5-10-2016

Aligning CityLab Biotechnology Curriculum with NGSS Standards and Practices

Arianna Jefferson

Aligning CityLab Biotechnology Curriculum with NGSS Standards and Practices

Arianna Jefferson

Submitted in Partial Completion of the

Requirements for Commonwealth Interdisciplinary Honors in Elementary Education and Biology

Bridgewater State University

May 10, 2016

Dr. Nicole Glen, Thesis Director

Dr. Jennifer Mendell, Thesis Director

Dr. Patricia Emmons, Committee Member

Aligning CityLab Biotechnology Curriculum with NGSS Standards and Practices

Arianna Jefferson

Introduction

I am currently pursuing Biology and Elementary Education degrees at Bridgewater State University with the hope that I will increase future students' excitement and desire to learn about science. I am interested in curriculum realignment as a way to utilize my knowledge from both of my majors in my honors thesis. I want my thesis to help me learn about the Next Generation Science Standards, NGSS. As a new teacher I am going to have to teach the standards, and therefore have to be comfortable and understand them. My research started as a way for me to learn the standards, participate in teaching science to students, and practice aligning standards with existing educational programs, or modules. As my time working on my thesis progressed, I realized the importance of this realignment because it provides CityLab with educational programs that are aligned to the new standards.

CityLab is part of Bridgewater State University's Center for the Advancement of STEM Education, CASE. CityLab is an outreach biotechnology laboratory for middle and high school students at Bridgewater State University. Biotechnology is the use of techniques from genetics in order to combine inherited characteristics from different organisms into one organism to produce helpful products (Merriam-Webster's online dictionary, n.d.). It is also the use of genetics to help create advantageous products, for example DNA. DNA fingerprinting is used to help identify people from their fingerprints. CityLab is presented in modules and incorporates activities for students to complete prior to and after visiting CityLab. A module is an educational program that includes laboratory experience in a simulated real world environment, along with content that helps to enhance the laboratory experience. CityLab has three existing modules:

Crucial Concentration, Lab Larceny, and Crooked Cell. One goal is to integrate the CityLab laboratory module into the students' existing school curriculum so that the experience builds upon students' knowledge.

The NGSS is broken up into three parts: Disciplinary Core Idea, Science and Engineering Practices, and Crosscutting Concepts. Disciplinary Core Ideas guide K-12 science curriculum, instruction and assessments toward the most important aspects of science. They are broad and cover multiple subjects or a crucial topic in a single subject, such as heredity in life science that does not necessarily relate to other ideas in physical science or earth and space science. In addition, the Disciplinary Core Ideas can be taught over multiple grade-levels to increase the depth of knowledge needed to understand more complex ideas and problem solving. They relate to life experiences of students or have societal or personal concerns. Science and Engineering Practices are behaviors that scientists engage in in the real world during investigations and engineers engage in as they design and build models. Finally, crosscutting concepts are used across multiple disciplines in science. These crosscutting concepts are concepts that are taught in multiple grade-levels and disciplines. They are not limited to one discipline and can even relate to English Language Arts or Mathematics.

Literature Review

Inquiry-based science education has been examined as a way to engage students in science. Colson and Colson (2016) report that in 1986, teacher Mary Colson noticed that her students appeared engaged in the lesson but did not want to explore the lesson further than what was assigned. This made her curious as to why her students only wanted to get the right answer. She thought it might be because there was no driving force (question) behind the activity, or that the focus was on what people already knew instead of discovering how they knew the information. The activity provided only information and not insight, and it did not engage students authentically in science.

Science is changing from rote learning to inquiry learning. Ediger (2014) stated that in inquiry science, students gain more in-depth facts, concepts, and generalizations because of the inquiry process. Science lessons and units need to focus on experimentation and students need to be involved in setting up and doing the experiments. Observations, creating and testing hypotheses, and reaching accurate conclusions are all parts of inquiry based learning.

National education standards have been debated for decades. Barton (2010) examined how people have varying opinions on what national education standards are, who should create and enforce them, and if the United States should have national standards. Previous attempts at national standards include No Child Left Behind (NCLB), the National Council on Education Standards and Tests, and the National Education Standards and Assessment Council, along with other policies and administrative legislation, such as Clinton’s Goals 2000. People often say they are for or against national standards; however, there are three different beliefs on what national standards are. National standards could be the content standards of what is taught at any grade in any school, establishing content standards as a way to increase rigor, or a way of “standardizing” what is taught in schools. All of these include nationally learning the same content but differ in how content is taught or the timeframe for content to be taught. Some national standards supporters argue for a national test that all students would have to take, whereas others want specific course content and a national test, yet others want the national standards to be optional and others who want all teachers to adhere to the standards. Finally, people differ on how national education standards should be created: should the government create and monitor the implementation of the standards, should the government create the standards and then an external body monitor the enforcement of the standards or should an external body create the standards and tests and the federal government enforce them?

