Lesson Plan

Title: Using photonics to detect presence of infection

Primary Subject Area: Biology

Grade Level: 9th grade Honors

Overview:

As the primary subject is biology, this lesson will use the basis of disease to explore how photonics can help detect the presence of an infection in the earliest stages. The unit will begin with an exercise to familiarize the class with the nature of waves and the concept of optical density. We will then focus on IRIS and how this technology uses light waves and optical densities to determine height differences in the scale of micro-meters. After a video and web-building exercise to briefly review the immune system, we will watch a video of how an experiment using IRIS would be conducted. Everything will be tied together in a formal written essay that connects what the students learned about light, IRIS, and the immune system to hypothesize how the technology can be used in the field of medicine.

Approximate Duration: 3 55 minute periods

MA Frameworks:

Life Sciences – 4.8: Recognize that the body's systems interact to maintain homeostasis. Describe the basic function of physiological feedback loop.
Physics – 4.1: Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, and period) and explain the relationship among them. Recognize examples of simple harmonic motion.
Physics – 4.4: Describe qualitatively the basic principles of reflection and refraction of waves.

Interdisciplinary Connections

This lesson will tie in with the above Physics frameworks. The knowledge needed to understand the end goal concept of this lesson revolves around the nature of light and waves, specifically reflection of light.

Lesson Objectives

1. Students will be able to identify the key parts of a wave of light: amplitude, frequency, and velocity
2. Students will know basic principles of reflection of light waves and optical density
3. Students will be able to explain how IRIS determines height of observed substances
4. Students will be able to relate IRIS to the field of medicine to describe its medicinal purpose

Lesson Materials and Resources – See attached worksheets

Slinkies of two different densities, string, two beakers, stirring rod, corn oil, worksheets, online videos

Technology Tools and Materials

Two online videos (links found in Learning Resources)

Background Information

This 3 day lesson will serve as a mini unit to introduce students to the concept that what they are learning in the classroom does actually relate to their lives. It will show them how various disciplines in science (physics, biology, medicine, and engineering) come together to create technologies that improve our abilities to better human existence. As incoming freshmen, most of these students will have almost no previous knowledge of biology or physics. This unit is therefore very basic and simplifies concepts a great amount. However, connecting the biological concepts to engineering sets the platform to increasingly tie different units in the curriculum to current research in engineering.

Useful Vocabulary

New Vocabulary Word	Meaning
Velocity	A measurement of the rate and direction of change in position of an

	object
Frequency	The number of occurrences of a repeating event per unit of time
Wavelength	The distance between one peak or crest of a wave of light, heat, or other energy and the next corresponding peak or crest
Amplitude	The distance between the highest point of a wave (crest or peak) and the lowest point of a wave (trough)

Essential Questions to be answered; Grand Challenges

1. How do waves act as they travel through substances? How do they act when they meet a substance they cannot pass through?
2. Generally speaking, how does the human body fight off disease?
3. How can we use light to help detect differences in height of miniscule substances?
4. How can technology like IRIS help advance the field of medicine?

Misconceptions

1. Waves are never bounced back towards the direction they came from
2. Light waves pass through every substance

Lesson Procedures

DAY 1

Opening: (10 min) Introduce the concept of waves with discussion of the beach and surfing: waves travel through a medium at a certain speed (frequency) with specific heights (amplitude)

During: Students will begin a worksheet. Working with slinkies, they will follow the prompts on the sheet to move the slinkies in such a manner to see amplitude, velocity, frequency, and changes in wavelength (30 min)

Closing: Class will group back together. We will build off what was just done by beaker and corn oil demonstration. As the corn oil and beaker have identical optical densities, you cannot see the smaller beaker in the larger when full of corn oil. I will show them this demonstration and have them do think, pair, share to try and come up with a reason for why this happened based on what they just learned. After a few minutes of discussion the groups will share their ideas. For homework, each student must research the actual reason behind this demonstration and write up the answer in an one-page response to be handed in the next day (10 min)

Assessment: This response will be collected at the start of class the next day. Once collected, we will discuss what the students came up with and go over why the demo worked

DAY 2

Opening: (5 min) Collect homework and review why the corn oil demonstration worked.

