Facilitating Motivation: Implementing Problem-Based Learning into the Science Classroom

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Facilitating motivation:

Implementing problem based learning into the science classroom

Danqing Li

Department of Education and Human Development: Adolescent Biology
Facilitating motivation: Implementing problem based learning into the science classroom

By: Danqing Li

APPROVED BY:

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Advisor                                                               Date

____________________                              _________
Director, Graduate Programs                               Date
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Introduction

Student motivation is an important precursor to learning, and therefore, is an important component in any successful science classroom. Studies have shown that the more students are engaged in the classroom, the better they will succeed. Several decades of research have shown that students’ engagement predicts their learning, grades, achievement, retention, and graduation (National Research Council, 2004).

One of the engagement strategies includes components to the Self-Determination Theory. According to the Self-Determination Theory, there are three factors that work together to motivate students: autonomy, competence, and relatedness. Autonomy refers to the degree of choice that students have about tasks and when and how to perform. Competence refers to students being able to grasp onto the material and effectively deal and take control of their learning. Students feel a sense of relatedness in the classroom when they feel a sense of attachment and importance to and amongst their peers (Deci & Ryan, 2008). There are many practices that teachers can embrace to promote autonomy, competence and relatedness in the classroom. One such strategy is Problem-Based Learning or PBL. PBL is an instructional approach in which students work in small collaborative groups where learning is driven by open-ended and authentic tasks that encourage students in engage in higher level thinking. PBL activities are a non-restrictive form of learning that allow students to solve real-world problems by applying their content knowledge in a team-based fashion (Mossuto, M., 2009).

Recent studies show that PBL confer a higher level of student engagement. One study found that the implementation of a PBL model had a significant impact on student attitudes towards science and perceptions of their learning environment. According to the study, students agreed that science would interest them more if they could choose science concepts or problems that were relevant to them; if they had more control of their learning; and that they enjoyed learning science when working in a group with peers. In addition, there was a positive impact of PBL on student problem-solving
skills (Ferreira, 2012). Another study revealed that students prefer PBL models over traditional models of teaching. Results also revealed that students appreciated the opportunity to improve their facilitation and teamwork skills as well as responsibility of their own learning (Nicholl, 2012). These studies suggest that PBL models provide a multitude of benefits to students which heighten their interests in science and sharpen many essential life skills.

PBL in the science classroom is an excellent practice for teachers to promote all three factors of the Self-Determination Theory in an effort to increase student motivation for success. PBL activities provide students with the autonomy to strategize with their peers to come up with solutions to real-world problems. PBL models require students to draw on their content knowledge to effectively arrive at solutions to open-ended questions. Teachers should take the opportunity to implement PBL models in their classroom to facilitate student engagement and higher student achievement.

Review of Literature

*Self-Determination Theory: What is SDT?*

The Self-Determination Theory is a motivational theory that is rooted in the idea of intrinsic motivation which integrates multiple personal and social factors that shape and encourage student engagement. According to the theory, people are intrinsically motivated when they are self-determined. Teachers can either support or undermine student’s fundamental needs that shape the Self-Determination Theory. Students need to feel a sense of relatedness in the classroom, like they are welcome and belong. Students also need to feel a sense of competence in the content and environment. Lastly, students need to experience a sense of autonomy or self-directed learning in the classroom. Teachers who promote all three factors in their teaching encourage students to stay motivated in the classroom (Connell & Wellborn, 1991; Deci & Ryan, 1985, 2000).
**Self-Determination Theory: Autonomy**

According to the Self-Determination Theory, students are intrinsically motivated when they are self-determined. When students develop a sense of control they see themselves as initiators of their own learning. Autonomy refers to the degree of choice students have about tasks and when and how to perform them (Pintrich & Schunk, 1996). Teachers in autonomy-supportive classrooms encourage students to solve problems in their own ways, persuade students to ask questions, and provide students’ with choices on assignments that cater to individual learning interests. In an autonomy-supported classroom students are encouraged to develop independent thought and facilitate an understanding that there are multiple ways to solve a problem (Valas & Solvik, 1993).

Classroom practices that encourage autonomy are guided by student interest and this, in turn, promotes a sense of ownership. Feelings of self-determination are strengthened when there is support for selecting and planning activities. Teachers can provide opportunities for student control by providing choice-making opportunities in the planning and delivery process. By giving voice to the wishes, concerns, problems of students, students will feel more respected, and in turn, feel more invested in their education (Vansteenkiste et. al. 2012).

**Self-Determination Theory: Competence**

The Self-Determination Theory also posits that students are more motivated when their needs for competence are met. The need to feel competent refers to perceived opportunities for having influence in a given situation, feeling effective and having a sense of confidence (Deci & Ryan, 2002). Students are more likely to engage in learning if they feel they have a firm grasp of the material and that they play a valuable role in the classroom.

Teachers can encourage competence in the classroom by making sure that learning activities are well matched to the level of the student’s knowledge and skills. The tasks should be challenging
enough to extend learning, but not so difficult to cause frustration or confuse the student (Brophy, 2004). It is the teacher’s responsibility to differentiate tasks in a manner that promotes a sense of competency in students. Teacher instructions should be thorough and explicit and students should be provided the rationale for the expectations they are held up to. Educators should strive to provide effective and immediate feedback in regards to student performance.

Self-Determination Theory: Relatedness

The final component of the Self-Determination Theory is relatedness which refers to a sense of belonging and attachment in the classroom. Forming and maintaining healthy relationships in the classroom contributes to student’s sense of relatedness. A classroom that promotes a sense of relatedness is one with a positive climate for collaboration (Moos, 2011). In addition, tasks that “hook” student interest also promote a sense of relatedness among peers and the content itself.

Classroom practices that facilitate relatedness among students include group activities that require students to work collaboratively. Each student in the group should acknowledge the importance of his or her role in the team. Students should feel as though they are an active, contributing member in their groups. Students must adopt the notion that the group must work together as a team in order to achieve the desired outcome (Doering, 2006). Based on these finding, teachers should be encouraged to devise learning tasks that require students to work collaboratively in an effort to achieve the objectives. Topics that teachers chose should center around student interests that they may be able to relate or connect to. Under these circumstances, students are able to feel a connection with their peers and their learning.

What is Problem Based Learning (PBL)?
Problem-based learning (PBL) originated in medical schools in the late 1960’s from the realization that traditional methods of instruction i.e. lecture and memorization had a limited effect on medical students’ academic performance (Barrows, 1996). According to Rhem, 1998 PBL is an instructional strategy in which students confront contextualized, ill-structured problems and strive to find meaningful solutions. As the name suggests PBL is a “problem” that is presented to a group of students that requires them to connect personal experiences, previous content knowledge and critical thinking skills in order to arrive at a solution (Mossuto, 2009). Unlike traditional forms of instruction, PBL students learn the concepts and principals outlined through the process of solving the problem (Norman & Schmidt, 2000). This method mirrors how problems are solved in the real-world. It requires a shift from teacher-centered pedagogy to student-centered learning. PBL requires students to embrace higher levels of thinking by applying their knowledge in order to solve an authentic problem in a collaborative fashion (Ferreira, 2012). According to Torp and Sage (2002), there are three main characteristics of PBLS

1. Engages students as stakeholders in a problem situation.
2. Organizes curriculum around a given holistic problem, enabling student learning in relevant and connected ways.
3. Creates a learning environment in which teachers coach student thinking and guide student inquiry, facilitating deeper levels of thinking.

**PBL – Relatedness**

Problem-based learning models, often times, require students to work collaboratively and closely in a group setting. Students typically devise a plan for gathering more information, then they do the necessary research, and then later reconvene to share and summarize their knowledge as a group. Although a portion of the PBL is conducted individually, the full benefits of PBL cannot be reached in isolation.
Research shows that students who work together in the solution of a problem develop better interpersonal skills. Schmidt et. al (2009) found that medical students who participated in problem-based learning performed much better in areas related to interpersonal skills, possessed better medical social skills, and were less likely to drop out of medical school than a comparable group who received a more traditional form of learning. Another study conducted by Nicholl in 2012 revealed that pharmacy students appreciated the opportunity to improve their facilitation and teamwork skills as well as responsibility of their own learning after undergoing a PBL model. According to the class surveys, 92% of the students either agreed or were satisfied with the format of the class and the instructional methods associated with the PBL model (Nicholl, 2012). A third study conducted by Ferreira in 2012 showed similar results. According to the analysis of the responses to items on the pre and post surveys administered before and after the PBL model, a greater number of students agreed that science would interest them more if they could choose science concepts or problems that were relevant to them and that they enjoyed learning science when working in a group with their peers. These results support the notion that PBL models create an atmosphere that encourages student relatedness to their group members and the content.

PBL-Autonomy

The problems presented to students in PBL models are complex and require students to work collaboratively where they must pool their expertise and experience in order to find a solution. The teacher’s only role is that of a facilitator who guides students’ reflection on their problem-solving experiences, require them to justify their approach, and help them articulate the concepts and skills they are learning. All of the planning, designing and implementing are left up to the students to decide. Students are granted the autonomy to decide how they want to go about solving these complex problems (Kolodner et. al., 2009). In a PBL model, students work as a group to share and document
their hypothesis and ideas pertaining to the problem that is presented. After considering the case with their existing knowledge, students divide up their learning issues they generated among the group and then investigate them. They then reconvene at the end to discuss and reflect on what they learned from the investigation to move further forward in their solutions. At this point in time, students may reconsider their hypotheses, generate new hypotheses, and generate new learning issues in light of their new knowledge.

Teachers utilizing PBL models not only encourage students to solve problems in their own ways and provide students’ with choices on assignments that cater to individual learning interests, they also encourage autonomy on how the students chose to share and present their solutions. Some of the ways students may chose to present their findings include charts, websites, PowerPoints, maps, videos, etc. The multitude of delivery options encourage students to present their research in a way that makes sense to them and provides students with a sense of ownership.

PBL- Competence

A well-designed PBL model enhances student comprehension of new content material, as well as develops higher level thinking skills. PBL help students develop deeper analytical skills. Analytical skills such as critical thinking and problem solving are essential skills in the real-world. Students start to develop skills such as research techniques, data analysis and working collaboratively with others (Gentry, 2000). In a study conducted by Wong & Day in 2009 high school science students were divided into two sections. One section was taught via the PBL method, while the other half, lecture-based learning method. Both sections were taught the same content material. The same pre and post tests which consisted of multiple choice and short structured response questions were used to assess the student’s academic performance for both sections. The results of the test revealed that the PBL group showed a significant improvement in student comprehension and the application of knowledge
over an extended period of time as opposed to the LBL group. According to the study, Students who participated in a PBL model acquired longer-term effects on the learning outcomes. PBL students performed significantly better than LBL students in nearly all categories of questions on the post-test and delayed post-test (Wong & Day, 2009). A study conducted by Ferreira, 2012 showed similar results. According to the analysis of the responses to items on the pre and post surveys, after the use of the PBL, a greater number of students agreed that they used science often, that science helped a person think logically, and that science taught them how to think. A greater number of students also agreed that science would interest them more if they could choose science concepts or problems that were relevant to them (Ferreira, 2012). In a third study, PBL instruction was found to have a positive impact on students’ epistemological beliefs in content area and by extension, an understanding of science. Epistemological beliefs are expert level ideas regard how science works. In a recent study in 2010 Freshmen engineering students in Turkey were administered two assessments—multiple choice used to measure understanding of content. A survey was also designed to measure to epistemological beliefs. Both forms of assessment were used in a pre/post format to allow researchers to compare the student’s performance and thoughts before and after PBL instruction. According to the researchers, the PBL model helped the engineering students improve their epistemological and conceptual understanding of science (Sahin, 2010). A fourth study conducted by Yeung at al. in 2003 found that students who received the PBL model claimed that it helped them develop self-directed learning skills and increased their interest in the subject matter. A fifth study revealed that students who participated in problem-based learning felt that it helped them become independent learning and the students reported a greater sense of personal growth, subject matter knowledge, and enjoyment of learning (Heppert, et al. 2001). These results lead researchers to believe that overall, students who partake in the PBL style learning, feel more competent as whole when compared to students that partake in more traditional forms of learning.
Considerations for Implementing Problem-Based Learning Models

The first step in designing an effective PBL lesson involves identifying the standards or objectives needed to be met by the students. By first selecting the outcomes, teachers can then selectively choose or design an appropriate PBL model that helps students reach their academic goals. These objectives should be conveyed explicitly to the students before they begin the activity. Students should also be presented with appropriate and concise rubrics on which they will be graded on so the expectations are clear.