Next Generation Science Standards (NGSS, 2013) is the new national (?) science standards developed by twenty-six states and their teams along with a forty member writing team and their partners. NGSS is based upon *A Framework for K-12 Science Education* which was developed by the National Research Council (NRC, 2011). *A Framework for K-12 Science Education* was developed to provide an evidence-based foundation for standards, and it examined current scientific research and identified what students should know in K-12 education (NRC 2011). NGSS standards were developed by states in collaboration using *A Framework for K-12 Science Education*. Thus far, very few states have adopted the standards and as stated on the NGSS website (2013), it was designed “for states, by states” which makes it state standards and not national standards. The federal government was not involved in the creation of the standards and is not requiring states to adopt NGSS. As of February 2016, 17 states have adopted the standards as is. They are Arkansas, California, Connecticut, Delaware, Hawaii, Illinois, Iowa, Kansas, Kentucky, Maryland, Michigan, Nevada, New Jersey, Oregon, Rhode Island, Vermont and Washington (Workosky, 2016). Massachusetts, which was part of developing the NGSS standards, has adopted similar science standards to NGSS (Best & Dunlap, 2014). West Virginia, which was part of the development of NGSS, rejected implementing NGSS because it teaches that global warming is a man-made event, but they have since adopted similar standards (Geiling, 2016). Nevada, which was not part of the creation of NGSS, adopted similar standards to NGSS (Best & Dunlap, 2014). Wyoming lawmakers banned the review and adoption of NGSS based on standards about climate science (Best & Dunlap, 2014). Each NGSS standard is divided into three parts: disciplinary core idea, scientific and engineering practices, and cross-cutting concepts (NGSS, 2013). NGSS was designed to be taught in context with concepts building throughout the grade levels coherently instead of topics being taught in isolation (NGSS, 2013). It is a dynamic growth process through students' K-12 science education (NGSS, 2013). Engineering is included in the science standards as an equal part of science education along with science inquiry and is used to emphasize science disciplinary core ideas in science and technology (NGSS, 2013).

NGSS standards are aligned with English Language Arts (ELA) and Mathematics Common Core Standards in terms of cognitive demand and help students become college and career ready (NGSS, 2013). Appendix F of NGSS describes the eight science and engineering practices that scientists and engineers engage in while investigating and building models and theories about the natural world. The eight science and engineering practices include: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information (NGSS, 2013). Also included in NGSS in Appendix G is the seven cross-cutting concepts, which are interdisciplinary concepts that help students connect knowledge from various disciplines. These include: patterns, cause and effect, scale, proportion, and quantity, systems and system models, energy and matter in systems, structure and function, and stability and change of systems (NGSS, 2013).

Previous science standards assessed content and application separately, but this is not how real world science application occurs (NGSS, 2013). The National Science Education Standards (NSES) were the precursor of NGSS and were written in 1996 (Stern & Roseman, 2001). NSES was divided into eight categories for knowledge, including unifying concepts and processes in science, science as inquiry, physical science, life science, earth and space science, science and technology, science in social and personal perspective, and history and nature of science (National Academy Press, 1996).

Prior to the release of NGSS, MA had adopted the Massachusetts Science and Technology/Engineering Framework in 1995 with a full revision in 2001 and revisions in 2006 at the high school level. These standards focused on earth and space sciences, life science (biology), physical science (chemistry and physics), and technology/engineering. The standards were focused on inquiry-based instruction, experimentation, and design which should be taught together. Specific skills were expected to be taught during certain grade bands. The standards provided ideas for teaching the standard as well as how to incorporate technology.

Liftig (2014) noted that NSES and previous Massachusetts Science and Technology/Engineering Framework lesson plans cannot necessarily change to NGSS lesson plans by adding lessons to the existing curriculum. With NGSS focusing on cross-cutting concepts and science and engineering practices in addition to the disciplinary core ideas, most lessons need to be realigned. In addition, engineering and technology need to be incorporated into the science curriculum and students need to use them as much as inquiry in science education (Liftig, 2014).

Stern and Roseman (2001) described the process of ensuring textbook alignment, which can be used to align curriculum as well, in middle and high school. When beginning textbook, curriculum, or lesson alignment it is important to ensure that the ideas the standards cover and not the topics are included in the table of contents. The headings in a chapter do not guarantee that the material in the chapter is what is included in the standard and could instead be material that is too hard, easy, or irrelevant to the standards. It is important to know what the standards are expecting students to know prior to determining if a textbook or lesson is aligned to determine if relevant material is covered. However, there are always some exceptions to the rule, for example when a lesson helps students understand a prerequisite idea or address student misconceptions.

Teachers and school districts are incorporating NGSS standards into their classrooms and through a variety of ways. Some teachers are using science activities as enrichment activities because of the lack of time during the day (Fruen, 2001). Others are incorporating inquiry based science into their classrooms (Colson & Colson, 2016). Another way teachers are incorporating science standards is through technology (Miller, 2011). Jeffrey Miller (2011) uses an online curriculum to meet the needs of students by using a digital library and traditional learning material. The curriculum allows for a collaborative learning community to develop. Some teachers are teaching integrated science in which discipline boundaries are ignored in favor of students making connections between subjects (Van Scooter et,al., 2000). When planning integrated science, it is important to focus on the coherence and quality of the material (Van Scotter et. al., 2000). Science is only required for two years at the high school level in many states (Van Scotter, et. al., 2000). Many schools in MA it is required for three years. Therefore, by integrating science schools are able to teach multiple subjects through one science course. Some districts are using curriculum mapping as a way to ensure that all standards are taught in a student’s K-12 education (DeClark, 2002).

One method that some school districts have implemented is curriculum mapping. DeClark (2012) found curriculum mapping ensured that national and state standards were included in the curriculum and help avoid unnecessary repetition. In this process, teachers and administrators were actively involved in the mapping in every step. Curriculum mapping was designed so that students could see the big picture about what they are learning. Also, the possibility for cross-curricular integration developed because curriculum maps were planned months in advance and give teachers a chance to compare maps in different subjects and plan for possible projects. In order for curriculum mapping to be successful, teachers need to be honest about what they were teaching and what they were skipping and discuss suggestions from others in their department and district. The district needed to allow the teachers at multiple grade-levels time to discuss what was taught in each grade level. When changes were made, teachers need to be reflective and analyze the use of their individualized maps in terms of writing or removing lessons, and then share lessons, labs, or units with teachers who were assigned a topic they previously taught.

