question	Strongly Agree	Agree	Disagree	Strongly Disagree
1. When I learn something new in biology, I am willing to spend my free time on it.				
2. I think it is fun for me to learn about general biology.				
3. My biology class is the most important class for me.				
4. When I am working on biology it can happen that I do not realize how time flies.				
5. It is personally meaningful for me to be a good biologist.				
6. It is important for me to know a lot in my biology class.				
7. It is important for me to remember the content learned in biology class.				
8. Biology is one of the most important disciplines.				
9. We should not spend so much money on research for biology.				
10. Biology yields more advantages than disadvantages.				
11. Today's life would be unthinkable without the results of biological research.				
12. Medical research is one of the most important disciplines.				
13. We should not spend so much money on research for medicine.				
14. Medical research yields more advantages than disadvantages.				
15. Today's life would be unthinkable without the results of medical research.				
16. Money should be spent on medical research even if the research is publicly controversial.				
17. Money should be spent on medical research if it benefits a large number of individuals affected by the disease.				
18. Money should be spent on medical research if it benefits a very small number of individuals affected by the disease.				
19. In this tight economy, research dollars should be focused primarily on major diseases.				
20. I know a lot of information about stem cell research.				
21. I understand the details of how stem cell research is done and how it can be applied to disease and injury.				
22. I know a lot of information about genetic research.				
23. I understand the details of how genetic research is done and how it can be applied to disease and treatment.				
24. I know a lot of information about biotechnology.				
25. I understand the details of how biotechnology is done and how it can be applied to disease and product development.				

Reading from the LearnGenetics (Univ. of Utah) website:

Imagine that you accidentally broke one of your neighbor's windows. What would you do? You could:

1. Stay silent: no one will ever find out that you are guilty, but the window doesn't get fixed.
2. Try to repair the cracked window with some tape: not the best long-term solution.
3. Put in a new window: not only do you solve the problem, but also you do the honorable thing.

What does this have to do with gene therapy?

You can think of a medical condition or illness as a "broken window." Many medical conditions result from flaws, or mutations, in one or more of a person's genes. Mutations cause the protein encoded by that gene to malfunction. When a protein malfunctions, cells that rely on that protein's function can't behave normally, causing problems for whole tissues or organs. Medical conditions related to gene mutations are called genetic disorders.

So, if a flawed gene caused our "broken window," can you "fix" it? What are your options?

1. Stay silent: ignore the genetic disorder and nothing gets fixed.
2. Try to treat the disorder with drugs or other approaches: depending on the disorder, treatment may or may not be a good long-term solution.
3. Put in a normal, functioning copy of the gene: if you can do this, it may solve the problem!

If it is successful, gene therapy provides a way to fix a problem at its source. Adding a corrected copy of the gene may help the affected cells, tissues and organs work properly. Gene therapy differs from traditional drug-based approaches, which may treat the problem, but which do not repair the underlying genetic flaw.

But gene therapy is not a simple solution - it's not a molecular bandage that will automatically fix a disorder. Although scientists and physicians have made progress in gene therapy research, they have much more work to do before they can realize its full potential. In this module, you'll explore several approaches to gene therapy, try them out yourself, and figure out why creating successful gene-based therapies is so challenging.



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Doctors test gene therapy to treat blindness

By [Ben Hirschler](#)

LONDON | Tue May 1, 2007 11:11am EDT

(Reuters) - A team of British doctors has carried out the world's first eye operations using gene therapy to try to cure a serious sight disorder, officials said on Tuesday.

The group from Moorfields Eye Hospital and University College London (UCL) has operated on a small number of young adults with Leber's congenital amaurosis, a type of inherited childhood blindness caused by a single abnormal gene.

The condition prevents the retina from detecting light properly, resulting in progressive deterioration and severely impaired eyesight. There is no effective treatment.

The new experimental procedure involves inserting normal copies of the faulty RPE65 gene into cells of the retina -- the light-sensitive layer of cells at the back of the eye -- using a harmless virus or vector.