Next, the teacher must select or design an appropriate PBL model. There are a multitude of sources that teachers can use to develop a PBL model. Teachers should implement topics that are current. For example, centering a PBL on the latest discoveries and innovations in cell therapy would provide students with a real-world application of their learning. Torp & Sage (2002) recommend scanning local newspapers and speaking with community members and colleagues about topics that could be centered on a PBL.

When choosing or designing a PBL, teachers should keep in mind that PBL models should allow for a variety of different perspectives. Choosing a controversial topic such as stem cell research might be interesting because students have the freedom to choose a perspective that interests them. This allows students to develop their own personal investment in finding a solution. Educators should also look for problems that provide a multiple ways in which the material can be displayed or presented in order to promote creativity.

Teachers need to keep in mind matching learning objectives, conveying concise expectations, and finding relevant and interesting topics, as well as flexibility in the presentation as major components in the design and implementation of PBL models.
General Narrative

Student motivation is an important component to academic success. According to the Self-Determination Theory, there are three factors that work together to motivate students: autonomy, competence, and relatedness. Autonomy refers to the degree of ownership that students possess over their learning. Competence refers to students being able to master concepts and ideas in the classroom. Relatedness refers to how well students connect with the learning materials, as well as their peers. There are many educational learning models that promote the factors instilled by the Self-Determination Theory. One such educational strategy is Problem-Based Learning or PBL. Problem-Based Learning is an instructional practice in which students work in small collaborative groups where learning is driven by open-ended, authentic tasks that promote higher level thinking.

Research reveals that there is a correlation between the implementation of Problem-Based Learning and a higher level of student engagement. A Problem-Based Learning module poses an authentic problem or dilemma to a group of students who have to work collaboratively to arrive at a solution. Students must pool together personal experiences, previous content knowledge and utilize their critical thinking skills in order to achieve the objectives outlined in each Problem-Based Learning module. Since Problem-Based Learning modules center on the idea of a student-centered learning environment, teachers provide minimal amount of instruction so that students receive a greater degree of autonomy over problem-solving approaches and strategies.

To this end, this capstone project attempts to provide high school biology teachers with an array of Problem-Based Learning modules that cater to the New York State Living Environment curriculum. Each module contains a detailed description and rationale, along with the specific New York State standard(s) that are addressed. In addition, common misconceptions that arise from the particular content are mentioned, as well as any helpful recommendations for each module. Materials are listed for each project, along with any supplemental worksheets and articles. Each module attempts
to promote the ideas behind the Self-Determination Theory by granting students a large degree of autonomy, requiring students to utilize prior or recently acquired content knowledge, and finally, encouraging collaborative teamwork. By promoting these components, students should feel a heightened sense of connection to their learning. These specific Problem-Based Learning modules were selected and/or designed with the notion that biology teachers can implement these projects in their classroom in an effort to facilitate student engagement, and in turn, higher student achievement.

**PBL #1- Genetic Technology Project**

This PBL module allows students to learn about genetic technologies in an inquiry based station’s activity. They will then organize their knowledge in order to complete an individual project that highlights what they’ve learned.

<table>
<thead>
<tr>
<th>Title:</th>
<th>Genetic Technology Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Genetics</td>
</tr>
<tr>
<td>Source/website:</td>
<td>Shared document from a teacher</td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
<tr>
<td>NYS Standard:</td>
<td>Performance Indicator 2.2 Students explain how technology of genetic engineering allows humans to alter genetic make-up of organisms.</td>
</tr>
</tbody>
</table>

**Summary:**

For this activity students will create a project that will help the Senate Committee on Science Funding determine how to divide up their budget. Each group will complete research using the resources and supplies provided in class to help them learn about 6 different genetic technologies. Each genetic technology will be presented in a station format where students have to interact with the artifacts provided at each station. Students will take notes and keep a journal that details their findings. Students will have approximately 30 minutes to at each station. This will be submitted in a binder format for a grade.

- At the end of the unit, each student will submit their findings as an individual in a project template of his or her choosing.
- The binder and individual project components will be assessed using the rubrics provided in the student packet.

- Excerpt taken from the Letter of Introduction:

"Dear US Biotech Researchers,

…As you know the Senate Committee on Science Funding is meeting in May to discuss the distribution of the National Science Budget. You can imagine what a daunting task this is for the members of the Senate, many of which are not familiar with current science research in the genetic field. Many special interest groups have already approached us to ask to increase their funding. We know that you and the members of your lab are considered experts in the genetic field and we are asking for your input to help us make important budget decisions. We are asking
you to help us to understand each of these areas so that we are able to decide what percentage of the budget if any should be spent in each of them.”

**Rationale:**

Genetics is a major part of the Living Environment curriculum. Genetics can be a challenging unit for students since many of the concepts are hard to conceptualize. This PBL helps students by:
- encouraging students to work collaboratively with other students in drawing out important information for each genetic technology using inquiry-based learning methods
- showing students the 21st century real world implications of genetic technologies
- granting autonomy to students in the presentation of their comprehension of the material

**Materials:**

*see attached

- Letter of Introduction from Martin VanVleet Senate Committee on Science Funding
- Genetics Technology Student Packet
  - Project Overview
  - Genetic Technology Note Sheets
  - Genetic Technology Journal Entries
  - Resources Sheet
  - Genetic Technology Summary Binder Rubric (assessment)
  - Genetic Technology Individual Project Rubric (assessment)

**Possible Misconceptions:**

- Students may be limited to the information for each genetic technology due to a broad spectrum of student research skills and a limitation on the number of updated resources provided by the teacher. In addition, there is the possibility of misinformation since the individual projects are based on student accounts and summaries of the research materials provided.

  - A study conducted by Shaw et. al. 2008 revealed that the single greatest number of misconceptions identified from a pool of high school students fell into the category of “genetic technologies.” In the analysis of student essays, researchers found that when answering the question “If you were a genetics researcher, what would you study and why?” students often expressed their goal of curing multiple unrelated diseases.

    - “The reality is that most genetics researchers are often several steps removed from work on specific cures but instead devote their efforts to improving the molecular understanding of disease with the ultimate goal of improved treatments” (Shaw, et. al. 2008).

  - Another misconception revealed that student essays suggested that genetic engineering allows us to put a gene from any species into another species to have that trait expressed in exactly the same manner as in the original species.

    - “Students do not understand the complexity of biotechnology and genetic engineering. They make broad leaps without demonstrating an
understanding for the multiple genetic and epigenetic (or environmental) factors that play a role in genetic regulation and manipulation of genetic materials in the laboratory setting” (Shaw et al., 2008).

-This problem-based learning module is a great way to dispel common misconceptions in the category of genetic technologies. Students are able to do so by manipulating the artifacts (i.e. reading articles, watching videos) and discussing each genetic technology with their group members.

### Recommendations:

The activity is best implemented when students work in groups of a minimum of 3 students to a maximum of 5 students. Depending on the length of the periods, this problem based learning module should take anywhere from a week to two weeks to complete. The PBL model includes rubrics and supplemental worksheets to help direct and guide the students. Students are required to submit all supplemental worksheets, science journals, and individual project pieces.

### Resources:

- Misconceptions-

---

Mr. <Student Name>
Senate Committee on Science Funding
160 Pennsylvania Avenue
Washington, DC 17495-3420

US Biotech
425 Langstrom Lane
Washington, DC 32598-1923

Dear US Biotech Researchers,

I am writing this letter to you and your colleagues at US Biotech to ask for your help. As you know the Senate Committee on Science Funding is meeting in May to discuss the distribution of the National Science Budget. You can imagine what a daunting task this is for the members of the Senate, many of which are not familiar with current science research in the genetic field. Many special interest groups have already approached us to ask to increase their funding. We know that you and the members of your lab are considered experts in the genetic field and we are asking for your input to help us make important budget decisions.

Currently special interest groups are asking for funding in the following areas:

- Genetic Engineered Foods
- Curing Genetic Diseases
- Genetic Screening
- Cloning
- Stem Cell Research
- Gel electrophoresis (Forensics and Paternity testing)

We are asking you to help us to understand each of these areas so that we are able to decide what percentage of the budget if any should be spent in each of them. We will be enlisting the services of 5 different area labs, asking each for a project to be presented to a Senate sub-committee by April 18th. After all labs have presented the sub-committee will convene to determine how to best spend the budget we were given.

Thank you in advance for your help. We expect your participation to be a learning experience for both your lab and the Senate sub-committee.

Sincerely,

Martin VanVleet
Senate Committee on Science Funding
Genetic Technology Project: Project Overview

The Senate Committee on Science Funding is in a dilemma! Only a certain amount of money is allotted for genetic technology research in the following six categories:

- Genetic Engineered Foods
- Curing Genetic Diseases
- Genetic Screening
- Cloning
- Stem Cell Research
- Gel electrophoresis (Forensics and Paternity testing)

These six different types of genetic technology hold a lot of potential for improving the quality of life for future generations. For this activity you will create a project that will help the Senate Committee on Science Funding determine how to divide up their budget. Each group will complete research as well as lessons in class to help them lean about 6 different genetic technologies. At the end of the unit each student will submit their findings as an individual in the form of a project (see below) to be assessed using the rubrics provided in this packet.

Project Requirements: The following things will be turned in and graded at the end of the unit. The grading rubrics have been provided to you at the end of your genetics packet.

- **Genetics Packet (group work)**
  - Note sheets for each of the genetic technologies
  - Journal entries for each genetic technology category
  - A list of additional resources that your group used

- **Genetic Technology Individual Project (individual work)**

The individual project will be completed using the research compiled by your learning team. This is basically an individual piece that summarizes the findings you and your group discussed during the stations activities and journal reflections.

**Individual Projects should include:**

- A description of each genetic technology *(including pictures)*
- The current or future uses of each genetic technology
- Pros and Cons of each genetic technology

**Project Modes include:**

- Brochure
- Poster board
- Tri-fold demo board
- PowerPoint
- Written Letter or essay
- Book

**Genetic Technology Note Sheets**

Directions: For each genetic technology category, record notes, sketches and examples after manipulating with the artifacts (i.e. magazine articles, websites, laboratory equipment) at each station. You will have 30 minutes to interact with the materials at each genetic technology station. Find and record at least five facts* and create two sketches* for each category.

*VERY IMPORTANT= Your five facts and two sketches have to somehow persuade the Committee to either channel funds into the genetic technology OR hold back their funds. If there are mixed pros and cons then you and your group members must weigh the benefits and deficits accordingly.

Example: Genetic Engineering
Genetic Technology Journal Entries

Directions: At the completion of each station, write down a minimum of three sentences that summarizes each genetic technology category. In your summary you must describe the pros and cons for each genetic technology category and the overall general consensus of its importance to improving the quality of life.

Example:

Date:_____ Stem Cells
_______________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________

As the last leg of this assignment, your team must rank the six different categories of genetic technologies starting from the most important to the least important in improving the quality of life and writing a brief explanation backing up your claim. This will help the Committee allocate their funds. Remember to use your journal entries to help you make this decision.

Example:

#1 is ____________ because
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________

Genetic Technology Summary Binder Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>All necessary information is presented for all genetic technologies. *Students show a complete understanding and are able to discuss at length the genetic tech, its pros and cons, and uses of each</td>
<td>Almost all of the necessary information is presented for all of the genetic technologies. *Students are able to discuss the pros, cons, and uses of most of the genetic technologies at length</td>
<td>Most of the necessary information is presented for all of the genetic technologies *Students show a surface level understanding of the genetic technologies investigated</td>
<td>Some of the necessary information is presented for all of the genetic technologies</td>
<td>Honestly… did you even go to the library during class? *missing 1 or more tech or lack of information on multiple</td>
</tr>
<tr>
<td>Accuracy</td>
<td>All information presented is accurate.</td>
<td>Almost all of the information presented is accurate</td>
<td>Most of the information presented is accurate</td>
<td>Some of the information presented is accurate</td>
<td>Did you do any research?</td>
</tr>
<tr>
<td>Mode of presentation</td>
<td>Project is neat, organized, and easy to read. *Project shows time in and out of class was well spent. *Student goes above and beyond the project requirements</td>
<td>Project is neat, organized, and easy to read. *Project shows time in and out of class was well spent. *Student meets all of the project requirements</td>
<td>Project is somewhat disorganized or difficult to read. *Student has met most of the project requirements.</td>
<td>Project is fairly messy and hard to read. *Student met some of the project requirements</td>
<td>Project…. What project?</td>
</tr>
</tbody>
</table>
PBL#2- What Happened to My Nighttime Melodies?