Lois Fruen (2001) from Breck School in Minneapolis, Minnesota used enrichment activities, which are done outside of class and receive a grade, as a means of covering science standards and meeting the diverse interests of students. Students use a menu approach and are able to select activities to complete by doing experiments, reading books and articles, watching videos, or researching questions. Each activity is designed to complement and enhance the curriculum because they have limited time to spend on science. Fruen also included that the enrichment activities are 10% of students' grades and that students can complete additional enrichment work for up to 10% of their grade as extra credit that benefits the entire class because students need to present their work to the class. The enrichment activities allow students to use their strengths when engaging in science, and inquiry or take-home experiments and parent supervision is sometimes required. Enrichment work is one way teachers are able to incorporate the science standards into their classroom.

In addition, science standards can be taught by incorporating reading and writing. When writing in science, the focus should be on writing like a scientist. English Language Arts (ELA) standards can be incorporated into a lesson or science unit, and NGSS incorporates possible connections to Common Core Standards, such as ELA and Mathematics (NGSS, 2013). Students can benefit greatly from learning how ELA writing and reading skills are found in different subject matter, especially science (Merten, 2015). Therefore, both standards can be taught and essential questions can be focused on. Afterward students can answer the questions after completing experiments (Merten, 2015).

Reflection is a critical aspect in teaching and enables a teacher to modify and refine lessons. By reflecting, Mary Colson (2016) was able to assess her students' lack of curiosity in the classroom and take steps to remedy the situation. A lesson might already involve inquiry based science but reflection is required to determine if it aligns with NGSS (Hunter, 2014). As teachers reflect on a lesson, they can determine why a lesson is being taught, if the order of the lessons is coherent, and how their enthusiasm for the material being taught effects how they teach the material to students (Schwoyer, 2002). Reflective questioning is one way to determine needed adaptations to existing curriculum (Hunter, 2014). Reflective practice could also lead to increased student engagement with the content (Hunter, 2014). Similarly, with curriculum alignment after realigning existing curriculum, the alignment should be reflected upon. Blank and Hill (2004) examined how students' achievement improves, especially in urban districts, when the teachers were able to reflect on their practices and beliefs.

Methods

In this research study I aligned three modules, Crooked Cell, Crucial Concentration, and Lab Larceny, from Bridgewater State University's CityLab. CityLab is an outreach biotechnology laboratory for middle and high school students. The students visit for one day and complete pre-visit and post-visit activities. It is located in the new Dana Mohler-Faria Science and Mathematics at Bridgewater State University, BSU, in a laboratory specifically for CityLab. CityLab is part of Bridgewater State University's Center for the Advancement of STEM Education, CASE. In addition to offering modules for students, professional development is offered for teachers through CASE. Some of the professional development opportunities available include: a) Probability: A Games Teachers Play Workshop, which is a workshop about using games that incorporate probability for preschool through 12^{th} grade math educators; b) Discover the Microbes Within, which is a workshop in conjunction with Marine Biological Institute about bringing inquiry based learning into a high school classroom; and c) Earthview Institute for Educators, which is a 2-morning workshop about incorporating geography in the classroom using Earthview for kindergarten through 12^{th} grade educators. In addition, there is Watershed Access Laboratory, which is an outreach laboratory for middle and high school students, next to CityLab.

One module that I worked with, Crucial Concentration, has students taking on the role of a scientist working to determine which drink has the highest protein concentration using a spectrophotometer. Another module that I worked with, Crooked Cell, has students taking on the role of a doctor. Students then have to diagnosis a patient as either having sickle cell disease, being a carrier, or having normal cells, using gel electrophoresis. The final module that I worked with, Lab Larceny, has students taking on the role of a forensic scientist to discover who was at the potential crime scene by using gel electrophoresis.

I began the alignment process first with Crucial Concentration, then Crooked Cell, and finally Lab Larceny. The first step for aligning the modules was to become familiar with the module I was aligning. Prior to beginning my curriculum alignment, I had observed and taught the modules in order to be familiar with the material and any modifications that educators had made since the lesson was originally written. This way I knew the concepts and the order as well as parts of the lesson that could potentially be modified or could not be removed because they were critical to the success of the module. I helped and taught for two semesters in CityLab in the Fall of 2014 for one day a week, and in the Spring of 2015 for two days a week. After I was confident in the material as well as what each educator added, I began to examine the NGSS standards and practices.

While helping during the Fall 2014 semester, I focused on learning and aligning Crucial Concentration to NGSS standards and practices since the new MA science standards had not been released. Since Crucial Concentration is a module that middle school students usually complete, I focused on that grade level in the standards. I broke down each section of the module and went line by line to determine if it could be aligned to a standard or practice. After I aligned the module with NGSS, I aligned it with MA ELA and Mathematics Curriculum Frameworks and noted, by describing why the material aligned to the standard and possible changes to help the modules align better with the standards in the table. Next, I aligned Crooked Cell following the same procedures as Crucial Concentration during the Spring 2015 semester. Crooked Cell is taught to middle and high school students and therefore needed to be aligned accordingly. Since I was already familiar with the standards it was easier and faster to complete this alignment because I did not need to read and search the standards for each line of the module. Finally, towards the end of the semester, I focused on aligning Lab Larceny using the same procedure. Lab Larceny is mainly taught to high school students and therefore I focused on aligning it with those standards. This module was the easiest to align because I was the most familiar with the standards and it was a module that I had taught the most. In the Fall of 2015, I presented the alignments and the methodology at the Massachusetts Association for Science Teachers, MAST, annual conference.

Examples of Alignment

For the full alignment of each of the modules please see the appendix.

Crucial Concentration Examples:

Students are shown the chemical reaction when protein interacts with BCA Assay. A spectrophotometer is then used to identify concentration of protein.