The British doctors are working alongside Seattle, Washington-based biotech firm Targeted Genetics Corp., which made the vector being used in the Phase I/II trial.

It will be several months before the success of the procedure can be properly assessed but medics said there had been no complications so far.

The move into human testing follows 15 years of laboratory and animal experimentation, including tests on dogs whose vision was restored to the extent they could navigate a maze with ease.

"Testing it for the first time in patients is very important and exciting and represents a huge step towards establishing gene therapy for the treatment of many different eye conditions," Robin Ali, professor of human molecular genetics at UCL, said in a statement.

The clinical trial was given 1 million pounds (\$2 million) of funding by Britain's Department of Health, which said the pioneering research underlined the country's leading position in gene therapy in Europe.

The idea of using gene therapy to fix diseases caused by genetic faults has long appealed to scientists, although getting the idea to work in practice has proved tricky.

Some gene therapy approaches have helped patients. But one 18-year-old volunteer died in a gene therapy experiment in 1999 and two French boys cured of a rare immune disease later developed leukemia.

Over 70 percent of gene therapy trials to date have been for cancer, where the process is complicated by the need to reach multiple sites in the body.

The eye, by contrast, is relatively straightforward, said Andrew George of London's Imperial College.

"The eye is good for gene therapy because it is a simple organ and it is easy to see what is going on. There is hope that once gene therapy is developed in the eye, scientists could move on to more complex organs," he said.

BSC 2010C Cell Unit Pre- & Post Test

Name _____ Date _____

Refer to the following terms to answer questions 1-9. Terms may be used more than once or not at all.

- a. lysosome
- b. plasma membrane
- c. mitochondrion
- d. Golgi apparatus
- e. none of the above

- _____ 1. Responsible for protein synthesis.
- _____ 2. Contains hydrolytic enzymes.
- _____ 3. Helps to recycle the cell's organic material.
- _____ 4. Site of cellular respiration.
- _____ 5. Involved in storage diseases such as Tay-Sachs.
- _____ 6. Contains its own DNA and ribosomes.
- _____ 7. Detoxifies alcohol in the liver.
- _____ 8. Has large pores in membrane.
- _____ 9. Contains cristae.

- _____ 10. A cell has the following molecules and structures: enzymes, DNA, ribosomes, plasma membrane, and mitochondria. It could be a cell from
- a. a bacterium
 - b. an animal, but not a plant
 - c. a plant, but not an animal
 - d. a plant or an animal
 - e. any kind of organism

For questions 11-16, match the structure to the proper cell type. Each answer may be used more than once or not at all.

- a. structure is a feature of all cells
 - b. structure is found in prokaryotic cells only
 - c. structure is found in eukaryotic cells only
 - d. structure is found in plant cells only
 - e. structure is found in animal cells only
- _____ 11. Plasma membrane
 - _____ 12. Cytoskeleton
 - _____ 13. Ribosomes
 - _____ 14. Plasmodesmata
 - _____ 15. Tight junctions
 - _____ 16. Golgi bodies

_____ 17. Which of the following relationships between cell structures and their respective functions is NOT correct?

- a. cell wall – support, protection
- b. chloroplasts – chief site of cellular respiration
- c. chromosomes – genetic control information
- d. ribosomes – site of protein synthesis
- e. mitochondria – formation of ATP

_____ 18. Which organelle is primarily involved in the synthesis of lipids?

- a. ribosomes
- b. lysosomes
- c. smooth endoplasmic reticulum
- d. mitochondria
- e. contractile vacuoles

_____ 19. What are the elevated regions (particles) seen in electron micrographs of split freeze-fractured membranes?

- a. peripheral proteins
- b. phospholipids
- c. carbohydrates
- d. integral proteins
- e. cholesterol molecules

_____ 20. All of the following cellular activities require ATP energy EXCEPT

- a. movement of O₂ into the cell
- b. protein synthesis
- c. Na⁺ ions moving out of the cell
- d. cytoplasmic streaming
- e. Exocytosis