This PBL module allows students to explore ecological impacts by reading a case study and conducting an owl pellet dissection. Students will gather information from both assignments to answer the critical questions.

Title: What Happened to My Nighttime Melodies?
Unit: Ecology
Source/website: http://sciencesupport.net/pblowl.htm
Course: Living Environment
NYS Standard: Performance Indicator 1.1 Students explain how diversity of populations within ecosystems relate to stability of ecosystems

Summary:
For this activity students will read a short story entitled “What Happened to My Nighttime Melodies?” They will then fill out a facts and questions worksheet. Next, each student will be put into a cooperative learning group with three other students. Each person in the group will be assigned one of the following roles: recorder, director, timekeeper, or secretary (see description sheet). Together as a team the students will brainstorm the facts and questions sheet on poster paper.

- Keeping the ideas discussed in mind, the groups will then conduct an owl pellet dissection. Each group will collect data from their owl pellet found in the region and record it in a data table. Each team will then construct a food web from pictures which are provided. From this activity the groups will determine how the loss of owls, as a result of hurricanes, affects humans and other organisms.

Rationale:
Ecology is a major unit from the Living Environment curriculum. This PBL helps students by:
- encouraging students to work in cooperative learning groups with assigned roles, using inquiry-based learning methods. Students will create their own set of “questions” based on the reading after organizing the facts. They then have the opportunity to share their thoughts with their group members and discuss possible solutions to the problem.

- showing students the 21st century real world examples ecological shifts/impacts in a community as a result of natural disturbances. This story was created based on a documentation of a real-life occurrence that took place in the region.

- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension in order to derive the facts. It also allows students to practice critical writing skills in the lab analysis section of this problem-based learning module.

Materials:
*see attached
- “What Happened to My Nighttime Melodies?” –short story
- “Facts and Questions Sheet”
- “Cooperative Learning Group: What is My Role?”
- Owl Dissection Lab

Possible There is the possibility of misinformation since the conclusions are drawn from
### Misconceptions:

Student observations of the owl pellets during the dissection. A student may “miss” an important key observation, which can potentially lead them to draw an incorrect conclusion about the food web system.

Below are some common misconceptions that pertain to the topic addressed in this problem-based learning module:

- Varying the population size of a species may not affect an ecosystem, because some organisms are not important (Munson 1991).
- Populations exist in states of either constant growth or decline depending on their position in a food chain (Munson 1991).
- More herbivores than carnivores because people keep and breed herbivores (Leach et. al. 1996).
- Communities change little over time (D’Avanzo 2003).
- In a food web, a change in size in one population will only affect another population if the two populations are directly related as predator and prey (Gallegos et al. 1994).

### Recommendations:

The activity is best implemented over the course of two consecutive lab periods. Students should be put into groups of four. The facilitator can assign the roles for the cooperative learning groups ahead of time to ensure special needs are met, i.e. avoid assigning the recorder role to a student who struggles in writing. Students are required to submit their facts and question sheets, group poster, and owl pellet dissection lab.

### Resources:

- Cooperative Learning Groups- [http://sciencesupport.net/pblmadcoople.pdf](http://sciencesupport.net/pblmadcoople.pdf)
- Misconceptions- [http://ecomisconceptions.binghamton.edu/adaptation.htm](http://ecomisconceptions.binghamton.edu/adaptation.htm)

### What Happened to My Nighttime Melodies?

What a week it's been. First there was panic as the stories poured in about the coming hurricane. Dad kept saying, “I think that we should stay. We've had so many false alarms and our house is constructed of cement block, anyway.” Mom disagreed vehemently. “Safety first, we need to think of the kids,” she said. We proceeded to frantically board windows, pack things and put them away in preparation for the storm. Although I've lived in southern Florida all my life, it never gets any easier when hurricane season comes. We were off to my Grandparents home in northern Florida to wait out the storm.

The hurricane swept through our town but we were lucky this time. There was very little damage to our home, considering how high the winds were that blew through the area. However, something is now different. I can't really put my finger on it yet. Is it just the calm after the storm? It's almost an eerie silence. What's missing?

I know what it is! It's the sounds of the owls from the nearby sugar cane fields. Did the storm blow the owls away? Why aren't they lulling me to sleep with their calming, serene, whoo…whooo…
<table>
<thead>
<tr>
<th>FACTS</th>
<th>QUESTIONS</th>
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Cooperative Learning Groups: What is my Role?

Example:

What is my job as Secretary?

- Record notes from posters
- Maintain accurate notes on group progress
- Participate in Brainstorming
How Did Hurricane Wilma Affect the Prey of Raptors (Southeastern Barn Owls)?

**Problem:** This may not only be a problem for owls but also for humans. Complete your owl pellet dissection and make a hypothesis as to why humans can be affected by the loss of the owl population.

The owl pellets that will be used in this lab originate from southeastern barn owls. This population of barn owls may have been affected by hurricane Wilma. Barn owls are found in fields and in places where they have easy access to rodents, which is their favorite prey. Barn owls consume their prey in small pieces and then regurgitate the parts that are not nutritious and cannot be digested. This is what makes up the owl pellets that you will be inspecting. They typically feed early in the evening. An owl will regurgitate approximately one pellet a day. The owl pellet is formed from undigested fur, feathers and bones. The bones and fur remain relatively intact for viewing after dissection.

The owl pellets that you will be dissecting in this lab have been sterilized. Fungi, carpet beetles and clothes moths are found in owl pellets. They feed on the feathers and the food in the pellet. Small black circles found in the pellets are feces from caterpillars. Cocoons made from fur often form on the outside of the owl pellet. In essence, the owl pellet provides food and shelter to other organisms.

**Materials**
- Southeastern Owl pellets
- Dissecting Needle/toothpicks & tweezers
- Riker Mount
- Bone Chart
- Labels

**Procedure**

1. Please take a digital photograph or make a drawing of your owl pellet in the box below:

![Image]

2. Complete the general information in the chart below. Measure the length, width and mass of your owl pellet. Observe to see if you find fur and feathers.

3. Use a sharp probe to pick apart the owl pellet layer by layer. Carefully pull out all bones for identification. Use the bone diagram to help you identify your bones and complete the chart. (HINT: You may use water to clean the remaining parts of the pellet)
### Owl Pellet Characteristics

<table>
<thead>
<tr>
<th>Owl Pellet Lab Group</th>
<th>Number of Bones</th>
<th>Length</th>
<th>Mass</th>
<th>Width</th>
<th>Fur?</th>
<th>Feathers?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>Average</td>
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</table>

4. Organize the bones into groups according to the attached chart. You will be provided with a Riker Mounting frame. Place labels in your frame in the same way they are provided on the sorting chart and place your bones in the correct place. Cover the Riker Mount and place the small nails back into the frame to hold the bones in place.

### Analysis

1. What do we know about the digestive system of an owl based upon the pellets?

2. Owl pellets not only can give us information about the diet of the owl, owl pellets also provide a habitat for other animals. What animals are found in the owl pellet?

3. Describe how the loss of the owl population during a hurricane might affect other populations of organisms and in turn cause problems for humans.

4. Use the pictures of the animals on the following page to construct a food web that includes the owl. Place these pictures on construction paper or poster board and draw arrows to indicate feeding relationships.
### PBL#3- Genetics

*For this PBL module students will build a DNA model using plastic pipes and connections, extract and analyze DNA, and complete a literacy activity on a science article.*

<table>
<thead>
<tr>
<th>Unit:</th>
<th>Genetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source/website:</td>
<td><a href="http://sciencesupport.net/genpblwhosdaddywhole.pdf">http://sciencesupport.net/genpblwhosdaddywhole.pdf</a></td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
<tr>
<td>NYS Standard:</td>
<td>Performance Indicator 2.1 Students explain how structure and replication of genetic material result in offspring that resemble their parents</td>
</tr>
</tbody>
</table>

**Summary:**

Students will begin this PBL by conducting a brain dump activity to brainstorm what they know about DNA. Each student will fill out a sheet that has three columns, “write/draw/describe” on DNA. The class will then conduct a class discussion and create a class chart. Each student will then be put into a group of four.

There are four main components to this lab:

**Part 1:** Each group will discover the structure and function of DNA by building a large scale DNA model using PVC pipe and connectors. The students will then manipulate the structure of DNA through the PBS DNA Explorer website and answer some follow-up questions.

After part one, the teacher will read a short story about a lady who was in an accident and ends up in a coma. Prior to her marriage she decided to become a surrogate mother. Shortly after being hospitalized, she is found to be pregnant. After the story is read, each student will write down facts and questions from the story. It is up to each group to determine who the father is. Each student will play the role of a genetic lab technician by extracting the DNA of one of the suspected individuals.

**Part 2:** Each team will extract DNA from the cheek cells of one of the individuals in the story through the use of calf thymus (simulated saliva sample). There will be follow-up questions after the procedure is completed.

**Part 3:** Students will then learn about the technical aspects of DNA analysis by reading a research article through the use of a literacy strategy. The article is broken down into five sections and each student is assigned a section. After students finish reading, they will take turns spinning the spinner at the table. They will then complete the chart using the word on which the spinner stopped. If a student gets a “free” space, he or she can pick any word from the spinner. After reading and completing the chart for each section, each student will share the information with the rest of the group. There will be follow-up questions for this section.

**Part 4:** Finally each team will complete a simulated gel electrophoresis using large poster paper and placing simulated DNA
samples on this paper. There will be follow-up questions for this section.

<table>
<thead>
<tr>
<th><strong>Rationale:</strong></th>
<th>Genetics is a major unit from the Living Environment curriculum. This PBL helps students by:</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>- encouraging students to work collaboratively using inquiry-based learning methods- Students are provided limited instructions on how to build a DNA molecule. They must use their background knowledge and the provided resources (i.e. website and supplemental worksheets) to help them construct an accurate model of DNA.</td>
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<tr>
<td></td>
<td>- showing students the 21st century real world examples of genetic engineering. The lab demonstrates how DNA is collected and analyzed in current labs across the world. Students are provided with samples and a back story that represents a real-life scenario.</td>
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<td>- providing students with a “hands-on” approach to learning. Students discover different genetic technologies by conducting simulated lab techniques that mimic many real-world lab procedures.</td>
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<tr>
<td></td>
<td>- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension skills and practice text analysis throughout the problem-based learning module, in particular, during the spinner activity.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Materials:</strong></th>
<th>-“ Brain Dump”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-Teacher preparation guides- “Part 1: Building DNA”</td>
</tr>
<tr>
<td></td>
<td>- “Part 2: DNA Extraction of Cheek Cell”</td>
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<tr>
<td></td>
<td>-“Part 3: Technical Background- DNA Analysis”</td>
</tr>
<tr>
<td></td>
<td>-“Part 4: Who’s the Daddy? A DNA Profiling Simulation”</td>
</tr>
<tr>
<td></td>
<td>-Student Worksheets</td>
</tr>
<tr>
<td></td>
<td>- “Part 1: Who’s the Daddy? Building DNA”</td>
</tr>
<tr>
<td></td>
<td>- “Part 2: PBL: Who is the Daddy? The DNA Sample and DNA Extraction”</td>
</tr>
<tr>
<td></td>
<td>-“Part 3: Who is the Daddy? DNA Analysis Spinner Activity”</td>
</tr>
<tr>
<td></td>
<td>-“Part 4: Who’s the Daddy? Simulated DNA Analysis”</td>
</tr>
</tbody>
</table>

| **Possible Misconceptions:** | In 2007 and 2008, the American of Society of Human Genetics education staff conducted a study on the understanding of genetic concepts among American high school students. The analysis of the data showed that there was a significant amount of genetic misconceptions. The misconception most frequently identified in the researcher’s analysis of the student essays was under the category of genetic technologies. Students showed incomplete understanding of the complexity of scientific research, including biotechnology and genetic engineering. |
Below is a figure that shows the prevalence of misconceptions by genetics topic. A total of 500 essays were chosen at random and were systematically reviewed for misconceptions. Frequently observed topics of misconceptions were identified and essays were cataloged on the basis of the type(s) of misconception(s) they revealed.