Scientists are often faced with the challenge of determining the concentration of a substance in solution. For example, they may need to measure levels of proteins, cholesterol, glucose or the rate of enzymatic activity. This investigation will focus on a colorimetric assay commonly used to measure protein concentrations called the Bicinchoninic Acid (BCA) Assay. It requires the students to incorporate several concepts and skills commonly used in a bioscience laboratory.	MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]

In Grades 6-8, students help to formulate ideas on how they could measure protein concentrations and then complete an experiment to determine the unknown protein solutions concentration. Students then explain why the data would be adequate to determine the protein concentrations. In Grades 9-12, students learn that the protein concentration is independent of the absorbencies reading on the spectrophotometer while the absorbencies reading is dependent on the protein concentration. They are able to discuss the relationship between the two variables.

Students are encouraged to share information and ideas. In attempting to solve the problem they will find that that they need to make a standard of known concentration be used to compare with the unknowns. By doing so the concepts of variables and constants must be observed. The instructor's role is one of a coach leading the students by inquiry where necessary, and making them aware of the concepts that they have applied such as the creation of a standard and the use of constants and variables. Thus the students will be challenged by problem solving skills at the start of the lesson. The concepts they "discover" will then be applied to a laboratory situation to measure an unknown amount of protein. Hence there is a bridge from the familiar to the unfamiliar.	Practice 6, grade 6-8 -Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion - Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future Practice 6 grade 9-12 - Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Students are asked to place bottles with food coloring in the correct order from lightest to darkest color. The students then have to describe why they ordered the bottles in that order. This provides the introduction as to why a spectrophotometer is needed to quantify protein concentration later in the laboratory.

<table>
<tr><td>Pipetting

Introduction: bottles with food coloring</td><td>Practice 5: Using Mathematics and Computational Thinking

Mathematical and computational thinking in 6–8 builds on K–5 Experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.

• Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering

6.RP.A.3 (math) Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-1),(MS-PS1-2), (MS-PS1-5)

6.RP.A.1 (math) Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities</td></tr>
</table>

It is at the beginning of the laboratory when the educator is explaining chemical reactions and how the students can use the chemical reaction to determine if protein is present in a solution. The purple color is then quantified using a spectrophotometer to determine the protein concentration.

Figure 1. Simplified chemical equations of BCA assay Protein + $Cu^{+2} \rightarrow Cu^{+1}$ Cu^{+1} + 2BCA $\rightarrow$Purple color Protein when mixed with bicinchoninic acid assay (BCA) changes the solution from green to purple when heated. The darkness of the color change is dependent on the concentration of protein. BCA has copper ions which start the reaction with protein.	MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.

The discussion allows students to discuss why food labels can be important in a person's diet and why certain people (people with diabetes, celiac, food allergies, etc.) need to pay more attention to food labels than other people. Students engage in the discussion and it builds upon their ideas while allowing them to express their own ideas.

Discussion about food labels	SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Students use the information from the table to complete the graph, thus converting words into a visual representation.

Graphing your data by hand and Excel	RST.6-8.7 (ELA: reading) Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-1), (MS-PS1-2), (MS-PS1-4), (MS-PS1-5)

Afterwards students complete a letter detailing the supporting evidence and how they followed the procedure. Students include relevant information to support their claims, including the standards and graph, to support their conclusion while answering the question of which sample has the most protein.

Letter afterwards	WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and gene rating additional related, focused questions that allow for multiple avenues of exploration.(MS-PS1-6) WHST.6-8.1: Write arguments to support claims with clear reasons and relevant evidence.

Crooked Concentration Examples:

Students identify controls and describe what they are used for once gel electrophoresis is explained. Students learn how controls are needed to support their claims.

Each student will also be given a hemoglobin sample from a person with normal hemoglobin, and another sample of a person who definitely has sickle cell syndrome to use as controls. They will use a technique called protein electrophoresis to diagnose their patient's hemoglobin.	Planning and Carrying out Investigations: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

Students learn potential symptoms of sickle cell syndrome that can be used to predict if a patient has the disease before completing the experiment. Students list the symptoms present along with the family history before listing potential causes that would produce the symptoms. The natural system is the human body and students have to figure out the potential cause for the symptoms, which is the effect.

The sickle-shaped red blood cells last only about ten days as opposed to the 120-day cycle of healthy blood cells. The bone marrow cannot produce enough red blood cells to keep up with the demand, which results in anemia. With an abnormally high amount of red blood cells breaking down, there is an excess of bilirubin present (bilirubin is a yellow pigment that results from the breakdown of hemoglobin). The liver usually removes bilirubin from the blood. If the liver cannot remove bilirubin fast enough, it builds up and jaundice results. Bilirubin can harden, causing gallstones.	MS-LS3-2: Cause and effect relationships may be used to predict phenomena in natural systems.

Students learn about alleles and how offspring have one chromosome from each biological parent.

What does this tell you about the inheritance of sickle cell syndrome? Is it dominant, recessive, co-dominant, or incompletely dominant?	MS-LS3-2: Inheritance of traits: Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. MS-LS3-2:Variation of traits: In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.

Students complete Punnett squares using different sets of parents with different phenotypes thus demonstrating children receive alleles from their parents at random and they have one allele from each parent, which can be the same or different. Students create proportional relationships of the likelihood of a child from the cross being normal, being a carrier, or having sickle cell syndrome. Students complete a ratio and percent for normal, carrier, or sickle cell syndrome in potential offspring dependent on the crosses.

Completing Punnett squares with ratios and percentages for potential offspring between normal, carrier and sickle cell syndrome.	MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.] 7.RP.A.2 (Mathematics) Recognize and represent proportional relationships between quantities. Practice 5 grades 6-8: Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.