_____ 21. The movement of potassium into or out of the cell requires

- a. low cellular concentration of sodium
- b. high cellular concentration of potassium
- c. ATP as an energy source
- d. glucose for binding and releasing ions

_____ 23. Which process accounts for the movement of solids into some animal cells?

- a. active transport
- b. facilitated diffusion
- c. pinocytosis
- d. osmosis
- e. Phagocytosis

- _____ 24. Carrier molecules in the plasma membrane are required for
- diffusion
 - osmosis
 - facilitated diffusion only
 - active transport only
 - both facilitated diffusion and active transport
- _____ 25. A cell with an internal concentration of 0.02 molar glucose is placed in a test tube containing 0.02 molar glucose solution. Assuming that glucose is not actively transported into the cell, which of the following terms describes the internal concentration of the cell relative to its environment?
- isotonic
 - hypertonic
 - Hypotonic
 - flaccid
- _____ 26. One of the functions of cholesterol in animal cell membranes is to
- facilitate the transport of ions
 - store energy
 - maintain membrane fluidity
 - speed diffusion
- _____ 27. Which of the following would move through the lipid bilayer of a plasma membrane most rapidly?
- CO₂
 - an amino acid
 - glucose
 - K⁺
 - starch
- _____ 28. The kinds of molecules that pass through a cell membrane most easily are
- large and hydrophobic
 - small and hydrophobic
 - large and hydrophilic
 - small and hydrophilic
- _____ 29. What membrane-surface molecules are thought to be most important as cells recognize each other?
- Cholesterol
 - Glycoproteins
 - Integral proteins
 - Peripheral proteins

- _____ 30. Which of the following would indicate that facilitated diffusion was taking place?
- Substances are moving against the concentration gradient.
 - A substance is diffusing much faster than the physical condition indicates that it should.
 - ATP is being rapidly consumed as the substance moves.
 - A substance is slowing as it moves down its concentration gradient.
- _____ 31. Which bonds must be broken in order for water to vaporize?
- ionic bonds
 - nonpolar covalent bonds
 - polar covalent bonds
 - hydrogen bonds
- _____ 32. The formation of ice during colder weather helps to temper the seasonal transition in winter. This is mainly because
- the formation of hydrogen bonds releases heat
 - the formation of hydrogen bonds absorbs heat
 - there is less evaporative cooling of lakes
 - ice melts each autumn afternoon
 - ice is warmer than the winter air
- _____ 33. Water's high specific heat is mainly a consequence of the
- small size of water molecules
 - high specific heat of oxygen and hydrogen atoms
 - absorption and release of heat when hydrogen bonds break and form
 - fact that water is a poor heat conductor
 - inability of water to dissipate heat into dry air
- _____ 34. What determines the cohesiveness of water molecules?
- hydrophobic interactions
 - high specific heat
 - covalent bonds
 - ionic bonds
 - hydrogen bonds
- _____ 35. Temperature usually increases when water condenses. Which behavior of water is most directly responsible for this phenomenon?
- change in density when it condenses from a liquid to a solid
 - reactions with other atmospheric compounds
 - release of heat by formation of hydrogen bonds
 - release of heat by breaking of hydrogen bonds
 - high surface tension

**A Study of the Impact of Translational Medical
Research and Biotechnology Laboratory Applications
on Student Understanding of Biomolecules and
Attitudes toward Stem Cell Practices**

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Abstract: High school students in advanced college level Biology courses face overwhelming amounts of detail while studying cellular and biomolecule mechanisms. Student motivation can drop during instruction, leading to lower student comprehension and performance. This proposal's goal was to implement more biotechnology and translational medicine in a Dual Enrollment Biology class, adding focus, excitement, and real life connections. Biotechnology and virtual computer labs and current clinical applications were incorporated into the required college curriculum. Analysis of the implementation's effect by student surveys, academic performance, and teacher reflections determined if (1) students remained engaged, (2) attitudes improved during biomolecule studies, and (3) information retention and comprehension increased. 100% Engagement was observed with meaningful discussions of medical applications. Pre- and post-Likert surveys showed consistent positive attitudes and a 29.4% increase in student interpretation of biotechnology and stem cell knowledge. Chapter tests and final grades were higher than seen in a previous comparable course.

