Using Biotechnology to Study the Dengue Fever Virus

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Abstract
This action plan is designed to incorporate biotechnology throughout the school year. In some cases, biotech activities replace “paper" labs or outdated labs. In others, a biotech lab is added to a unit for which no lab was planned.

The diagnosis of a case of dengue fever in Marion County in July 2010 provides the basis for an emerging pathogens focus for the labs and activities involved in this project. During Unit 1, an introduction to biology and methods of study, students will research dengue fever, collect mosquito larvae, identify the types of mosquitoes breeding in the area, and analyze their data. Unit 3 deals with biochemistry. An ELISA simulation to look for antibodies to dengue virus in patient serum will illustrate the function of proteins as antigens and as antibodies, as well as making use of a protein’s enzyme activity. Unit 6 includes instruction on DNA structure and function. A *Mission Biotech* lesson plan will introduce students to DNA extraction techniques and PCR, then use gaming technology to reinforce student learning.

Rationale
The biologic sciences are increasingly turning to technology for advancement. It is still very important that students learn the fundamentals of cell biology, biochemistry, inheritance, classification and ecology in high school biology. However, we owe it to our students to teach them the skills they will need as scientists in higher education and in the workplace. Equipment and protocols that have become commonplace in scientific research and science-based industry should not be absent from the biology class curriculum.

Strategies that link knowledge to its application increase understanding of concepts and reinforce memory. Students are most engaged in a task when they are able to connect it to something that interests them and concerns them personally. This action plan links biotechnology lab tasks to viral pathogens that are emerging in Florida. Students will find this topic interesting, challenging, and perhaps a little frightening – all excellent motivators for careful work, critical thinking, and thoughtful analysis. One result of incorporating engaging, biotechnology-based activities into the biology lesson plans will be students with a better understanding of biology. Another result will be students who really like science class.

Module 1: Dengue fever in Marion County

BEFORE THE LESSON

Students will be introduced to various methods of data collection and know the difference between quantitative and qualitative data. They will be able to use tables to organize information, and will be aware that data must be analyzed in order for it to be meaningful.

SET

A pre-test will determine what students think about dengue fever, where it is found, its symptoms, cause, and how it is spread. Students will then be given three newspaper articles: the first discusses dengue as a problem in Key West, the second reports a diagnosis of dengue fever in Marion County in July 2010, and the third reports a second case diagnosed in August 2010.

ACTIVITY 1: DENGUE FEVER RESEARCH

Given a webquest, students will conduct research to

- describe the symptoms of dengue and consequences of repeat exposure to the virus,
- name *Aedes aegypti* and *Aedes albopictus* as the vectors that carry the virus,
- locate the regions of the world where dengue is found,
- explain why dengue is considered an emerging pathogen in Florida.

Assessment: Students will complete a worksheet to show they are able to locate and interpret information about dengue.

ACTIVITY 2: THINK/PAIR/SHARE

Following a presentation about A*. aegypti* and *A. albopictus* habitats and life cycles, students will address the following questions in a think/pair/share format:

Does the appearance of one case of dengue fever mean that dengue is an endemic disease in Marion County?

If dengue virus vectors are in Marion County, is dengue endemic here?

How can we determine if the vector mosquitoes are here?

Assessment: Think/Pair/Share charts will show individual student ideas and understanding. The class discussion that follows pairs sharing out should generate the proposal of collecting and identifying mosquitoes to see if the *Aedes* species are present in the community. This outcome would indicate an understanding of the role of vectors in the spread of disease.

ACTIVITY 3: FIELD RESEARCH

Students will look for standing water around their homes and examine it for the presence of mosquito larvae. Water samples will be brought to the lab and placed in mosquito breeders. When the adults hatch, genus and species will be identified. Students will determine if the vectors that can carry dengue are present in the community and if so, the percentage of mosquitoes that are possible dengue virus carriers.