Lab Larceny

Effects of mutations at restriction sites are examined when using Restriction Fragment Length Polymorphism to determine fragment length when examining DNA.

Introduction to restriction sites of Restriction Fragment Length Polymorphisms and effects of mutation at the restriction site in terms of DNA fragment length.	HS-LS3-2: In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.

Students examine crime scene photos and ask questions to determine what could have happened at the crime scene.

Examination of crime scene photos.	Practice 1 Grades 9-12: Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

In grades 6-8, students determine the source of the blood samples and support it with evidence from DNA fingerprinting when discussing it with classmates. In grades 9-12 students determine the source of the blood samples and support it with evidence from DNA fingerprinting when discussing it with classmates.

Students work in groups to determine who the two blood samples came from and support it with evidence.	Practice 7 Grades 6-8: Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Practice 7 Grades 9-12: Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

At the end of the module students analyze the results of their agarose gel that they ran during the module to determine who was at the potential crime scene.

Analyzing the agarose gel to determine who the blood samples at the crime scene were from.	Practice 4 Grades 6-8: Analyze and interpret data to provide evidence for phenomena. Practice 6 Grades 9-12: Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Implications

The new alignments of the CityLab modules allow teachers to justify their visit to CityLab with their principals. Teachers will be able to show their principals which standards the module they wish to cover and how it builds upon what students are learning in their classroom. This way students are able to engage in hands-on science at CityLab that incorporates what they learned in their classroom. Teachers will be able to use the alignments to help determine when to have their class visit CityLab so that the visit coincides with what students are learning in school.

Now that the modules are better aligned, teachers may be more willing to complete pre- and post-visit activities in their classrooms that extend the learning that the modules promote. This way students' visit to CityLab would build upon what they are learning in the classroom. The pre-visit activities help to build background knowledge for the module. By doing these prior to coming to CityLab, it would help the students to be better prepared and have the background knowledge to help them complete the modules. In addition, since the post-activities align with standards that need to be taught to students, teachers may be more likely to complete the activities.

In the future, modifications can be made to the modules to help them align to NGSS standards and practices better not sure what you mean here. For example, the standards expect students to develop a model to describe why sexual reproduction results in offspring with genetic variation. In Crooked Cell, students use Punnett Squares to show how sexual reproduction creates genetic variation. However, they do not develop a model to describe why it results in offspring with genetic variation. Revisions can be made to parts of the modules to help them align even better with the new standards. Overall the modules align fairly well.

Conclusion

Each standard in NGSS is broken into three parts: Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts. My thesis work helped me to learn the NGSS standards and practices and also practice aligning the standards to existing curriculum. This will help me when I want to teach something in my classroom in the future that is not already aligned to NGSS. I was also able to see teachers teaching science and become familiar with the standards. My honors thesis also helped to update CityLab's current modules so that they are aligned to NGSS in an effort to help recruit schools to visit.

References

Barton, P. E. (2010). National education standards: To be or not to be? *Educational Leadership,* (April), 22-29.

Best, J., & Dunlap, A. (2014). Next Generation Science Standards: Considerations for curricula, assessments, preparation, and implementation. Retrieved from http://www.ride.ri.gov/Portals/0/Uploads/Documents/Instruction-and-Assessment-World-Class-Standards/Science/NGSS/Policy Brief - NGSS Considerations.pdf

Biotechnology. n.d. In Merriam-Webster.com. retrieved from http://www.merriam-webster.com/dictionary/biotechnology

Blank, R., & Hill, S. (2004). Analyzing instructional content & practices using data to improve of science instruction with state and national standards. *The Science Teacher,* (January), 54-58.

Colson, M., & Colson, R. (2016). Planning NGSS-based instruction do you start? *Science and Children,* (February), 23-25.

DeClark, T. (2002). Curriculum mapping: A how-to guide using curriculum mapping to align instruction. *The Science Teacher*, (April), 29-31.

Ediger, M. (2014) The changing science curriculum. *College Student Journal*, *48*(4), 648-650.

Fruen, L. (2001). Enriching the curriculum. *The Science Teacher*, (January), 8-8.

Geiling, N. (2016, February 29). West Virginia votes to block science standards because they teach global warming. Retrieved March 14, 2016, from http://thinkprogress.org/climate/2016/02/29/3754731/west-virginia-house-halts-science-standards-over-climate/

Hunter, J. C. (2014). Reflecting on lab practices. *Education Research Complete, 134*(3), 380-383.

Kromphout, O. M., & Butzin, S. M. (1993). Integrating computers into the elementary school curriculum: An evaluation of nine project child model Sschools. *Education Research Complete, 26*(1).

Liftig, I. (2014). The NGSS call to reengineer your curriculum. *Science Scope*, (April/May), 1-1.

Merten, S. (2015). Reading and writing alignment across content areas. *Science Scope*, (February), 12-18.

Miller, J. (2011). Customizing curriculum with digital resources. *The Science Teacher*, (October), 46-50.

National Academy Press. (1996). *National Science Education Standards: Observe, interact, change, learn* (5th ed.).

Schwoyer, M. C. (2002). Finding a purpose: Reflecting on curriculum and assessment. *The Science Teacher*, (November), 12-12.

Stern, L., & Roseman, J. (2001). Textbook alignment. *The Science Teacher,* (October), 52-56.

Van Scotter, P., Bybee, R. W., & Dougherty, M. J. (2000). Fundamentals of integrated science what teachers should consider when planning an integrated science curriculum. *The Science Teacher,* (September), 25-28.