Rationale: As a teacher at Sandalwood High School, a suburban school with a diverse student population, I have taught various levels of Biology and Chemistry. This year, my classes included students who were in a Dual Enrollment Biology class, and these students obtained both high school and college credit after successfully completing the course. This particular group was taught material with a high degree of rigor comparable to a college course that would be given on a college or university campus. Some of the students from a similar course that I have taught, AP Biology, tended to get overwhelmed and often lose focus as we worked through the biochemistry, genetics, and biotechnology sections due to the amount of detail involved in understanding the functions, processes, and reactions of biomolecules. Initially, I anticipated that this year's students would be eager to learn the type of enriched material that we were presented with during the Bench to Bedside program, and that they would be open to learning about the novel ways in which biotechnology is applied to medical dilemmas and to experience some of the supporting laboratory methods needed to carry out these studies. By adding current medical approaches as an application to the basic framework of facts about biomolecules, there was the expectation that student engagement and confidence would increase while students learned how important biotechnology is beyond the forensics that they are familiar with from the media.

Learning scientific concepts requires much more than mere cognition, and can be greatly impacted by student interest and attitude as well as a healthy self-concept, which is the student's expectation of how well they will learn new material (Nieswandt, 2007). In fact, students with strong self-concepts have more challenging personal academic goals, enjoy working more, have a higher level of engagement, and tend to retain newly learned concepts as long-term knowledge. In a report of a study of 9th grade German chemistry students, Nieswandt describes the importance of *meaningful conceptual understanding*, or the ability to connect diverse pieces of information together and to make connections to real life situations. This type of understanding includes content knowledge, procedural knowledge consisting of rules and steps of a process, and conditional knowledge of when and why procedural knowledge should be used. The comprehension of biological concepts certainly encompasses content knowledge

and procedural knowledge due to its combination of factual and applied material coupled with the stepwise processes of metabolism and cellular mechanisms. The Nieswandt study found that utilization of a learning approach with a large amount of hands-on activities and inquiry based labs sustained a positive self-concept and gave students a sense of ownership for their learning, thereby increasing comprehension levels.

In order for students to master the scope of biochemical, genetic, and biotechnological concepts, they must have a firm foundation in basic molecular structure and how cells use molecules in metabolism. According to Gabel (1999), chemistry becomes confusing due to the need of the student to make distinctions between three levels of understanding. Laboratory observations demonstrate phenomena that occur at the macroscopic levels (organismal as well as cellular observations) that can be perceived through one's senses, which students are expected to relate to interactions at the sub-microscopic or particulate level that they must be able to imagine and visualize. Both levels need to be linked to the symbolic level used in formulas and equations. These three types of distinctions are often blurred unintentionally by teachers who readily move from one level to another and may be unaware of the struggles students are having making such distinctions. Educators often do not realize the need to give students multiple opportunities to look at reactions and other chemical situations and to practice representing and manipulating each level present. During the study of biology, students encounter these three levels and a multitude of facts and reactions that the classes of biomolecules are involved in, so understandably, students can find themselves quickly overwhelmed. A conscientious pedagogic approach would embrace assisting students in mastering these levels and in supporting acquisition of meaningful conceptual understanding as well.