Assessment: Written lab reports will demonstrate student proficiency in collecting and organizing qualitative and quantitative data. Reports will also demonstrate students' ability to analyze results and form logical conclusions based on data analysis.

At the end of Module 1, a post-test will measure increased knowledge about dengue fever and disease vectors.

Module 2: ELISA Testing to confirm a diagnosis

BEFORE THE LESSON

Students should know that viral proteins can serve as antigens, antibody proteins form as part of the immune response, and the detection of antibodies to a viral antigen in the blood indicates exposure to that virus. Students should also understand that enzymes are proteins that function as catalysts for chemical reactions.

SET

Students will be given a scenario in which fictional residents of Marion County have been seen by a physician presenting symptoms which may indicate dengue fever. These patients will be tested to confirm or rule out a dengue fever diagnosis.

ACTIVITY 1: ELISA ANTIBODY TEST ANIMATION

Students will view the ELISA Antibody Test animation by Bio-Rad to see how ELISA uses the various functions of proteins to detect the presence of antibodies in a patient's serum.

Assessment: Students will produce a diagram illustrating and explaining the steps of the ELISA antibody test.

ACTIVITY 2: MICROPIPETTE BY COORDINATES

Given a set of instructions and a 96-well microplate, students will practice the use of micropipettes to accurately deliver colored solutions to prescribed wells.

Assessment: Successful reading of the instructions and accurate pipetting will result in a recognizable design in the microplate.

ACTIVITY 3: ELISA ANTIBODY TEST

Students will perform a simulated ELISA antibody test on samples from patients and family members to determine who has been exposed to dengue fever.

Assessment: In their role as lab technologists, students will demonstrate successful and accurate completion of the ELISA by preparing a report of the lab results, transferring information from case studies and recording the ELISA results for each patient.

ACTIVITY 4: INTERPRETING AND REPORTING DATA

Taking on the role of family physician, each student will examine the Activity 3 lab results and prepare a written report that explains the results to the patients.

Assessment: Students will demonstrate their understanding of the action of antibodies, the immune response, and the importance of basing their conclusions on data by preparing a report that explains several situations: positive ELISA for a patient with severe symptoms, positive ELISA for a patient with mild symptoms in the past, but not ill at the time blood was drawn, negative ELISA for a patient with flu-like symptoms, negative ELISA for a patient with fever.

Module 3: Mission Biotech Gaming

BEFORE THE LESSON

Students should know about the structure of DNA and its function.

SET

Students will be given a pre-test to determine their knowledge about biotechnology equipment, techniques, and careers. They will be told that they are taking part in an experiment to determine if gaming technology can help students learn about science topics.

ACTIVITY

A 2-week Mission Biotech lesson plan will be implemented. Classroom lessons and lab activities covering biotech equipment, viruses, PCR and PCR analysis will be alternated with game play. All game play will be conducted during class time.

Assessment: Increased knowledge about biotechnology equipment, techniques, and careers will be measured using a post-test.

References

Belcher R. 2010 July. Micropipette by Coordinates Activity. University of Florida Center for Pre-collegiate Education and Training Summer Institute.

Bio-Rad, Inc. ELISA antibody test [animated tutorial]. Available at www.bio-rad.com.

Connelly, R C. 2010 July 16. Insect vectors and Florida's public health [lecture]. University of Florida Center for Pre-collegiate Education and Training Summer Institute.

Grady D, Skipp C. 2010 July 23. Key West concerned about dengue fever, its impact on the island's tourism. Ocala Star-Banner; section B, 7.

Klosterman M, Sadler T, Barko T, Bokor J, Brown J, Echevarri JF, Mandell T. 2010. Mission Biotech Teacher Guide. University of Florida College of Education.

Sadler T, Annetta L, Ferdig R, Snyder R, Koroly MJ, Mandel T, Bokor J, Echevarri JF, Klosterman M, Liu F. 2010. Mission Biotech. [CD-ROM]. University of Florida College of Education, North Carolina State University College of Education.