Workosky, C. (2016, February 18). Hawaii adopts the Next Generation Science Standards [Web blog post]. Retrieved from http://ngssblog.nsta.org/latest-news/

Appendix

Crucial Concentration

Paragraph from Crucial Concentration	Strand/practice	Why does it align?
Scientists are often faced with the challenge of determining the concentration of a substance in solution. For example, they may need to measure levels of proteins, cholesterol, glucose or the rate of enzymatic activity. This investigation will focus on a colorimetric assay commonly used to measure protein concentrations called the Bicinchoninic Acid (BCA) Assay. It requires the students to incorporate several concepts and skills commonly used in a bioscience laboratory.	MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]	Students are shown the chemical reaction when protein interacts with BCA Assay. A spectrophotometer is then used to identify concentration of protein.
To do the BCA Assay a series of standard protein solutions	Practice 5 grades 6-8 Apply mathematical concepts	Grades 6-8:

are made to create a standard curve. The standard curve is then used to measure the quantity of protein in an unknown solution that the students will be given. Since the protein is colorless, a chemical reaction will be used to produce a purple color the intensity of which is in direct proportion to the amount of protein present. The reaction requires the use of copper II (Cu+2) and BCA. The chemical structures of bicinchoninic acid and the color producing product, as well as a simplified reaction are diagrammed below.	and/or processes (e.g.,ratio, rate, percent, basic operations, simple algebra) to scientific and engineering Practice 5 grades 9-12 Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations	By creating a standard curve, students are examining the ratio of protein concentration and the absorbencies reading produced by the spectrophotometer. They can then determine the unknown concentrations. Grades 9-12: By having known protein concentrations students are able to use the standard curve to estimate the concentrations of the unknown. They are then able to describe and support their conclusions using the graph.
The concept of developing a standard for measurement is frequently applied to solve quantitation problems. This concept is often familiar to	Practice 5 grades 6-8 Apply mathematical concepts and/or processes (e.g.,ratio, rate, percent, basic operations,	Grades 6-8: The food coloring drops added to the bottle go up in increments of five for the knowns and are labeled on the

students although they may not recognize it as such. The students will be introduced to the concept of measuring concentrations by starting off with a problem using soda bottles, water and food coloring. In this exercise students will be challenged to determine the number of drops of food coloring in a bottle of water. Resources will be provided for students to use as they find necessary.	simple algebra) to scientific and engineering Practice 5 grades 9-12 Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations	top. Students then can see a ratio between them and then have to compare the unknowns which are unknown. Grades 9-12 Students are unable to support claims of where the unknowns go because they are unable to support their claims with data. This leads to a discussion on how it could be quantified.
Students are encouraged to share information and ideas. In attempting to solve the problem they will find that that they need to make a standard of known concentration be used to compare with the unknowns. By doing so the concepts of variables and constants must be observed.	Practice 6, grade 6-8 -Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion - Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments)	Grades 6-8: Students help to formulate ideas on how they could measure protein concentrations and then complete an experiment to determine the unknown protein solutions concentration. Students can then explain why the data would be adequate to

The instructor's role is one of a coach leading the students by inquiry where necessary, and making them aware of the concepts that they have applied such as the creation of a standard and the use of constants and variables. Thus the students will be challenged by problem solving skills at the start of the lesson. The concepts they "discover" will then be applied to a laboratory situation to measure an unknown amount of protein. Hence there is a bridge from the familiar to the unfamiliar.	and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future Practice 6 grade 9-12 - Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.	determine the protein concentrations. Grades 9-12: Students learn that the protein concentration is independent of the absorbencies reading on the spectrophotometer while the absorbencies reading is dependent on the protein concentration. They are able to discuss the relationship between the two variables.
To demonstrate how a spectrophotometer works, shine a flashlight through the bottles so that the light reflects on a white background. Ask the class to assign each intensity a number from 1 to	MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on	The first activity demonstrates visually what is occurring inside of the spectrophotometer which is unable to be seen. Students can witness what happens when light is reflected onto the

10, one being the lightest and 10 being the darkest. Record the values assigned by the class for each standard. This is what a spectrophotometer does. Next have the students graph the results of with the concentration on the concentration on the x-axis and the number assigned on the y-axis. When the best-fit line is drawn they will have constructed a standard curve.	both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.	paper and then identify which one produces the darkest reflection. Students use the model of the bottles and the light reflected as a comparison to the spectrophotometer.
After the pipetting practice, each group will be given the unknown samples of protein in order to find the concentration of protein in each sample. They will then create an assay of known protein using bovine serum albumin (BSA), BCA working reagent and distilled water. The spectrophotometer will be used to measure the	Practice 1: Grades 6-8 Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • to determine relationships between independent and dependent	Grades 6-8: Students learn through the process of making a standard curve that the concentration of protein is independent of the absorbency reading. They then use the absorbency of the unknowns to determine the protein concentration of the unknowns.

absorbencies, and the data will be used to develop a standard curve. Students will use the standard curve to measure the concentration in their samples. You will find the student manual attached. It includes the procedures and worksheets necessary to complete the investigation.	variables and relationships in models Practice 1: Grades 9-12 • to determine relationships, including quantitative relationships, between independent and dependent variables.	Grades 9-12: Continuing from the understanding students in grades 6-8 receive students then use quantitative data to determine the unknown variables using the dependent variables. This aligns with determining relationships.
Figure 1. Simplified chemical equations of BCA assay Protein + $Cu^{+2} \rightarrow Cu^{+1}$ Cu^{+1} + 2BCA $\rightarrow$Purple color	MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.]	Students combine protein along with BCA assay which then goes into a warm water bath. Before BCA assay and protein is heated it is a colorless liquid, after it is heated it turns a purple color based on the concentration of protein. Students can examine the test tubes to determine if a chemical reaction occurred or did not occur (control with no protein added).