Another factor affecting student attitude, engagement, and comprehension is having a personal experience or finding a real life connection to facts. Dawson's study of Australian high school students exposed to a standard science curriculum revealed that younger students (12-13 years old) had limited understanding of biotechnology (Dawson, 2007). However, 16 year olds who had been taught lessons in genetic engineering and biotechnology showed a greater understanding of potentially controversial subjects such as genetically modified foods or gene therapy and were able to state clear opinions about these topics. Markowitz (2004) conducted a follow-up study of students participating in a summer molecular biology academy with research opportunities. The positive outcomes for students included greater understanding of science and research, subsequent improvement in advanced courses such as AP Biology and other science classes, and pursuit of further extracurricular science experiences. Many of the students (80%) expressed an increased interest in a science career, and some specified consideration of a research-oriented career. Eleventh grade students who were involved in a summer internship "came to appreciate the stereotypical nature of their previous understandings of science and laboratory practice" (Roth *et. al.*, 2009), i.e., that scientists were regular people much like themselves (however, students also commented on the complexity of the work and the time input required). Another aspect noted in this study dealt with the students' realization of the value of applying knowledge to a research problem rather than just learning and memorizing facts.

Although most high school students will not have the opportunity to work within the framework of such internships, using actual biotechnology laboratory equipment and being

exposed to current applications of these techniques in medical research should provide an enlightening experience which will increase student engagement. According to Gabel (1999), as complex activities such as certain experiments become familiar, the concepts involved in the activity can be processed from short- to long-term memory. This conversion often appears to be missing with students who do well on assessments administered immediately following content delivery but whose grades drop on semester or end of year finals.

The purpose of this study was to use biotechnology lab activities and translational research to see if these strategies could increase engagement of advanced biology students during studies of biomolecules. Students were introduced to a unit either by exploring a current medical disease being studied by researchers seeking novel treatment outcomes or by discussing the details of a controversial area such as stem cell therapy. By adding both biotechnology and virtual labs, students had the opportunity to make the connections between bench techniques, research strategies, and positive patient benefit. The dissemination of the link between these topics and the fundamental biology knowledge provided the motivation needed for longer concept retention time and student interest, as well as illustrating the importance of biotechnology. Ultimately, student academic performance in these areas improved as a result.

Action research intervention: The implemented interventions were hands-on lab experiences, simulated computer experiments, exposure to translational medical research, and interactive discussions. The objectives of this intervention were to see if (1) students were engaged during class time, (2) attitudes improved or remained positive during biomolecule studies, and (3) retention and comprehension of information increased. All 12 dual enrollment Biology students were selected for data analysis. Activities were aligned with collegiate curriculum guidelines through the presentation of material concerning the nature of science, cellular theory, and biotechnology concepts. Students learned how to pipet properly and to use this skill during restriction enzyme digestion and DNA agarose gel electrophoresis. They also learned how stem cell lines are created and what biomarkers are present on stem cells. The translational research focus highlighted excerpts of the lectures presented by Dr. Darwiche, Dr. Petersen and Dr. Terada during Bench to Bedside, and included the movie “Extraordinary Measures” as an illustration of the struggles of pharmaceutical marketing. The option of including the DNA microassay simulation designed by Dr. Charles Lawrence was omitted due to time constraints. A book study of the graphic novel [The Stuff of Life \(A graphic guide to genetics and DNA\)](#) by Mark Schultz was also added, and part of this study’s funds went towards the purchase of several copies of the novel. The stem cell and movie viewing took place during the cell unit, and the remaining activities were done at the beginning of the biotechnology unit, with assessments immediately following unit completion.

Connections to Bench to Bedside:

- Pipetting by Design
- Stem cell activity by Science Take-Out
- Restriction enzyme digestion
- DNA agarose gel electrophoresis
- Use of PowerPoint information from Dr. Darwiche (and other Univ. of Florida medical presenters including Dr. Petersen and Dr. Terada)
- Movie viewing of “Extraordinary Measures”
- Lab simulations from Utah Genetics site (Create a Stem Cell Line)

Data collection and analysis: The outcomes of this proposal were measured using two general parameters. The first component was improved engagement and attitude towards the subject matter. The second parameter was student performance and comprehension. These two areas were assessed by both quantitative and qualitative means.