Star-Banner Staff. 2010 August 28. Officials urge spraying after new dengue fever case. Ocala Star-Banner; section B, 1.

Star-Banner Staff. 2010 July 15. Dengue fever confirmed; mosquito spray requested. Ocala Star-Banner; section B, 2.

Budget

6 Mosquito breeders	BioQuip 1425DG	$67.70
2 ELISA Immuno Explorer Kits	Bio-Rad 166-2400EDU	$310
11 Adjustable micropipettes	Bio-Rad 166-0552EDU	$148 each (available at no cost on loan from CPET equipment locker)
1000/pkg TBR-35 pipette tips	Bio-Rad 223-9347EDU	$51 (available on loan from CPET)
60/pkg, 96-well microplates	Fisher Science Education 12-565-226	$118 (available on loan from CPET)

Lesson Title	Using Biotechnology to Study the Dengue Fever Virus
Grade Span	9th Grade
Content Emphasis	Science – Honors Biology 1
Targeted Benchmarks	SC.912.L.14.6 Explain the significance of environmental factors and pathogenic agents to health from the perspectives of both individual and public health. SC.912.L.16.10 Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues. SC.912.L.18.4 Describe the structures of proteins and amino acids. Explain the functions of proteins in living organisms. Identify some reactions that amino acids undergo. Relate the structure and function of enzymes. SC.912.L.18.11 Explain the role of enzymes as catalysts that lower the activation energy of biochemical reactions. Identify factors such as pH and temperature, and their effect on enzyme activity. SC.912N.1.4 Identify sources of information and assess their reliability according to the strict standards of scientific investigation. SC.912.N.1.6 Describe how scientific inferences are drawn from scientific observations. HE.912.C.1.3 Evaluate how environment and personal health are interrelated. MA.912.S.1.2 Determine appropriate and consistent standards of measurement for data to be collected in a survey or experiment. MA.912.S.3.2 Collect, organize and analyze data sets. Determine the best format for the data and present visual summaries.
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Lesson Preparation

Learning goals:

Students will be able to illustrate and explain the steps of the ELISA antibody test including a description of how different proteins function as antigens, antibodies, or enzymes.

Students will be able to use micropipettes to accurately deliver a solution to specified wells of a microplate.

Students will successfully complete the procedures of ELISA antibody tests and accurately report their results.

Students will be able to determine diagnoses based on laboratory test results and information about patient symptoms.

Estimated time:

This project is comprised of a series of lessons and activities that will be completed during four 55-minute classes and one 90-minute class.

Materials/Resources:

Bio-Rad ELISA test simulation kit
ELISA kit reagents
96-well microplates
20ul-200ul micropipettes
Micropipette tips
Simulated case studies
Reporting forms for lab results

Teacher Preparation:

Obtain a class set of micropipettes, pipette tips, and 96-well microplates.
Prepare colored solutions for pipette use practice.
Purchase ELISA test materials and reagents.
Compose a variety of case study simulations that describe symptoms that can be indicators of dengue fever.
Create a lab report form based on the CDC form for dengue testing.
Gather other miscellaneous lab supplies.

Lesson Procedure and Evaluation

Introduction:

Using a series of articles which appeared in the local newspaper over the summer, students will be introduced to dengue fever and its emergence in Marion County. Students will research dengue fever, the pathogen that causes it, and identify dengue virus vectors. Students will conduct a field study to determine if the larvae of mosquitoes that carry dengue are present in standing water around their homes.

During the biochemistry unit, students will study the structure and function of proteins. Students will know that the proteins of viruses can serve as antigens and that other proteins, antibodies, may be made as part of the immune response. Additionally, enzyme proteins can be involved in chemical reactions both in the body and in the laboratory. The ELISA test for antibodies makes use of all three of these protein functions.