Genetic technology and patterns of inheritance are the top two categories where misconceptions fell. This problem-based learning module seeks to eradicate some of those common misconceptions by providing students with informative, accurate texts that they have to analyze with their peers, as well as giving students a hands-on approach that simulates how to extract and analyze genetic material in real-life.

**Recommendations:**
The activity is best implemented over the course of 4-6 consecutive days, (depending on the duration of the class period). Students work in groups of four. Students are required to submit all the worksheets associated with each part. Preparation for this PBL can be time consuming. It is recommended that the DNA model pieces and lab equipment be prepared ahead of time. The materials collected and assembled are re-useable from year to year.

**Resources:**
Helpful website- http://www.ashg.org

Helpful website-
http://www.genome.gov/Pages/Education/DNADay/NewsAndFeatures/ASHGStudyPressRelease.pdf


PBL#4- Understanding the Mysteries of the Great Salt Lake: Is There Something Fishy Going On?

For this PBL module students will use their knowledge acquired from the case study to conduct a shrimp lab where they must design their own experiment.

<table>
<thead>
<tr>
<th>Title:</th>
<th>Understanding the Mysteries of the Great Salt Lake: Is There Something Fishy Going On?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Environmental Science</td>
</tr>
<tr>
<td>Source/website:</td>
<td><a href="http://sciencesupport.net/livingenvbrineshrimpbl.pdf">http://sciencesupport.net/livingenvbrineshrimpbl.pdf</a></td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
<tr>
<td>NYS Standard:</td>
<td>Performance Indicator 7.2: Students explain the impact of technological development and growth in human populations on living and nonliving environments.</td>
</tr>
</tbody>
</table>

Summary:

For this problem-based learning module each student will read the article, “Is There Something Fishy Going On?” Each student will then record the facts and write down any questions he or she has. The class will then come together and share their thoughts and the teacher will compile all the ideas on giant poster paper. Each student will then be put into a group of four. Each team will conduct the first part of the lab where they count the number of shrimp that thrive in varying salt solutions. Each group will be given a set of lab materials and, as a team, the students must develop their own investigation using the scientific method design matrix provided. Each team’s job is to act as the scientific consultant to Salt Creek, Inc Work and find a way to test the cause of the increased productivity of brine shrimp.

Rationale:

Environmental science is a crucial unit from the Living Environment curriculum. This PBL helps students by:

- students to work collaboratively using inquiry-based learning methods. Students are encouraged to ask questions based on the
facts and back story that are provided. They must turn these questions into an investigation where they have to design and perform an experiment in order to find a solution to their problem. Students are provided with very little instruction on the experimental process.

- showing students the 21st century real world examples of how environmental impacts can cause changes in the population of organisms that thrive in that ecosystem. The case of the rising population of brine shrimp is based on the documentation of a real-life occurrence.

- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension and text analysis as they navigate through the story. The lab write-up encourages them to practice their writing skills as well.

**Materials:**
*see attached*

- “Understanding the mysteries of the Great Salt Lake: Is there something fishy going on?”
- “Facts and Questions Sheet”
- “Brine Shrimp Inquiry Lab”
- “Experimental Design Matrix”

**Possible Misconceptions:**

Possible misconceptions that pertain to the topic covered in this problem-based learning module:

- Density-dependent factors are biotic, and density-independent factors are a biotic (Lavoie, 1997).

- Populations increase until limits are reached, then they crash and go extinct (McComas, 2002).

- Some ecosystems are limitless resources and provide an opportunity for limitless growth of a population (Munson, 1991).

**Recommendations:**

The activity is best implemented over the course of 2-3 consecutive lab days, (depending on the duration of the class period). Students work best in groups of four. It is strongly encouraged that the facilitator performs an informal “teacher check” throughout the problem-based learning activity. This allows the teacher to make sure the groups stay on track with the activity. For example, the teacher should read over the experimental
procedures before the student groups sets off to conduct their experiment in an effort to prevent students from veering completely off topic. These check intervals give the facilitator an opportunity to provide helpful hints and offer guidance should the students miss the “big picture.”

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<thead>
<tr>
<th>Resources:</th>
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<tbody>
<tr>
<td>Misconceptions- <a href="http://ecomisconceptions.binghamton.edu/misconceptions.htm">http://ecomisconceptions.binghamton.edu/misconceptions.htm</a></td>
</tr>
</tbody>
</table>

Understanding the Mysteries of the Great Salt Lake: Is There Something Fishy Going On?

It was a warm summer day and the air was heavy. Gary had waited a long time for summer this year. The winter was long and very cold, one of our worst, according to reports of past years. He anxiously awaited the perfect time to collect his yearly tadpoles. Last year after attentively caring for the developing tadpoles for what seemed like an eternity, his brother Carl, carelessly and foolishly dumped them out of their tub of water. Down the driveway they rolled with the tiny waves of water. Their little tails flipped and flopped in an attempt to escape the hot pavement. All of his attempts to recover them failed.

This was the year he was determined to succeed in watching his catch of tadpoles develop to maturity. He would protect them from the viciousness of his brother by hiding them behind the bushes in the side yard. It would be very important to collect them on the right day, and to nurture them so they could develop successfully into young frogs. One more day, he thought, after checking the creek just before dinner. As he returned to the house his dad was pulling into the driveway.

Excited, Gary exclaimed, "Dad, I'm going to collect my polliwogs tomorrow! They are just about ready!"

Dad said, “Do you remember when you thought you were collecting dinosaur bones and it ended up being baskets full of horse bones that you put under the porch of the cottage?”

Gary said, “But Dad, this is different! These are real live tadpoles that are going to turn into real live frogs.”

Gary had mistaken horse bones for dinosaur bones, dug up a horse grave and hidden the bones under the lake cottage. Needless to say, his dad was less than enthusiastic about tadpoles.

Carl came around the corner and added, “Hey Gary, when are you going to go get those little guys out of the creek? I’m waiting!”

Gary replied, “You keep your paws off my tadpoles.”

Their dad continued to chew on his big green cigar and headed into the house, shaking his head saying, "You boys need to learn to get along. Now get ready for dinner. I'm anxious to see your mom and I'm hungry.”

Mom called from the door, “YooHoo! Come into the house for dinner.”

After school the next day, Gary ran home, changed into his jeans, and then headed back to the creek. As he stepped toward the gentle twist of water, something very viscous and black flowed over his white sneakers. His socks immediately soaked up the dark slippery fluid and his nice new school socks now appeared translucent as they clung to his leg underneath. The fluid was slippery and a strong odor emanated from the creek.

As Gary reached down to collect his precious tadpoles, to his dismay, only curved tails and rounded bodies floated to the top of the murky dark water.

“What happened to my tadpoles?” He shrieked.

He was outraged, disappointed and ready to seek justice at any cost. It was 1967, a prime time to act to protect the environment with a vengeance.
“Was this some sort of sabotage?,” he exclaimed.

Quickly, he glanced around the edges of the creek. More thick black fluid was floating slowly in the moving water. There was so much that it was impossible to see anything at the bottom of the creek bed. He was amazed at how much black fluid was floating past.

Gary decided to go down the street, door to door and recruit the neighbors in his mission to find out what was going on. Petitions were the most common form of civil action so Gary took a petition to Mr. Derdeck first.

Gary said, “Mr. Derdeck, do you realize that all of the tadpoles in the creek are dead?” Do you know that there is something strange floating in the creek?”

Mr. Derdeck replied, “Why no, Gary, but do you want me to sign something for you?”

Gary said, “Yes. Do you know where that fluid may have come from?”

Mr. Derdeck said, “No, but I’m sure it will be straightened out soon. Here, I’ll sign your paper. You have a nice day and stop by again.”

Gary's neighbors were friendly enough and their houses lined the creek. He was unsure that they would have the concerns that he did about the situation. After all, it seemed like most people were to busy to care about the health and safety of the tadpoles in the area. Gary thought about how alive those tadpoles were the day before he noticed the fluid. He thought about how very fragile their life really was and wondered how his neighbors whose homes lined the creek, might be affected by the oil as well. The businesses on the other side of the creek seemed to not care at all and often dumped papers, tires and cans over the bank. It was an unsightly mess.

Down stream from his house, the creek ran under a culvert that allowed it to pass under Main Street. Gary had to pass over a walking bridge to get to his favorite store in town, Petersons Drug Store. Petersons had a wide variety of sports cards and candy. The water below the bridge seemed to have a putrid odor and appeared different from the rest of the creek. He couldn’t help but stop and look, although the smell almost knocked him over. There was a blue and red film on top of the shallow water. Gary's mother always told him not to climb down in the culvert, but he could never figure that out. Drowning was not a possibility in such shallow water.

**PBL#5-The Case of the Two Sick Dogs**

*For this PBL module students will work collaboratively to determine what killed the two dogs using the information provided in the case study, a science article and a video news clip. Students will also conduct a literacy activity after reading the science article.*

<table>
<thead>
<tr>
<th>Title:</th>
<th>Moving to Gilbert, Nevada: The Case of the Two Sick Dogs</th>
</tr>
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<tbody>
<tr>
<td>Unit:</td>
<td>Cells and Evolution</td>
</tr>
<tr>
<td>Source/website:</td>
<td><a href="http://sciencesupport.net/cellskillbeeteacherinst.pdf">http://sciencesupport.net/cellskillbeeteacherinst.pdf</a></td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
<tr>
<td>NYS Standard:</td>
<td>Performance Indicator 3.1 Students explain mechanisms and patterns of evolution.</td>
</tr>
<tr>
<td>Summary:</td>
<td>This problem-based module will begin by a class discussion on cells and creating a KWL on the SmartBoard as a class. Each student will read the short story, “Moving to Gilbert, Nevada: The Case of the Two Sick Dogs.-Introduction” He or she will then write down two facts and two questions. Next, each student will be put into a team with three other group members. Each student will each be assigned a role including the following: Director, Secretary, Spokesperson, and Recorder. Each student will brainstorm facts and questions in his or her PBL groups on a large sheet of poster paper. Each student will then proceed to read the next</td>
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</table>
section of the story, “Sick Dogs: Part II.” Each student will write down two additional facts and two questions and then get back in his or her PBL groups and brainstorm additional facts together and write them on the poster paper. Together as a group the students will write down some predictions as to what they think might be happening to the dogs. Next, each group member will pick a vocabulary work from the Know, Heard of, Don’t know worksheet. The group will then watch the CNN Newscast, and then each group member will independently read the research article. Afterwards, the group will come back together to and share and discuss their word definitions. The group will revisit their predictions and together create a paragraph that states what exactly killed the dogs based on the facts discussed throughout the activity.

<table>
<thead>
<tr>
<th>Rationale:</th>
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<tr>
<td>Cells and evolution are important topics in the Living Environment curriculum. This PBL helps students by:</td>
</tr>
<tr>
<td>- encouraging students to work collaboratively using inquiry-based learning methods. Students are provided with a back story, a video news report, and a scientific article. They are asked to formulate a prediction of the outcome based on the facts provided with minimal instructional guidance. This encourages students to use critical thinking skills to piece together the mystery of the dead dogs.</td>
</tr>
<tr>
<td>- showing students a 21st century real world examples of how evolution and genetics can affect our lives. The case of the killer bees was an actual documented incident that took place. This activity helps students see the relevance of the content material in our everyday lives.</td>
</tr>
<tr>
<td>- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension, text analysis, and writing skills as they navigate through the problem-based learning module.</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Materials: *see attached</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Moving to Gilbert, Nevada: The Case of the Two Sick Dogs”</td>
</tr>
<tr>
<td>- <a href="http://sciencesupport.net/cellskillerbeesmovie.m4v">http://sciencesupport.net/cellskillerbeesmovie.m4v</a> (News Report Video)</td>
</tr>
<tr>
<td>- “The Killers are Coming! The Killers are Coming!”</td>
</tr>
<tr>
<td>- What Do You Know? What Have You Heard About? What Do You Not Know?”</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Possible Misconceptions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below are two misconceptions related to the topic covered by the</td>
</tr>
</tbody>
</table>

"Evolution has never been observed." Weinberg, J.R., V.R. Starczak, and D. Jorg, 1992, “Evidence for rapid speciation following a founder event in the laboratory.” *Evolution* 46: 1214-1220

This activity provides students with an authentic, real-life example of how evolution impacts us and dispels any misconceptions that evolution cannot be observed.