During:

1. We will then focus on the part of the worksheet that deals with waves bouncing back, more specifically how waves can be reflected by certain surfaces instead of passing through them due to optical densities. This ties in to the demo from yesterday in that since both the beaker and corn oil have the same optical densities the light waves pass through both of them. The key fact here is that the stirring rod has a different optical density and light is therefore reflected back so we are able to see the rod. This is also relates to the section of the worksheet when a slinky is tied to a string and pulsed towards string. When a wave hits a substance with a higher optical density, the wave flips and is sent back. When a wave reflects off a less optically dense substance (the string), the returning wave is still oriented in the same direction. (10 min)
2. After going over these basic properties of light, I will introduce IRIS to the class. I will use a diagram to show them the structure of each piece of the equipment. We will walk through the process, showing how the light from the LEDs passes through the beam splitter, onto the stage where it is reflected back through the beam splitter and into the camera to produce an image on the computer. We will then go over how this allows IRIS to detect the height of a substance by layering a chip, such as the one we use. (20 min)
3. Students will begin a worksheet providing different problems related to height differences using IRIS (15 min)

Closing: (5 min) We will end the class by watching a 2 minute video of a very general overview of how the body fights a virus (see Resources). For homework, each student must write 5 facts that they learned from the video, 5 new ones that they must research, as well as a paragraph explaining how they think IRIS and the immune system could be

related.

DAY 3
Opening: (25 min) The class will be divided into groups of 4. They will create two webs, one with 'IRIS' in the middle and the other with 'Immune System' in the middle. Around these centers the groups will list all the facts they came up on the immune system for homework as well as everything they know about IRIS. The class will then reconvene and we will create two giant webs on the board that list everything the class came up with. In the middle of these webs we will list the ideas that the students came up with for how the two are related.

During: (25 min) We will then go over how IRIS was used this summer during my research. Specifically, how we placed the antibodies on a chip, took images of the chip, incubated the chip in a solution with the antigen (virus, bacteria, etc.) and then imaged the chip again with IRIS to see if there was a change in the height which would tell us that the antigen bonded to the antibody. To help with understanding this, we will watch the Jove video of using IRIS (see Resources). Any remaining questions will be answered after the video.

Closing: (5 min) As a homework assignment, each student must prepare a final write-up. They must tie in how IRIS works and how the body fights disease to explain how this technology can help us beat an infection. There will be several objectives that the student must accomplish. See attached worksheet.

Assessment Procedures

1. Worksheet from Day 1 will be reviewed and returned to students the following class
2. Problem sheet from Day 2 will be collected and graded at end of period
3. Final write up will be collected two days after Day 3 and scored as a test grade

Accommodations/Modifications

1. Written scripts and/or recordings of videos will be provided
2. Lesson unit can be extended to spend more time to understand meaning behind slinky worksheet

Reproducible Materials

See worksheets below

Explorations and Extensions

Bonus credit type stuff, what else can they do on their own

Lesson Development Resources

http://www.pbs.org/teachers/connect/resources/5320/preview/
http://www.jove.com/details.php?id=2694

Reflections

Contact Information

Name:
Date:

1. Take the large slinky and the small slinky and link the two together. You can do this by coiling the smaller slinky around the first few links of the larger one. Place the attached slinkies on the floor with you holding one end and your partner holding the other. Move away from your partner to stretch out the slinky. While one partner holds his end of the slinky still, have the other partner send a single pulse down the slinky. Draw a picture of what you see and explain your drawing.

2. Using one slinky, have each partner hold an end on the floor. While stretching the slinky have one partner send a single pulse towards the other partner. Draw and explain what you observed.

3. Stretching a slinky out on the floor, have each partner send a single pulse in OPPOSITE directions towards the other partner. Observe what happens when the two pulses meet. Draw and explain.

4. Stretching a slinky out on the floor, have each partner send a single pulse in the SAME direction towards the other partner. Observe what happens when the two pulses meet. Draw and explain.

Name:
Date:

1. Using IRIS, you found that the height of the first layer on a chip was 5.68 µm. When you observed the chip after adding your final layer of protein, the height was determined to be 9.37µm. How think is the final layer?

2. You were home sick yesterday so you need to review what your lab partner did while you were gone. However, our lab partner does no keep his lab notebook very well organized. Looking at his data you can only find the final height of 13.487µm and the height of the protein layer which was 4.29µm. What was the height of the initial layer on the chip?

3. Draw a diagram of a chip below where the first layer is 4.98µm thick and the overall height of the chip is 12.48µm.

4. You are trying out a new chip in IRIS. This time, you have three layers instead of the normal two (the antibody and final protein layer) but still need to determine the heights of each layer. Draw a diagram of the chip and explain how you would use IRIS to find the heights of each layer.

Name:
Date:

Help Your Body Fight!

Over the past three days we learned a little bit about how our body fights an invading virus and about a new technology called IRIS. Yet there's still a big piece of the puzzle missing. Even though we know IRIS can help determine an antigen binding to an antibody, how does this help us? What is the purpose of checking the binding between these two proteins? What can we do with this knowledge? In a minimum of two pages, double-spaced, explain your hypothesis of what significance IRIS has in the world of medicine. Make sure you include the basic steps of how IRIS functions and why the layering of the chip is important (connect this back to what you learned in the corn oil and beaker demonstration!). Feel free to use outside sources if you need to but it is not necessary. If you do however, make sure these sources are properly cited. This paper will be counted as a test score so take your time and do a thorough job.