	[Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.	
Pipetting Introduction: bottles with food coloring and mixing of samples to demonstrate ratios and describe the ratios between the microcentrifuge tubes	6.RP.A.3 (math) Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-1),(MS-PS1-2), (MS-PS1-5) 6.RP.A.1 (math) Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities	Students make standards unknowingly to compare ratios between different mixes of food coloring in microcentrifuge tubes. After comparing the standards to the other samples students are asked why they would have the same color and discover that all the microcentrifuge tubes have a 1:1 ratio of the two food coloring colors.
Discussion about food labels	SL.8.1 (ELA: speaking and listening) Engage effectively in a range of collaborative discussions (one-on-one, in groups, and	The discussion allows students to discuss why food labels can be important in a person's diet and why certain people (people with diabetes, celiac, food

	teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.	allergies, etc.) need to pay more attention to food labels than other people. Students engage in the discussion and it builds upon their ideas while allowing them to express their own ideas.
Following the lab procedure	RST.6-8.3 (ELA: reading) Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6)	By properly reading the lab procedure, students are able to follow the lab procedure and are able to complete the lab experiment and get results.
Graphing your data by hand and Excel	RST.6-8.7 reading Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-1), (MS-PS1-2), (MS-PS1-4), (MS-PS1-5)	Students take information in a table to complete the graph thus converting words into a visual representation.

Concluding levels of protein in the unknowns based on the graph	6.RP.A.3 (math) Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS1-1),(MS-PS1-2), (MS-PS1-5)	Students determine the relationship between absorbency and protein concentration using the knowns and then solve to find the unknown protein concentrations. They can solve it using a mathematical ratio.
Determine the unknowns based on the graph and what the numbers symbolize	6.SP.B.5 (math) Summarize numerical data sets in relation to their context (MS-PS1-2)	After solving how much protein each unknown contains, students compare the samples to determine which sample has the most protein and therefore which company is telling the truth about having the most protein in their drink.
Letter afterwards	WHST.6-8.7 (ELA: writing) Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and gene rating additional related, focused	Afterwards students complete a letter detailing the supporting evidence and how they followed the procedure. Students include relevant information to support their claims, including the standards

	questions that allow for multiple avenues of exploration.(MS-PS1-6) WHST.6-8.1 (ELA: writing) Write arguments to support claims with clear reasons and relevant evidence.	and graph, to support their conclusion while answering the question of which sample has the most protein.

Crooked Cell

Paragraph from Crooked Cell	Strand/practice	Why does it align?
The most common adult hemoglobin (hemoglobin A) is comprised of two alpha chains and two beta chains of amino acids. Sickle cell hemoglobin (hemoglobin S) is identical to hemoglobin A except the sixth amino acid in each of the beta chains is valine instead of glutamic acid. This single change in amino acids causes the hemoglobin S molecules to	LS3.A: Inheritance of Traits ♣Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins,	There is a discussion about what happens when a mutation occurs in the beta chain resulting in one amino acid to change in the protein and how the structure is altered. The ability for hemoglobin S to carry oxygen is diminished which is discussed and covers how protein function is altered because of a gene mutation.

connect to other hemoglobin S molecules within the RBC. These linked units of hemoglobin S distort the shape of the cell, producing a characteristic sickle shape. A low concentration of oxygen contributes to the formation of hemoglobin S connections. The switch in amino acids also causes hemoglobin S to have a less negative overall charge.	which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1) LS3.B: Variation of Traits In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS-LS3-1)	 Variation of traits: Mutations, such as the original change in the amino acid, can be passed down genetically and it can be harmful to those with the syndrome without medical intervention. Students learn about the mutation but also how it is passed on in sexual reproduction.
The sickle-shaped red blood cells last only about ten days as opposed to the 120-day cycle of healthy blood cells. The bone marrow cannot	Cause and Effect ♣Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)	Students learn potential symptoms of sickle cell syndrome that can be used to predict if a patient has the disease before completing the

produce enough red blood cells to keep up with the demand, which results in anemia. With an abnormally high amount of red blood cells breaking down, there is an excess of bilirubin present (bilirubin is a yellow pigment that results from the breakdown of hemoglobin). The liver usually removes bilirubin from the blood. If the liver cannot remove bilirubin fast enough, it builds up and jaundice results. Bilirubin can harden, causing gallstones.		experiment. Students list the symptoms present along with the family history before listing potential causes that would produce the symptoms. The natural system is the human body and the cause is what is causing the symptoms with the effects being the symptoms themselves.
Pre-visit Station A: Four microscopes are set up; each with one slide marked either "P" for patient's blood or "N" for normal blood. Every team member observes	Structure and Function ♣Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes,	Students use microscopes to view microscopic differences between patient and normal blood. By examining structures under the microscope students learn

each sample. They are to draw and describe what they see. When everyone is finished the drawings and descriptions are compared, and the students will determine how they think the patient's blood differs from normal blood.	composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS3-1)	about a natural system and how it might potentially function.
Pre-visit Station B: Students are given models that represent blood vessels and red blood cells from a patient with sickle cell syndrome. They are asked to find the effect of the patient's cells on the flow of blood through the circulatory system. The team will be required to record the conclusions they have made from their observations.	Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. ♣Develop and use a model to describe phenomena. (MS-LS3-1),(MS-LS3-2) Practice 8 Grades 6-8: Communicate scientific	Using the model students are able to observe the phenomena of blood from a patient with sickle cell syndrome effects the circulatory system. Grades 6-8: Students need to

	and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.	communicate with their group what they discovered through their observations about sickle cell syndrome and the circulatory system.
Station C: Models representing red blood cells are present. One set represents the patient's blood, and the other set represents normal blood. Each set contains pieces that represent hemoglobin. The response of normal and sickle cell hemoglobin in conditions of low oxygen concentration are described. Based on this information, students use the models to determine how the cell shape is altered by the different hemoglobin structures.	Develop and use a model to describe phenomena. (MS-LS3-1),(MS-LS3-2)	Students use models to describe the phenomena of hemoglobin and how normal and sickle hemoglobin differ in oxygen concentration based on shape.