**Recommendations:**
The activity is best implemented over the course of 2-3 consecutive lab days, (depending on the duration of the class period). Students are encouraged to work in a group of four to ensure that each student plays a role in their respective cooperative learning groups.

**Resources:**
Mayr, Ernst. 1991. One Long Argument

<table>
<thead>
<tr>
<th>Vocabulary</th>
<th>Know</th>
<th>Heard Of</th>
<th>Don't Know</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Mitochondria</td>
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<tr>
<td>Energy (ATP)</td>
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<tr>
<td>Organelles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutritious</td>
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<tr>
<td>Dominant</td>
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</tr>
<tr>
<td>Commercial</td>
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</tr>
</tbody>
</table>

Name: _______________________  Date: ___________________________
PBL #6- The Galapagos

For this PBL module students will break off into groups to research the Galapagos Island phenomena. Each group will take on a different role in the community. Groups will reconvene and write a position paper together.

<table>
<thead>
<tr>
<th>Title:</th>
<th>The Galapagos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Evolution</td>
</tr>
</tbody>
</table>
| Source/website: | Nancy A. Schiller and Clyde Freeman Herreid  
                    University Libraries / National Center for Case Study Teaching in Science  
                    University at Buffalo |
| Course:       | Living Environment       |
| NYS Standard: | Performance Indicator 3.1 Students explain mechanisms and patterns of evolution. |

Summary:
For this problem-based learning module each group will analyze the geological origins of the Galapagos Islands, their colonization, species formation, and threats to their biodiversity in this story of a graduate student caught between local fishermen and government officials fighting for control of the islands’ natural resources. Each student will begin this activity by reading Part 1- In The Beginning. Afterwards, students will answer the study questions at the end of the section. Next, students will exchange and share their responses in their PBL teams. These steps are repeated for Part II-Darwin’s Finches, and Part III- The Tortoise and the Sea Cucumber. During the discussion period, each student will assume the role of a particular interest group vying for a piece of the action in the Galapagos. The interest groups include the following: fishermen, storeowners, tourists, scientists, Sierra Club members, and politicians in Ecuador. When students receive their roles, they will form a new PBL group that consists of students that are assigned the same interest group. These newly formed groups are essentially “experts” of this interest group. Each student’s task is to research the case from a particular perspective and talk over his or her position within their group and develop a position paper. Next, members of each interest group will split up to meet with people from other interest groups, i.e., the instructor will form new consensus-seeking groups, each of which will have one member from each of the interest groups present. So, a consensus group will have a fisherman, a storeowner, a tourist, scientist, Sierra Club representative, and politician. The politician’s job is to run a discussion to see if the group can come to some consensus on how to resolve the crisis. The group has to collectively write a position paper laying out the group’s plan.
**Rationale:** Evolution is an important topic in the Living Environment curriculum. This PBL helps students by:
- encouraging students to work collaboratively using inquiry-based learning methods. Students are asked to generate a stance on a particular interest’s groups’ position on the action being taken in the Galapagos based on a back story. They must be able to draw out the facts and consider how these facts can impact their interest group under the circumstances. Later, each consensus group must collectively arrive at an agreement as to how to resolve the crisis. This requires students to practice their listening, speaking and negotiating skills. Students must work together in order to write the paper(s).
- showing students a real world example of how evolution affects our lives. The back story of this problem-based learning module was created based on real-life events that took place at the Galapagos. This basis of the dilemma has been documented throughout many other parts of the world. Many modern day activists are stricken with this dilemma in real life. This gives students an opportunity to see how the concepts behind evolution can impact our modern day society.
- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension, text analysis, and writing skills in order to complete the PBL learning module.

**Materials:**
*see attached


**Possible Misconceptions:** Below are two misconceptions that pertain to the topic of evolution discussed by this problem-based learning module:


"Evolution has never been observed." Weinberg, J.R., V.R. Starczak, and D. Jorg, 1992, "Evidence for rapid speciation following a founder event in the laboratory." Evolution 46: 1214-1220

**Recommendations:** The activity is best implemented over the course of 4-5 consecutive lab days, (depending on the duration of the class period). Students work in groups of four in the first PBL assignment. They will then be put into a group of three to four (depending on the class size), when they reassemble
for the PBL interest and consensus seeking groups. Teachers are encouraged to carve out specific roles for each student in their respective groups. For example, the facilitator may want to assign a student the role of a director so that he or she can lead and guide the discussion in an orderly fashion. The teacher may also want to implement a group member rating assessment at the end of the activity to ensure that all students are held accountable to the work.

Resources:

Background Information-
http://www.discovergalapagos.com/tortoise.html

Background Information-
http://sciencecases.lib.buffalo.edu/cs/files/galapagos.pdf

Misconception- Mayr, Ernst. 1991. One Long Argument


---

**PBL #7- AIDS and the Duesberg Phenomenon**

*For this PBL module students will interact with a series of scientific texts on the cause of HIV. They must work collaboratively to analyze the major points made by Duesberg using the information they extracted from the articles.*

<table>
<thead>
<tr>
<th>Title:</th>
<th>AIDS and the Duesberg Phenomenon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Cell and Human Body System</td>
</tr>
<tr>
<td>Source/website:</td>
<td>Clyde Freeman Herreid University Libraries / National Center for Case Study Teaching in Science University at Buffalo</td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
<tr>
<td>NYS Standard:</td>
<td>Performance Indicator 5.2 Explain disease as a failure of homeostasis</td>
</tr>
</tbody>
</table>

5.2f Some viral diseases, such as AIDS, damage the immune system, leaving the body unable to deal with multiple infectious agents and cancerous cells.

| Summary: | For this problem-based learning module students must help determine whether or not Dr. Peter Duesberg’s position on AIDS is accurate. Duesberg is a renowned virologist that does not believe that HIV causes AIDS. Rather, he claims that AIDS is the result of recreational and anti-HIV drugs. To begin, each student will read two science papers, as well as the author’s respective rebuttals. Students will then get into groups of four to identify the issues and questions that are important in the papers. Each team will also look up any terms, concepts and information that they need |
to understand in order to resolve those issues. The class will have access to a variety of resources including textbook, journal articles, internet websites, and books.

The second part of this module involves interpreting three more science papers that discuss how HIV attacks the human body. Again, as a group, students will identify any terms and concepts that are foreign. Students may use the classroom resources to do so.

Each group is now experts on the topic of HIV. For the third part of this problem-based learning module, each group must evaluate the nine points made by Duesberg in his original article where he claimed that “HIV is not the cause of AIDS because it fails to meet the postulates of Koch and Henle, as well as six cardinal rules of virology.” Each team will write a brief summary of each of the nine points in light of the information you have collected.

| Rationale: | Cellular processes and the human body system are important topics covered in the Living Environment curriculum. This PBL helps students by:
|            | - encouraging students to work collaboratively using inquiry-based learning methods. Students are provided with science articles that represent two sides of a debate. They must work through the informative texts in order to reach a consensus on whether or not they agree with Dr. Duesberg’s perspective on HIV. Students are provided minimal directions on how to go about analyzing the texts.
|            | - showing students that science is not always set in stone. There are many controversial debates in the world of science. It is important for students to be able to arrive at their own conclusion after analyzing the facts.
|            | - incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension, text analysis, and writing skills in order to successfully complete the problem-based learning module. |

| Materials: | AIDS and the Duesberg Phenomenon |

| Possible Misconceptions: | Below are two misconceptions that pertain to the topic of HIV covered in |
this problem-based learning module:

- “An HIV-positive person who receives antiretroviral treatment will not spread the virus” (http://www.hpb.gov.sg/HOPPortal/health-article/6260)

*Antiretroviral therapy can reduce the amount of HIV in the body. However, HIV remains in the body and can be transmitted to others.

-“Transmission of HIV can occur via the sharing of a toothbrush, kissing and sharing food and utensils” (Choy et. al. 2013).

Recommendations: The problem-based module is best implemented over the course of 4-5 consecutive lab days, (depending on the duration of the class period). Students are recommended to work in groups no larger than four. This is to ensure that each student takes an active role in the research process. The facilitator should supply a variety of resources for students to use during the research component of this assignment. He or she should also make sure that the texts are appropriately chosen to meet the reading levels of the students. It is recommended that the teacher conduct a peer grading assessment at the end of the activity to ensure that each group member is held accountable to the work.

Resources: Background Information- http://www.hpb.gov.sg/HOPPortal/health-article/6260


PBL #8- Nature or Nurture? You Decide “The Hatfields and McCoys”

For this PBL module students will investigate the cause of an infamous family feud by interacting with the various artifacts provided. Students must work collaboratively within their groups to write a position paper supporting their claim.

<table>
<thead>
<tr>
<th>Title:</th>
<th>Nature or Nurture? You Decide “The Hatfields and McCoys”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Genetics</td>
</tr>
<tr>
<td>Source/website:</td>
<td><a href="http://sciencesupport.net/pblgen.htm">http://sciencesupport.net/pblgen.htm</a></td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
<tr>
<td>NYS Standard:</td>
<td>Performance Indicator 2.1 Students explain how structure and replication of genetic material result in offspring that resemble their parents.</td>
</tr>
<tr>
<td>Summary:</td>
<td>For this problem-based learning module students will read the article entitled, “Nature or Nurture? You Decide- The Hatfields and McCoys.” The story discusses the infamous family feud that took place between the</td>
</tr>
</tbody>
</table>
Hatfields and the McCoys which began in 1865 and lasted nearly one hundred years. After the reading, each student will watch a documentary about the Hatfields and McCoys. Next, students will read an article which suggests that the feud that brewed between these two families could have been a result of a genetic disease. The task for the students is to determine whether or not the Hatfield-McCoy feud was caused by nature (a genetic disease), or caused by nurture (the environment and extenuating circumstances). Once each student has taken his or her stance, he or she may find one or two (max) individuals that share the same stance. Each group will then write a position paper that discusses their opinions. In the group position paper, students must pick and describe one article from the opposing position and two from the group’s position. After reading the articles, team members must list four arguments that agree with their position and four arguments that disagree with their position. Finally, each group will use the information collected to write a position paper following the guidelines provided.

**Rationale:**

Genetics is an important topic covered in the Living Environment curriculum. This PBL helps students by:

- encouraging students to work collaboratively using inquiry-based learning methods. Students are provided with text resources that provide both sides of the debate. It is up to the student to rationalize their stance based on the facts that are presented to them. Students are provided with minimal guidance from the facilitator as to which stance is correct. Students must back up their position based on the facts drawn from the reading resources.

- showing students the controversial nature of science. There are many controversial debates in the world of science. It is important for students to be able to arrive at their own conclusion after analyzing the facts.

- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension, text analysis, and writing skills in order to successfully complete the problem-based learning module.