Quantitative data analysis was performed on each of the two study units, the cell unit and the biotechnology unit. A pre-test and post-test of the same specific content knowledge questions was given with the cell unit, and questions were a mix of moderate and higher order types. Students used the unique identifier system from the Bench to Bedside surveys for the pre-test and post-test as well as the Likert surveys designed for the qualitative data collection. Scores improved from 29.7% (pre-test) to 42.0% (post-test). The chapter tests administered during the unit ranged from 53.7%-94.6% with an average of 78.2%, which was several points higher than the 71.5% average found for students in my last AP Biology class. The low score seen on the post-test in comparison to the chapter test probably reflects the students' realization that the chapter test counted as part of their grade, while pre- and post-tests are not.

For the biotechnology unit, no pre-tests and post-tests were done due to lack of time as the course progressed. However, the chapter test scores for this area ranged from 44-88% with an average of 65%. The lower average observed for the biotechnology unit compared to the cell unit was most likely due to the fact that the biotechnology unit (1) consisted of the first detailed exposure to these concepts while the cell unit contained some prior knowledge, (2) presented more complex procedures such as plasmid construction and PCR, (3) included embedding of tools such as restriction enzyme analysis and gel electrophoresis with multiple applications that some students found confusing, and (4) occurred at the end of the course when students were overwhelmed with the content of this course and the demands of other advanced courses on their schedules. As an additional quantitative measure, all students passed the course with 44% earning an A, 33% a B, and 22% a C; normally, at least one student has either a D or F for the first semester of AP Biology.

Qualitative data collection and analysis was utilized to monitor changes in student motivation towards studies of biomolecules and to see whether students felt that their grade performance improved as a result of the described interventions. A Likert survey to determine student attitudes was prepared and given to students before the cell unit and at the end of the biotechnology unit. The survey utilized a scale of 1-4 to reflect a range of 'strongly disagree' (1) to 'strongly agree' (4). Four of the questions focused on the students' general attitude about Biology, and their positive attitude essentially remained constant with a value of 2.8 before the activities and 2.9 afterwards. The questions which asked about the students' perception to their knowledge after stem cells and biotechnology exhibited a change from 1.7 before to 2.2 after the units, or a 29.4% difference. Regarding the importance of medical research and whether funds should be budgeted for clinical research, the students' opinions increased from 3.4 before

to 3.8 after completing the two units for a difference of 11.8%. 7 out of 9 students who took both surveys had increased values in all 3 areas, indicating that student attitude benefitted from the implemented activities.

I kept a teacher journal was kept during the class periods, thereby becoming an active participant observer during all activities. All students were fully engaged during lab activities, got correct answers for the virtual stem cell lab worksheet, properly executed the Pipetting by Design lab, and produced the expected results for the restriction enzyme digests and gel electrophoresis. The only issue observed was the 3 of the students struggled with completing the pedigree activity that was linked to the gel electrophoresis data. During both informal questioning during class and lab, and from formal individual formal interviews conducted with 4 students at the end of the semester, students recommended that the specific interventions be included in future classes and mentioned that the activities were helpful in their comprehension of the unit concepts. In conclusion, I will continue to use this approach to teaching either AP Biology or Dual Enrollment Biology in the future, since both the change in student attitude and the excitement and engagement level were significant in producing greater learning and improved grade performance.

Literature Cited:

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Markowitz, D. G. (2004). *Evaluation of the Long-Term Impact of a University High School Summer Science Program on Students' Interest and Perceived Abilities in Science*. Journal of Science Education and Technology, 13, 395-407.

Roth, W., Van Eijck, M., Hsu, P., Marshall, A., & Mazumder, A. (2009). *What high school students learn during internships in biology laboratories*. The American Biology Teacher, 71(8), 492-496.

Budget and budget justification: The following materials were ordered with the \$200 allotment (final prices included shipping):

Extraordinary Measures movie: \$20

Stem Cell kits from Science Take-Out: \$80

The Stuff of Life Novels: \$100

Permissions: Standard lab safety forms were signed by students and parents. The class syllabus had a clause to cover movie viewing and Internet permission which was signed by students and parents. The standard Duval County Public Schools photographic release was edited so that the Bench to Bedside program was covered.