Exploration:

SET
Students will be given a scenario in which fictional residents of Marion County present symptoms which may indicate dengue fever. Their physician determines that the patients should be tested to confirm or rule out a diagnosis of dengue fever. Students will first take on the role of the lab technologists responsible for testing patient serum for the presence of antibodies to dengue virus. Once tests are complete and results recorded, students will take on the role of the physician, reporting and explaining the results to the patients.

ACTIVITY 1: ELISA ANTIBODY TEST ANIMATION
Students will view the ELISA Antibody Test animation by Bio-Rad to see how ELISA uses the various functions of proteins to detect the presence of antibodies in a patient's serum.

Assessment: Students will produce a diagram illustrating and explaining the steps of the ELISA antibody test.

ACTIVITY 2: MICROPIPET BY COORDINATES
Given a set of instructions and a 96-well microplate, students will practice the use of micropipettes to accurately deliver colored solutions to prescribed wells.

Assessment: Successful reading of the instructions and accurate pipetting will result in a recognizable design in the microplate.

ACTIVITY 3: ELISA ANTIBODY TEST
Students will perform an ELISA antibody test on simulated patient serum samples to determine which samples indicate the presence of antibodies to dengue virus.

Assessment: In their role as lab technologists, students will demonstrate successful and accurate completion of the ELISA by correctly recording the ELISA results for each patient. They will complete the preparation of a lab report form by evaluating and transferring patient symptom information from the case studies.

ACTIVITY 4: INTERPRETING AND REPORTING DATA
Taking on the role of family physician, each student will examine the Activity 3 lab results and prepare a written report explaining the results to the family.

Assessment: Students will demonstrate their understanding of the action of antibodies, the immune response, and the importance of basing their conclusions on data by preparing a report that explains several situations: positive ELISA for a patient with severe symptoms, positive ELISA for a patient with mild symptoms in the past, but not ill at the time blood was drawn, negative ELISA for a patient with flu-like symptoms, negative ELISA for a patient with fever.

Application:

The use of micro-techniques is not limited to biologic assays. Students' abilities to perform this type of procedure correctly and with confidence will be useful to them in a variety of laboratory situations.

The biologic sciences are increasingly employing technology for advancement, and the ELISA test is commonly found in research facilities and medical laboratories. Students continuing their studies in biology are likely to encounter this assay again.

The ability to accurately record, report, analyze, and explain information is important regardless of the situation or subject matter. Students will find these skills to be vital as they enter higher education and the workplace.

Assessment:

Activity 1 Assessment: Students produce a diagram that illustrates and explains the steps of the ELISA antibody test.

SC.912.L.18.4 Describe the structure and function of proteins.
SC.912.L.18.11 Explain the role of enzymes and factors that affect them.

Activity 2 Assessment: Students successfully read and follow instructions and demonstrate accurate micropipette use.

MA.912.S.1.2 Determine standards of measurement.

Activity 3 Assessment: Students complete ELISA tests and record results for each patient. Students evaluate case studies and transfer patient symptom information to their reports.

SC.912.L.16.10 Evaluate the impact of biotechnology.
MA.912.S.1.2 Determine standards of measurement.
MA.912.S.3.2 Collect and organize data.
SC.912N.1.4 Identify sources of information and assess their reliability.

Activity 4 Assessment: Students prepare a report that explains several different combinations of ELISA results and possible symptoms of dengue.

SC.912.L.14.6 Explain the significance of several factors to individual health and public health.
SC.912.L.16.10 Evaluate the impact of biotechnology.
SC.912.L.18.4 Describe the structure and function of proteins.
SC.912.L.18.11 Explain the role of enzymes and factors that affect them.
SC.912N.1.4 Identify sources of information and assess their reliability.
SC.912.N.1.6 Describe how scientific inferences are drawn from scientific observations.
HE.912.C.1.3 Relate environment to personal health.

Teacher Self-Reflection: Record your thoughts on the lesson and describe any modifications you would recommend based on the outcomes.