**Materials:**

- “Nature or Nurture? You Decide-The Hatfields and McCoys”
- Documentary about the Hatfields and McCoys
- Four agreements/disagreements worksheet
- Formal write-up worksheet
- “Mystery ‘rage’ disease blamed for infamous feud”
- “VonHippel-Lindau Disease (VHL) Information Page: National Institute of Neurological Disorders and Stroke”
| **Possible Misconceptions:** | Below are four common misconceptions that pertain to the topic covered in this problem-based learning module:

- “Your genes determine all of your characteristics, and cloned organisms are exact copies of the original” (Dougherty et. al., 2012)

- “One set of alleles is responsible for determining each trait, and there are only 2 different alleles (dominant and recessive) for each gene.” (Dougherty et. al., 2012)

- “Your genes determine all of your characteristics, and cloned organisms are exact copies of the original” (Dougherty et. al., 2012)

- “Only certain people have the ‘disease’ gene” (Dougherty et. al., 2012)

This activity dispels these common misconceptions, particularly the third one. While genes play a huge role in how an organism develops, environmental factors also play a role. The basis of this problem-based learning module is a good introductory lesson into the topic of epigenetic. Additionally, the fourth misconception is addressed since the articles address the fact that genetic diseases are caused by mutations of genes that all individuals have. In other words, there was no particular “rage” gene. |

| **Recommendations:** | The problem-based module is best implemented over the course of 2-3 consecutive lab days, (depending on the duration of the class period). Students are recommended to work in groups no larger than three. This is to ensure that each student takes an active role in the research process. The facilitator should supply a variety of resources for students to use during the research component of this assignment. He or she should also make sure that the texts are appropriately chosen to meet the reading levels of the students. It is recommended that the teacher conduct a peer grading assessment at the end of the activity to ensure that each group member is held accountable to the work. |

| **Resources:** | Background Information-http://www.nbcnews.com/id/17967965/

PBL #9-The Case of the Dividing Cell: Mitosis and Meiosis in the Cellular Court

*Students will work through a series of hands-on, kinesthetic and visual learning activities to learn about mitosis and meiosis in this PBL module.*

<table>
<thead>
<tr>
<th><strong>Title:</strong></th>
<th>The Case of the Dividing Cell: Mitosis and Meiosis in the Cellular Court</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit:</strong></td>
<td>Genetics: cellular function and division</td>
</tr>
<tr>
<td><strong>Source/website:</strong></td>
<td><a href="http://sciencesupport.net/pblgen.htm">http://sciencesupport.net/pblgen.htm</a></td>
</tr>
<tr>
<td><strong>Course:</strong></td>
<td>Living Environment</td>
</tr>
</tbody>
</table>
| **NYS Standard:** | Performance Indicator 1.2-Describe and explain the structures and functions of the human body at different organizational levels (e.g. systems, tissues, cells, organelles)  
Performance Indicator 2.1- Explain how the structure and replication of genetic material result in offspring that resemble their parents |
| **Summary:** | Students will begin this problem-based learning module by conducting a class read-out-loud of the story, “The Case of the Dividing Cell: Mitosis and Meiosis in the Cellular Court. Part 1- The First Day of Testimony.” The teacher will randomly assign roles to six students. After the read-out-loud, each student will complete the 3 Facts and 3 Questions worksheet individually. Next, the students will brainstorm their thoughts using poster paper in their assigned PBL groups. Next, the students will complete the sockosome mitosis activity and complete the worksheet that goes along with the activity. After the sockosome activity is conducted, the remainder of the script is read out loud. Students are to add to their facts and questions sheets and discuss them in their respective PBL groups. Next, the teacher will redistribute the role cards so a new group of students can read out loud, “The Case of the Dividing Cell: Mitosis and Meiosis in the cellular court.” |
Cellular Court Part II- Meiosis Exposed.” At the completion of the class reading, the students will break into their PBL groups and work together to sequence the meiosis cards in the correct order based on the information provided in the script. The teacher will conduct a teacher check after the groups are finished. Finally students will work individually to complete the Venn diagram at the end of the activity.

**Rationale:**
Cellular function and division are important topics covered in the Living Environment curriculum. This problem-based learning module helps students by:

- encouraging students to work collaboratively using inquiry-based learning methods. The students must draw information from the narrative in order to conduct the Sockosome Mitosis activity as well as determine the sequence of the meiosis cards. In order to do this, they must be able to share their facts and questions sheet amongst their group members and summarize their findings.

- providing them with a kinesthetic activity that demonstrates the abstract process that takes place in cells during cellular division. Cellular replication is a hard concept to teach to students because students can’t “see” the process unfold. The sockosome activity enables the students to simulate the process of mitosis in a hands-on approach.

- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension, text analysis, and writing skills in order to successfully complete the problem-based learning module. Students must compare and contrast the two cellular processes, which require higher level thinking.

**Materials:**
- “The Case of the Dividing Cell: Mitosis and Meiosis in Cellular Court: Part 1- The First Day of Testimony”
- Facts and Questions sheet
- Roles cards
- Sockosome Mitosis
- 4 pairs of socks for each group
- Yarn
- Sockosome-directions for assembly (for teachers)
- “The Case of the Dividing Cell: Mitosis and Meiosis in Cellular Court: Part II- Meiosis Exposed”
- Meiosis Cards
- Meiosis and Mitosis Venn Diagram

**Possible Misconceptions:**
Below are eight common misconceptions that pertain to the topic covered
in this problem-based learning module:

- “The X-shaped chromosomes are homologous pairs” (Clement, 1982)
- “Interphase is the resting phase of the cell cycle” (Clement, 1982)
- “During mitosis a parent divides into two identical daughter cells” (Fisher and Lipson, 1986)
- “Diploid cells are formed as a result of meiosis” (Fisher and Lipson, 1986)
- “DNA replication occurs during prophase” (Dikmenli, 2009)
- “Interphase is the resting phase of mitosis” (Dikmenli, 2009)
- “the chromosome number is doubled in prophase of mitosis and halved in anaphase of mitosis” (Dikmenli, 2009)
- “a chromosome always has two chromatids during cell division” (Dikmenli, 2009)

**Recommendations:**

The problem-based module is best implemented over the course of 4-5 consecutive lab days, (depending on the duration of the class period). Students are recommended to work in groups no larger than four. This is to ensure that each student takes an active role in activity. Teachers should prepare the materials and setup for the Sockosome Mitosis activity the day before. Facilitators should also copy and cut out each meiosis card set and place them in envelopes for each group prior to the activity. It is recommended that the teacher conduct a peer grading assessment at the end of the activity to ensure that each group member is held accountable to the work.

**Resources:**


PBL #10-No Baby?

In this PBL module students play the role of a doctor and analyze a series of artifacts to determine the cause of the young couple’s infertility. They will also extract text-based evidence from multiple sources to back their claim. Finally, students will create an informative poster about the condition.

<table>
<thead>
<tr>
<th>Title:</th>
<th>No Baby?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Human Body System: Anatomy and Physiology</td>
</tr>
<tr>
<td>Source/website:</td>
<td><a href="http://bioquest.org/lifelines/megan.html">http://bioquest.org/lifelines/megan.html</a></td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
<tr>
<td>NYS Standard:</td>
<td>Performance Indicator 5.2 Explain disease as a failure of homeostasis</td>
</tr>
</tbody>
</table>
| Summary:          | Students will begin this problem-based learning module by reading the case story on Joe and Mary Smith, a young couple who are having trouble conceiving a baby. The question students are trying to investigate is: what are the likely causes for infertility for this couple? Students will work together in their problem-based learning groups and generate a list of facts and questions they have about the case. Some questions include: “what is this case about?” “What are some important points that help to diagnose a patient?” “What questions would you like to ask the patient?” Next, Joe’s test results are passed out to each group. Joe’s tests include semen analysis, male hormone levels, and female hormone levels. Each group member will also exam slides of Joe’s sperm under a microscope. The “How to Conduct a Sperm Count” worksheet will help with this procedure. Each team will look over and discuss the data compiled from Joe’s doctor. This concludes day 1.

The following day, each group will work in the library and gather resources to help you solve the case. Students will have the whole class period to research certain diseases and conditions that might pertain to Joe’s condition.

On the third day each PBL team will be responsible for putting together an informative poster on Joe’s condition, how it affects fertility, other side effects, and ways to prevent it. For the poster, the teams must determine the target audience, (i.e. high school athletes, pharmacists, doctors). Students will be graded on the following categories: Aesthetics: will your poster catch the interest of your target audience? Scientific content: does your poster describe the science? And Clarity: Is your poster easy to read?

On the fourth day each group will get a chance to present their posters to the rest of the class. Each student will receive a research grade, a
presentation grade, and a peer review grade (from your other team members).

**Rationale:** The human body system is an important topic covered in the Living Environment curriculum. This problem-based learning module helps students by

- encouraging students to work collaboratively using inquiry-based learning methods. Students must draw information from the case story in order to come up with the right questions to investigate. They must work together to examine the lab results from Joe’s doctor in order to figure out what might be the culprit of his infertility. Very little instruction is provided to the students in terms of what condition Joe might be suffering from. They must share ideas and rely on the “clues” from the data provided in order to figure out Joe’s condition.

- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension and text analysis of the artifacts. Students are provided with lab data that mimics real-life test results obtained in a lab setting which they must analyze. Students must also pull information out of library resources that pertain to the case (text-to-text analysis).

- providing them with a hands-on approach to learning that mimics real-world laboratory procedures conducted by medical professionals. Students take on the role of a doctor as they examine the lab results from an individual (Joe). They also take on the role of a lab technician by using a microscope to examine sperm slides and practice the procedure of counting out sperm cells.

**Materials:**
- Case story
- Joe’s laboratory results
- Slides of Joe’s semen
- “Joe’s Semen Worksheet”
- A microscope
- “How to Conduct a Sperm Count” handout
- An array of medical textbooks, articles, websites

**Possible Misconceptions:** Below are four common misconceptions that pertain to the topic covered in this problem-based learning module:

The digestive system and the circulatory system are not connected (Buckley, 2000; Carvalho et al., 2004).

Nothing can pass through the walls of capillaries (AAAS Project 2061,
Capillaries are found only in the extremities, such as the hands and feet (AAAS Project 2061, n.d.).

Capillaries are found only in internal organs, such as the lungs and the intestines (AAAS Project 2061, n.d.).

**Recommendations**

The problem-based module is best implemented over the course of four consecutive days (periods ranging from 45-60 minutes). Students are recommended to work in groups no larger than four. This is to ensure that each student takes an active role in the activity. Since not a lot of instruction is given during the research aspect of this module, (Day 1 and 2), it is strongly encouraged for the facilitator to monitor and provide verbal feedback to each group as they conduct their research. It might also be a good idea for the teacher to spend some time prior to this activity to review the parts of a microscope and the proper way to use it. It is also recommended that the teacher conduct a peer grading assessment at the end of the activity to ensure that each group member is held accountable to the work. Teachers may also want to create a rubric for the poster assignment to ensure that students include all the necessary parts.

**Resources:**

- Background Information- http://www.pinelandpress.com/faq/hormonelevels.html#male
- Background Information- http://www.steroidsinfo.com/

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**Case Story: No Baby?**

Joe and Mary Smith had been trying to conceive a child for the last several years. In July they decided to see a reproductive physiology specialist after several years of doctor consultations. Dr. Martine proceeded to ask health history questions searching for potential problems.
From taking their health histories, Dr. Martine determined Mr. Smith had been a star athlete in high school, and had even been recruited heavily by universities until he had been diagnosed with severely high blood pressure, potential atherosclerosis and slightly elevated levels of low-density lipoproteins. Blood was taken from both individuals and a sperm sample was taken from Mr. Smith.