Pre-visit Station D: A pedigree of sickle cell syndrome in the patient's family will be available. Students will use it to investigate the pattern of inheritance of the disease.	LS3.B: Variation of Traits ♣In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2)	A pedigree depicts how traits can be passed down in a family because of genetics and how half of the genes come from each parent.
Pre-visit: After each group completes all four stations, they will have some time (10-15min) to get an outline of their findings on sickle cell syndrome together. They will then put an outline on the board, and give an oral presentation explaining these findings.	SL.8.4 (ELA: speaking and listening strand) Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.	Students present to the remaining groups on the evidence they discovered in the four stations providing relevant evidence. This allows students to present what they feel is important to the rest of the class with supporting evidence.

Pre-visit Closure: Ask the students to make a concept map depicting what they learned today about sickle cell syndrome.	RST.6-8.7 (ELA: reading strand) Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	Students are taking written observations and creating visual representation (concept map) thus integrating quantitative information into a simple visual representation.
Each student will also be given a hemoglobin sample from a person with normal hemoglobin, and another sample of a person who definitely has sickle cell syndrome to use as controls. They will use a technique called protein electrophoresis to diagnose their patient's hemoglobin.	Practice 3 Grades 6-8 Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.	Students identify controls and describe what they are used for once gel electrophoresis is explained. Students learn how controls are needed to support their claims.
What does this tell you about the inheritance of sickle cell	MS-LS3-2: Inheritance of traits	Students learn about alleles and how offspring have one

syndrome? Is it dominant, recessive, co-dominant, or incompletely dominant?	Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. Variation of traits: In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2)	chromosome from each biological parent.
Analyzing the agarose gel to diagnose the patient.	Practice 4 Grades 6-8: Analyze and interpret data to provide evidence for phenomena.	Students analyze and interpret, with help if needed, the patient’s diagnosis based on the controls.

Discussion about how to treat sickle cell syndrome with gene therapy.	MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]	Students discuss possible treatments for sick cell syndrome and learn about gene therapy as an option. Also, they learn that it is an expensive treatment but a worthwhile treatment method and thus has positive impacts on society.
Completing Punnett squares with ratios and percentages for potential offspring	MS-LS3-2. Develop and use a model to describe why asexual	Students complete Punnett squares using different sets of parents with different

between normal, carrier and sickle cell syndrome.	reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.] 7.RP.A.2 (Mathematics) Recognize and represent proportional relationships between quantities. Practice 5 grades 6-8: Apply mathematical concepts	phenotypes thus demonstrating children receive alleles from their parents at random and they have one allele from each parent, which can be the same or different. Mathematics: Students create proportional relationships of the likelihood of a child from the cross being normal, carrier, or having sickle cell syndrome. Grades 6-8: Students complete a ratio and

	and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.	percent for normal, carrier, or sickle cell syndrome in potential offspring dependent on the crosses.
Letter to the Patient	WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. Practice 6 Grades 6-8: Construct an explanation using models or representations.	Writing: Students diagnose the patient in a letter and provide evidence that supports their diagnosis. Grades 6-8: Students use the agarose gels to support their diagnosis in their letter to the patient.
Following the lab procedure	RST.6-8.3 (ELA: reading) Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6)	By properly reading the lab procedure, students are able to follow the lab procedure and are able to complete the lab experiment and get results.

Lab Larceny

Paragraph from Lab Larceny	Strand/practice	Why does it align?
Introduction to restriction sites of Restriction Fragment Length Polymorphisms and effects of mutation at the restriction site in terms of DNA fragment length.	LS3.B: Variation of Traits ♣In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)	Effects of mutations at restriction sites are examined when using Restriction Fragment Length Polymorphism to determine fragment length when examining DNA.
Examination of crime scene photos.	Practice 1 Grades 9-12: Ask questions that arise from careful observation of	Students examine crime scene photos and ask questions to determine what

	phenomena, or unexpected results, to clarify and/or seek additional information.	could have happened at the crime scene.
Analyzing the agarose gel to determine who the blood samples at the crime scene were from.	Practice 4 Grades 6-8: Analyze and interpret data to provide evidence for phenomena. Practice 6 Grades 6-8: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	Students analyze and interpret, with help if needed, the results from DNA fingerprinting to determine which person samples came from and provide evidence for that determination. Grades 6-8: Students determine who the suspect is by comparing it to crime scene samples using DNA fingerprinting.

	Practice 6 Grades 9-12: Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	Grades 9-12: Students determine who the suspect is by comparing it to crime scene samples using theories of DNA fingerprinting. DNA fingerprinting is used to support who else was in the room with the victim at the time of the incident.
Students work in groups to determine who the two blood samples came from and support it with evidence.	Practice 7 Grades 6-8: Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Practice 7 Grades 9-12: Construct, use, and/or present an oral and written argument	Grades 6-8: Students determine the source of the blood samples and support it with evidence from DNA fingerprinting when discussing it with classmates. Grades 9-12: Students determine the source of the blood samples and support it with evidence

	or counter-arguments based on data and evidence.	from DNA fingerprinting when discussing it with classmates.
Answering the questions.	WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. (HS-LS2-1), (HS-LS2-2), (HS-LS2-3)	Students explain results and draw conclusions based on the results. They explain the reasoning for certain aspects of the procedure.
Following the lab procedure	RST.6-8.3 (ELA: reading) Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6)	By properly reading the lab procedure, students are able to follow the lab procedure and are able to complete the lab experiment and get results.