



Energizing Engineering Education Research Experience for Teachers



Using Lasers to Make the Invisible Visible

Lesson 4: Lasers in Medicine – Disease Detection

Subject Areas: Physical Science, Physics, Chemistry, Science and Technology, Measurement, Biology, Life Science

Grade Level: 9-12

Time Required: 2-3, 1 hour class periods

Group Size: 2-3 students

Expendable Cost Total US \$115, Carolina (<http://www.carolina.com>)

Note: Sugar Concentration of Laser Pointer Activity should be completed prior

Summary

In the previous activity, students learned how they could use lasers to measure the concentration of a certain molecule present in solution. This is commonly practiced in medicine as ELISA, assays, which are used to check for the titer (concentration) of certain antibodies in the blood. The presence of these antibodies and their concentration can indicate the presence or exposure to many different diseases and pathogens.

Carolina Biological Supply Company sells a kit to perform ELISA assays for hypothetical diseases with storylines provided for a given disease. I recommend selecting a situation where students need to measure the titer (the concentration of antibodies) of the solutions in order to determine whether the patient has the disease. Once students have performed the ELISA tests, they will develop a protocol similar to the one used in the previous activity to diagnose the patient.

Note: The Carolina kit is not usually intended to be used with lasers. It is an introduction to ELISA testing and is intended to be qualitative. The final step is to usually place the samples into a spectrometer to measure the titer. For my classes, students apply what they learned in the last activity and use Snell's laws to determine the concentration/titer of non-real, non-hazardous viral antibodies in theoretical patients.

Engineering Connection

There is a significant amount of research into cheap substrates and easy procedures that can be used for assays for use in underdeveloped countries. Much of the focus is how to field test in an efficient, cheap, iso-environmental, immunological assay that can be used to diagnose diseases like HIV, AIDS, and Influenza.

Engineering Category

2. Engineering analysis or partial design

Keywords

ELISA, immunology, assay, antibody, antigen, immunity

Educational Standards

State STEM Standard

III.I.I.4. Understand the scientific foundations of common technologies.

II.I.III.12. Describe how waves are used for practical purposes (e.g., seismic data, acoustic effects, Doppler effect).

ITEEA Standard

H. Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.

(Grades 9 - 12)

W. Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.

(Grades 9 - 12)

Pre-Requisite Knowledge

Background reading on the body's defense system, antigen-antibody interactions, and the immune response should be completed. This is provided in the Carolina kit.

Students should have already performed the activity on Snell's Law in order to fully understand this activity.

Learning Objectives

After this activity, students should be able to:

- Describe how an ELISA test can be performed to detect for diseases in the blood
- Understand how lasers can help us determine the diagnosis and treatment of a patient

Materials List

https://www.vet.purdue.edu/engagement/files/documents/sepa/elisa_simulation_kit.pdf

Each group needs:

- Patient profiles for Influenza Testing (provided in kit by Carolina)
- Laser pointer
- Blank white paper
- Microtiter plate
- Plastic pipets

To share with the entire class:

- Positive and negative controls (provided in kit)
- Patient samples, A-F (provided in kit)
- Simulated antigens, secondary antibodies, and chromogens (provided in kit)

Introduction / Motivation

Immunosorbant assays are commonly used in the diagnoses of many diseases. What does using a laser have to do with diagnosing a disease? Learn how laser light is applied to the diagnosis of a disease in medicine.

Vocabulary / Definitions

Word	Definition
ELISA	The enzyme-linked immunosorbent assay is a test that uses antibodies and color change to identify a substance
Immunology	a branch of biomedical science that covers the study of all aspects of the immune system in all organisms.
Antibody	a large Y-shape protein produced by plasma cells that is used by the immune system to identify and neutralize foreign objects such as bacteria and viruses
Antigen	any substance which provokes an adaptive immune response
Immune system	a system of biological structures and processes within an organism that protects against disease

Procedure

Background

This activity should allow students to understand how we can use antibodies present in human blood to detect the exposure or infection of the patient to pathogens such as viruses and bacteria.

Because this lab activity has been simplified to qualitatively determine whether the fictitious patients either do or don't have the disease, I recommend complicating the procedure where the titer needs to be at a certain threshold in order to diagnose the patient with the disease. This is needed in order to apply what they learned in the last activity to this lab activity.

Before the Activity

Thaw samples approximately 30 minutes before starting each lab.

Make aliquots of reagents for student groups (see Teacher Instructions)

With the Students

1. Students should read background information on ELISA testing and the body's defense system.
2. Read patient profiles.
3. Complete lab notebook and understand all procedural components before beginning.
4. Perform ELISA tests on patients.
5. Use your understanding of lasers and Snell's Law to measure the titer (concentration) of antibodies in the reaction wells.

Safety Issues

- No actual human samples are used in this lab
- Ensure proper laser safety

Assessment

Students will write a comprehensive lab report based on the unit focused on explaining how they determined the presence of antibodies, how they determined the titer, and what diagnosis they would make for each patient.

References

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