### Joe’s Laboratory Test Results:

These results are provided after students discuss the case:

The semen analysis results for Joe are as follows:

<table>
<thead>
<tr>
<th>Sperm Concentration ( Millions/ml)</th>
<th>~ 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sperm Count ( M/ejaculate)</td>
<td>~ 10</td>
</tr>
<tr>
<td>Motility (.5 - 2 hr after ejaculation)</td>
<td>&lt; 30</td>
</tr>
<tr>
<td>Vitality (% live)</td>
<td>45 %</td>
</tr>
</tbody>
</table>

The results for male hormone levels:

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Normal Values</th>
<th>Joe’s Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSH</td>
<td>1 18 mlU/ml</td>
<td>0.9 mlU/ml</td>
</tr>
<tr>
<td>LH</td>
<td>10 - 60 pg/ml</td>
<td>30 pg/ml</td>
</tr>
<tr>
<td>Prolactin</td>
<td>&lt; 20 ng/ml</td>
<td>25 ng/ml</td>
</tr>
<tr>
<td>Free Testosterone</td>
<td>.95 - 4.3 ng/dl</td>
<td>.98 ng/dl</td>
</tr>
<tr>
<td>Total Testosterone</td>
<td>270 - 1100 ng/dl</td>
<td>245 ng/dl</td>
</tr>
<tr>
<td>Progesterone</td>
<td>.3 - 1.2 ng/ml</td>
<td>.8 ng/ml</td>
</tr>
</tbody>
</table>

The results for female hormone levels:

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Normal Levels</th>
<th>Mary’s Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSH</td>
<td>.4 - 4 ulU/ml</td>
<td>2 ulU/ml</td>
</tr>
<tr>
<td>LH</td>
<td>&lt; 7 mlU/ml</td>
<td>3.5 mlU/ml</td>
</tr>
<tr>
<td>Prolactin</td>
<td>&lt; 24 ng/ml</td>
<td>30 ng/ml</td>
</tr>
<tr>
<td>Total Testosterone</td>
<td>6 - 86 ng/dl</td>
<td>30 ng/dl</td>
</tr>
<tr>
<td>Estradiol</td>
<td>100+ pg/ml</td>
<td>150 pg/ml</td>
</tr>
<tr>
<td>Progesterone</td>
<td>&lt; 1.5 ng/ml</td>
<td>1.0 ng/ml</td>
</tr>
</tbody>
</table>
Joe’s Semen Worksheet

1. How many sperm were on the first slide sample?______
2. How many sperm were on the second slide sample?______
3. Compare your answers to other students in your group. What are some reasons your answers may differ?______________________________________________________________________________________________________
____________________________________________________________________________________________________________
4. Sketch a picture of your slide sample (you pick!) Be sure to write down the magnification. Label the parts of one of the sperm.
magnification: _______

How to Conduct a Sperm Count:

Count all sperm heads with more than half the sperm head within the area indicated by a triple set of lines. For example, in this square, there are 29 sperm counted. The sperm with an * were not counted because these sperm were either more than half way outside of the counting area or were not on the top or right side of the large square.

PBL #11- What’s Wrong with Amadi?

*Students will investigate the cause of Amandi’s condition by exploring a series of resources including the case study, websites, medical books, and science articles. Students will work collaboratively to build a model of a protein. Finally students will compare and contrast a normal protein by exploring the protein data bank website.*

<table>
<thead>
<tr>
<th>Title:</th>
<th>What’s Wrong with Amadi?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Human Body System: Anatomy and Physiology</td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
<tr>
<td>NYS Standard:</td>
<td>Performance Indicator 5.2 Explain disease as a failure of homeostasis</td>
</tr>
<tr>
<td>Summary:</td>
<td>Students will begin this problem-based learning module by reading the case story entitled, “What’s Wrong with Amadi?- Part 1.” After reading the first section, each student will write down any facts and questions that he or she may have. Students will then join their PBL groups and share</td>
</tr>
</tbody>
</table>
their responses. The case analysis question, “What disorder is causing Amadi’s symptoms?” will be posed and students will have the rest of the class period to work collaboratively in their groups to conduct research and come up with an answer.

Students will begin the second class by reading “What’s Wrong with Amadi?-Part 2.” Each student will then write down any facts and questions they may have. Students will then take turns sharing their thoughts within their teams. The case analysis questions, “How are the symptoms related to the physiological cause of the disorder?” “How does hemoglobin work?” and “What is different about sickle cell hemoglobin?” will be posed. Each PBL team will have the rest of the class time to research the answers to these questions.

Students will begin the third class by writing a short report identifying the disorder, discussing the symptoms and function of hemoglobin and cause of sickle cell anemia. Students will use the research notes from the previous two classes to help them with this assignment. Some helpful websites include:

- The Sickle Cell Information Center: http://www.emory.edu/PEDS/SICKLE/
- The American Sickle Cell Anemia Association: http://www.ascaa.org/
- New Hope for People with Sickle Cell Anemia (FDA Consumer): http://www.fda.gov/fdac/features/496_sick.html

Next, each PBL group will assemble a cardboard amino acid using the materials provided.

On the fourth day, the pbl teams will work together to investigate the amino acid sequence differences between normal hemoglobin (Hb A) and sickle cell hemoglobin (Hb S) using the “Protein Data Bank” (PDB) website. Students will explore this website to answer the following case analysis question, “How does the actual shape of the normal protein compare with the shape of the sickle cell version?”

Rationale: The human body system is an important topic covered in the Living Environment curriculum. This problem-based learning module helps students by
- encouraging students to work collaboratively using inquiry-based learning methods. Students must draw information from the case story in order to come up with the right questions to investigate. In addition each group has to construct a protein using the materials given. Very little instruction is given as to how to go about this task. The idea is for students to simulate the different components of a protein (i.e. amino acids) using only the materials provided. Students must also explore the protein data bank website in order to answer the higher level thinking analysis question.

- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension and text analysis of the case story and library resources which include book, journal articles, internet sources etc. Students also practice their writing skills by completing the research reports.

- providing students with a hands-on approach to learning. Students are given a box of supplies and asked to assemble a protein using the provided materials. This kinesthetic activity allows students to manipulate artifacts in order to understand the complex structure of proteins.

- Case story “What’s Wrong with Amadi?” Part 1 and Part 2
- Research handout
- “Report: What’s Wrong with Amadi?”
- An array of medical textbooks, articles, websites
- “Protein Data Bank Activity” worksheet
- “3-D Protein Model” handout
- Cardboard boxes, scissors, tape, glue, straws, string

Possible Misconceptions: Below are four misconceptions that pertain to this problem-based learning module:

- The interior of a cell is completely filled with water (AAAS Project 2061, n.d.).
- The interior of a cell is filled with air (AAAS Project 2061, n.d.).
- The interior of a cell is solid (AAAS Project 2061, n.d.).
- Red blood cells do not supply oxygen to muscle or nerve cells (AAAS Project 2061, n.d.).

Recommendations: The problem-based module is best implemented over the course of four consecutive days (periods ranging from 45-60 minutes). Students are recommended to work in groups no larger than four. This is to ensure that each student takes an active role in the activity. It is also recommended that the teacher conduct a peer grading assessment at the end of the
activity to ensure that each group member is held accountable for the work. Since a very small amount of instruction is provided for the research and designing of the protein model, it is imperative for the facilitator to monitor and provide immediate verbal feedback to the groups. This is to ensure that the students remain on task and focused on the case analysis questions.

**Resources:**

Misconceptions: http://assessment.aaas.org/topics/BF#, tabs-185-188-193/2

The Sickle Cell Information Center:
http://www.emory.edu/PEDS/SICKLE/

The American Sickle Cell Anemia Association: http://www.ascaa.org/

Medline Medical Encyclopedia:

The Protein Data Bank: http://www.rcsb.org/pdb/

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**Case Story:**

**The Case:**

**What's Wrong With Amadi?**

**Part I. The Symptoms**

18 year old Jake and his friend Amadi, a Nigerian exchange student, were having a great time playing soccer, when Amadi suddenly doubled over in pain, completely out of breath. “What's wrong?” Jake asked, in a panic. But Amadi’s Mom had already rushed over to comfort him. She took out some “medicine” and gave it to him. “This is a bad one Mom”, Amadi said, gasping. His eyes were filled with tears and had a strange yellow tone to them. “I know Son, these pain episodes really hard. But the medicine will help.” They left and Jake went home, puzzled and confused.

http://www.concussionsafety.com/riskysports.htm

When he saw Amadi at school 2 days later, Jake noticed he had a big bandage on his leg.

“What happened?” Jake asked. “Did you fall?”.

“No, I get these big sores once in a while. It usually happens after those awful pain episodes”. Jake was very concerned about his friend and didn’t understand what was happening to him.
Part II: Getting to the Cause (to be given out after Part I has been investigated)

Jake had invited Amadi over to his house to help him work on his pet project, restoring a 1967 Firebird. Jake loved to work on the engine and get into all the little parts so he could understand exactly how each piece allowed the engine to work properly. As they sat together, putting with the parts, Jake asked, “Amadi, I understand that your pain episodes and leg ulcers are caused by Sickle Cell Anemia, but I don’t understand how all that works.”

“Remember in biology class how we learned that the blood carries oxygen to the different body tissues? It’s kind of like the parts of this engine,” Amadi explained. “Our red blood cells have this protein in it called hemoglobin, which is the part that actually carries the oxygen.” In my body, the hemoglobin isn’t the right shape, so it causes my red blood cells to clog up my blood vessels.”

http://library.thinkquest.org/16985/sicklecellmain.htm

Always wanting the details, Jake asked, “But how did that shape wind up wrong, and how would the wrong shape clog your vessels?”

Research Day 1: (10 points)
You must have a minimum of two sources per analysis question.

- What disorder is causing Amadi’s symptoms?

Source 1:
Source 2:

Research Day 2: (30 points)

- How are the symptoms related to the physiological cause of the disorder?

Source 1:
Source 2:

- “How does hemoglobin work?”

Source 1:
Source 2:
Source 1:
Source 2:

- What is different about sickle cell hemoglobin?

Source 1:
Source 2:

Report: What's Wrong with Amadi?

Directions: Write a short report, (minimum of four paragraphs) identifying the disorder, discussing the symptoms and function of hemoglobin and cause of sickle cell anemia. Use your research notes from the previous two classes to help you. (20 points)

Source 1:
Source 2:

Protein Data Bank Activity

Go to the following website: http://www.rcsb.org/pdb/ In the search engine type in “hemoglobin” then “sickle cell hemoglobin.” Read through the structure description. Use this information to answer the following case analysis question: **How does the actual shape of the normal protein compare with the shape of the sickle cell version?** (20 points)

Source 1:
Source 2:

3-D Protein Model

Using the materials provided construct a 3-D model of a protein. Use the various cardboard pieces to design a chain of “amino acids” and bend it to form a completed protein. Be sure to include a key and label what each part is suppose to represent.

Key:

In the space below, sketch a picture of your protein.

**PBL #12- The Salty Brow**

*For this PBL module students will extrapolate information from the case study to steer their research on cystic fibrosis. They will then create a brochure on the disease as a team.*

<table>
<thead>
<tr>
<th>Title:</th>
<th>The Salty Brow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Human Body System: Anatomy and Physiology</td>
</tr>
</tbody>
</table>
**Source/website:** http://bioquest.org/lifelines/summer2002/morrisongraham.htm  
**Course:** Living Environment  
**NYS Standard:** Performance Indicator 5.2 Explain disease as a failure of homeostasis  

**Summary:** Each student will begin this problem-based learning module by reading the case story entitled, “The Salty Brow - Part 1.” Students will underline the important clues in the case and write down any facts and questions that they may have. Students will then take turns sharing their thoughts with their group members. Afterwards the students may proceed on to “The Salty Brow - Part 2” and repeat the same procedures. The following case analysis questions will be posed: “What is cystic fibrosis?” “What do we know about the case and about cells already?” and “What do we need to know to understand this disease?” Students will use these questions to help guide their research. Each pbl group will have the rest of the class time to explore the answers to these questions. There will be a multitude of various sources available to students. These include the internet, reference books, science articles, medical books, and encyclopedias.

Students will have the entire second class period to continue their research. Some helpful websites sources include:

**General Resources:**

http://www.people.virginia.edu/~rjh9u/cfsciam.html  

**Diagnosis:**

http://www.noah-health.org/english/illness/respiratory/cystic.html#DIAGNOSIS  
http://.pediatrics.wisc.edu/childrenshosp/sweat/sweat.html  
http://www.cf-web.org/info-zone/med-compl.html  
http://www.cysticfibrosis.co.uk/diagnosi.htm

On the third day of this module, each team must devise a brochure to explain cystic fibrosis to Julia’s parents. The brochure must include the cellular basis of the disease and how it relates that to the symptoms and treatments. Below are some additional guidelines to follow:

Column 1: the cell biology of cystic fibrosis  
Column 2: disease symptoms related to the underlying cell biology
### Column 3: explanation for the treatments for the disease

On the fourth day, each pbl team will share your brochure materials to another group. The viewing group will complete an inter-group critique for the presenting group. The roles the groups will be switched. Each group will then get the chance to refine their brochure before they submit the final copy in for a grade.

### Rationale:

The human body system is an important topic covered in the Living Environment curriculum. This problem-based learning module helps students by

- encouraging students to work collaboratively using inquiry-based learning methods. Students must draw important clues from the case story in order to come up with the right questions to investigate. They must provide text based evidence to explain the disease using a variety of different sources to create a brochure as a team. Peer editing requires students to practice listening and communication skills.

- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension and text analysis of the case story and library resources which include books, journal articles, internet sources etc. Students also practice their writing skills by creating a brochure.

- showing students a 21st century real world example of how a disease can be the result of a disturbance in the homeostasis of the human body. In this case, students learn about the real world implication on an individual suffering from cystic fibrosis.

### Possible Misconceptions:

Below are five misconceptions that pertain to this problem-based learning module:

- Cells do not need a way to eliminate waste materials to function (AAAS Project 2061, n.d.).
- Red blood cells do not supply oxygen to muscle cells (AAAS Project 2061, n.d.).
- Red blood cells do not supply oxygen to cells of the lung (AAAS Project 2061, n.d.).
• Blood does not carry oxygen to the cells of the body (AAAS Project 2061, n.d.).
• Nothing can pass through the walls of capillaries (AAAS Project 2061, n.d.).

**Recommendations:**

The problem-based module is best implemented over the course of four consecutive days (periods ranging from 45-60 minutes). Students are recommended to work in groups no larger than four. This is to ensure that each student takes an active role in the activity. It is also recommended that the teacher conduct a peer grading assessment at the end of the activity to ensure that each group member is held accountable for the work. Since a very small amount of instruction is provided for the research component of this module, it is imperative for the facilitator to monitor and provide immediate verbal feedback to the groups. This is to ensure that the students remain on task and focused on the case analysis questions.

**Resources:**

Misconceptions: http://assessment.aaas.org/topics/BF#/tabs-185-188-193/2

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**The Case:**

**The Salty Brow**

**Case Scenario Part One:**

"Just one more push Sandra and we'll have a baby here" the midwife said with that Julia entered the world. Julia was a healthy 7lb 2oz baby girl complete with 10 toes and 10 fingers. Sandra and Jim took their new daughter home and besides being short on sleep, they settled into being a family.

Julia was a good eater but at her 6 month checkup her doctor noticed that Julia's weight gain was not keeping pace with the growth charts. In the months that followed she began to get fussier and she seemed to have a runny nose constantly. Sandra knew all babies get colds, but when Julia developed a bad cough Sandra got concerned and called Julia's pediatrician.

"Hello Dr. Miner, I'm concerned about Julia. She started coughing yesterday and it's getting worse."

"Is she coughing up any mucus?"

"Yes, the mucus is thick and has a greenish color" Sandra replied.

"Sounds like I should have a look" Dr. Miner responded. "Bring her in."

Dr. Miner checked Julia's weight and carefully listened to Julia's lungs. "Have either of you noticed any changes in her eating or bowel habits?"

"Her stools appear kind of greasy now that she is eating some solid foods" Sandra recalled.

"I swear they are more frequent then they used to be too" added Jim.

Before handing Julia back to her parents, Sandra noticed that Dr. Miner gently kissed Julia on the forehead. "I'm going to start
her on some antibiotics for her cough and order some tests to see what is going on. My nurse will be right in to draw some blood. I'm also going to schedule Julia for a sweat test. If her cough doesn't get better let me know. I'll give you a call after the test results come back.

Case Scenario Part Two:

A week later Dr. Miner received the results of the sweat test. They confirmed her fears. Julia has cystic fibrosis. This explains her very thick mucus and other symptoms. Dr. Miner schedules an appointment for Jim and Sandra to meet Cathy the new Nurse Educator. This will be Cathy's first consultation and she has a lot of work to do before she's ready.

Case Analysis

This case is about cystic fibrosis and the ramification of a missing chloride channel in epithelia cells. To analyze the case students will need to ask

- What is cystic fibrosis?
- What do we know about the case and about cells already
- What do we need to know to understand this disease

PBL #13- What’s Wrong with Uncle Sam?

For this PBL module students will investigate a mystery condition using the clues provided in the case study. Students will create a presentation using a format of their choice on the perspective disease.

<table>
<thead>
<tr>
<th>Title:</th>
<th>What’s Wrong with Uncle Sam?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Human Body System: Anatomy and Physiology</td>
</tr>
<tr>
<td>Source/website:</td>
<td><a href="http://bioquest.org/lifelines/unclesam.html">http://bioquest.org/lifelines/unclesam.html</a></td>
</tr>
<tr>
<td>Course:</td>
<td>Living Environment</td>
</tr>
</tbody>
</table>
**NYS Standard:** Performance Indicator 5.2 Explain disease as a failure of homeostasis

**Summary:** Students will begin this problem-based learning module by reading the case story entitled, “Part 1: What’s Wrong with Uncle Sam?” “…Your friend Pat is very concerned about his Uncle Sam. He tries to describe what he witnesses in an email to you.” After the students read this section they will fill out the student handout. Once the charts are completed, the class will have a discussion on the possible disease that Uncle Sam could have based on the clues that were given in the emails. Each problem-based learning group will then have the opportunity to pick a different disease to research. Each group will begin by researching the disease. Students will have access to variety of resources including textbooks, medical journals and articles, encyclopedias, and the internet.

Each team will have the whole second day of class to continue their research. Students will then prepare a presentation using a format of their choice. Students will be graded based on the components outlined in the grading rubric.

On the third day of this module, each pbl group will wrap up any loose ends on the projects. Each team will then present their findings. After the presentations, Part 2 of the case study will be handed out. A class discussion will be conducted to determine which disease Uncle Sam has based on the additional information provided.

**Rationale:** The human body system is an important topic covered in the Living Environment curriculum. This problem-based learning module helps students by

- encouraging students to work collaboratively using inquiry-based learning methods. Students must draw important clues from the case story in order to come up with the right questions to investigate. They must provide text based evidence to explain the condition described in the case study. Students must use a variety of different sources and work as a team to create a presentation using a format of their choosing. The team component encourages students to practice their listening and communication skills.

- incorporating Common Core reading and writing skills. This activity requires students to utilize reading comprehension and text analysis of the case story and library resources which include books, journal articles, internet sources etc. Students also practice their writing skills by creating a brochure.

- showing students a 21st century real world example of how a disease can be the result of a disturbance in the homeostasis of the human body. In this case, students learn about the real world
implication on an individual suffering from Parkinson’s disease or Multiple Sclerosis.

- Case story “What’s Wrong with Uncle Sam?” Part 1 and Part 2
- Student Handout: What’s Wrong with Uncle Sam?
- An array of science textbooks, medical articles and journals, encyclopedias, websites
- Poster boards, construction paper, scissors, glue, markers, colored pencils, crayons

**Possible Misconceptions:**

Below are two misconceptions that pertain to this problem-based learning module:

- Systems operate in isolation from each other
- Muscles are not found all over the body.

**Recommendations:**

The problem-based module is best implemented over the course of three consecutive days (periods ranging from 45-60 minutes). Students are recommended to work in groups no larger than four. This is to ensure that each student takes an active role in the activity. It is also recommended that the teacher conduct a peer grading assessment at the end of the activity to ensure that each group member is held accountable for the work. Since a very small amount of instruction is provided for the research component of this module, it is imperative for the facilitator to monitor and provide immediate verbal feedback to the groups. This is to ensure that the students remain on task and focused.

**Resources:**

Misconceptions:

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**Part 1: What’s Wrong with Uncle Sam?**

Your best friend, Pat, is spending the summer with Aunt Betsy and Uncle Sam in Washington, D.C. Pat is concerned since Uncle Sam seems different from 4 years ago when they came to visit with Pat’s parents. Pat has sent you the following e-mail to describe Uncle Sam.
Student Handout: What’s Wrong with Uncle Sam?

**DEFINE the question carefully**

<table>
<thead>
<tr>
<th>What are you trying to find out?</th>
<th>List and information needed to answer the question.</th>
</tr>
</thead>
</table>

**EXPLORE**

possible answers to the above question. List these below.

**NARROW**

your choices start, prioritize, eliminate

**TEST**

your ideas, obtain further information

Rubric for Presentation: What’s Wrong with Uncle Sam?
### Include the following

<table>
<thead>
<tr>
<th>Description of the disease</th>
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</thead>
<tbody>
<tr>
<td>Effects on the nervous system: e.g., anatomical and physiological descriptions</td>
</tr>
<tr>
<td>Causes - molecular, cellular, genetic</td>
</tr>
<tr>
<td>Symptoms</td>
</tr>
<tr>
<td>Progression of the disease</td>
</tr>
<tr>
<td>Changes in lifestyle</td>
</tr>
</tbody>
</table>

| Total points |

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**Part 2.**

A month later, Pat includes more information about Uncle Sam.

Hey Justine,

You'll never guess what happened with Uncle Sam now. He is refusing to go anywhere with us. He says he wants to stay at home and be alone. Once, I saw him in his recliner and his head kept twitching. It scared me so I left the room without him knowing. When I talked to my cousin about it, he said that his Dad had been doing that for the past few years. It didn't seem like a big deal to him. If it were my Dad, I'd be worried. P.S. My cousin's friend is already going steady. Bummer. See you in 2 weeks. I can hardly wait. Luv ya, Pat
Reflective Summary

Research supports the idea that Problem-Based Learning is a great instructional tool to enhance student motivation. When students are engaged in their learning they are more likely to achieve academic success. Throughout the compilation of the literature review, it was deduced that PBL modules enhance student competence of the content, encouraged student ownership of their learning, and promoted collaborative team work amongst their peers. PBL fosters the components stressed in the Self-Determination Theory: competence, autonomy, and relatedness. Teachers who promote the three factors of the Self-Determination Theory in their day-to-day lessons are thought to increase student motivation, and in turn, high academic achievement.

Each module was designed to cater to the three components of the Self-Determination Theory. The modules are centered around the idea of autonomy, competence, and relatedness. Students are allotted a great deal of choice in many of these projects. They are required to draw upon their prior skills and apply them to each problem. Each module also requires them to work effectively in a group setting.

Each Problem-Based Learning module starts out with an authentic question or dilemma. Students must work together to find a solution without receiving too much explicit instruction. This requires them to pool together their knowledge and resources to navigate their plan of attack. This activity draws upon their communication, reading, writing, and higher-level thinking skills in order to solve the problem.

This project sought to provide teachers with a collection of problem-based learning modules that address the New York State Living Environment Learning Standards. Careful consideration was put into the creation of each PBL module. An in-depth summary and rationale was provided for each assignment. Common misconceptions that centered on each topic and how
the PBL module was able to dispel those misunderstandings were included. For each module helpful tips such as recommended group size and assessment methods were provided.

Many of the problem-based modules address the skills required to meet Common Core standards. For instance, in part 3 of the Genetics PBL module the students are asked to analyze a research article on the technical aspects of DNA analysis using a literacy strategy during the spinner activity. All of the modules demonstrate 21st century real world examples of how the content relates to students’ lives. For example, in the PBL module: The Case of the Two Sick Dogs, the killer bees described in the case story was an actual documented incident that took place in the United States. Finally, all of the PBL modules encourage students to work collaboratively using inquiry-based learning methods via hands-on learning activities. For example in the PBL module: No Baby? the students are asked to work together in teams to examine the Joe’s lab results in an effort to determine the culprit of his infertility. Very little instruction is provided to the students in terms of what condition Joe might be suffering from. They must share ideas and rely on the “clues” from the data provided in order to figure out Joe’s condition. Students take on the role of the lab technician as they use a microscope to examine sperm slides and practice the procedure of counting out sperm cells.

The purpose of this capstone project was to provide biology teachers with an array of PBL modules that they can easily incorporate into their curriculum. Each module was carefully instructed to provide teachers with a rationale, explicit instructions, resources, and helpful insights. The hope is that through the implementation of these modules, students will become more engaged with the content material, which will translate into higher academic success.
References


Two empirical studies based on Deci and Ryan’s theory of motivation. Learning and Instruction, 3, 281-298.

Vansteenkiste, M., Sierens, E., Goossens, L., Soenens, B., Dochy, F., Mouratidis, A., & ...