Blank Lesson Template

Yellow highlight = required component

Subject Area(s) Physics

Associated Unit Kinematics

Lesson Title Kinematics in the Immune System Microenvironment

Header Insert Image 1 here

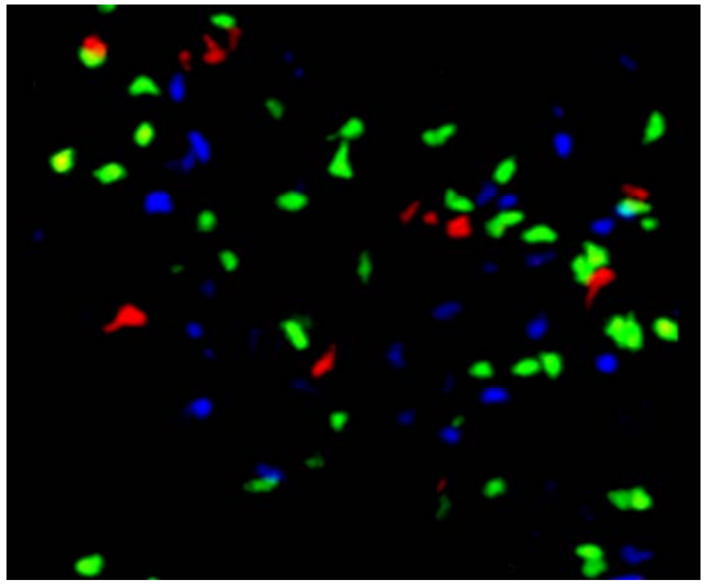
Image 1

Image file:

ADA Description: Image from a fluorescence microscopy movie showing different types of immune cells

Source/Rights: Copyright © http://labs.idi.harvard.edu/vonandrian/Pages/Henricksonvideos-NI.htm

Caption: Antigen-specific P14T cells (green), control OT-I T cells (blue), DC cells (red)



Grade Level 11 (10-12)

Lesson # 1 of 1

Lesson Dependency None

Time Required 45 minutes

Summary
Application of physics concepts to real world problems gives students a better understanding of the underlying physical phenomena surrounding them. In this lesson, we aim to introduce the use of kinematic equations within the context of system biology. More specifically, we use the kinematic equations to describe the motion patterns of immune system cells such as thymocyte cells (also known as T-cells) and cancer cells as well as their interaction.

Engineering Connection

Biomedical and computer engineers work together with biologists and doctors to better understand the behavior of immune cells in the presence of cancer cells. This is done by looking at the motion phenotypes of the immune system cells. Biomedical and computer engineers design algorithms that can detect cells in microscopic images i.e. locate each cell in the image, and then track the cells over time. After that, they design computer programs that can compute measurements such as location, speed, acceleration, total displacement of a cell…etc. These measurements are then used to describe/characterize the kinematics of the cells in order to better understand the immune system response to drugs and other kinds of treatment.

Engineering Category = #1

Choose the category that best describes this activity's amount/depth of engineering content:
1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords
Biomedical engineer, speed, velocity, distance, displacement, acceleration, T-cells, cancer cells.

Educational Standards
Texas TEKS

Pre-Requisite Knowledge
A basic knowledge of cell biology, algebra and physics skills.

Learning Objectives
After this lesson, students should be able to:
- Understand the equations of motion, displacement, velocity and acceleration
- Apply the equations of motion to the motion of organisms in the immune system microenvironment.

Introduction / Motivation
(Start by showing a video clip showing for example a killer T cell attacking cancer cells). Can you describe what happened in that video clip? What kind of motion were the cells exhibiting, in other words, was it a constant velocity motion, an accelerated motion or other kind of motion? How can an engineer based on his knowledge help extract information from these videos that can aid in understanding the motion of these cells? How can an engineer quantify the motion of these cells, in other words compute the displacement, speed and acceleration of the cells? Do you think it is a difficult task to calculate these measurements?

Lesson Background & Concepts for Teachers

There are a variety of quantities associated with the motion of objects - displacement (and distance), velocity (and speed), acceleration, and time. Knowledge of each of these quantities provides descriptive information about an object's motion.

The kinematic equations are a set of four equations that can be utilized to predict unknown information about an object's motion if other information is known. The equations can be utilized for any motion that can be described as being either a constant velocity motion (an acceleration of 0 m/s/s) or a constant acceleration motion. They can never be used over any time period during which the acceleration is changing. Each of the kinematic equations includes four variables. If the values of three of the four variables are known, then the value of the fourth variable can be calculated. In this manner, the kinematic equations provide a useful means of predicting information about an object's motion if other information is known. For example, if the acceleration value and the initial and final velocity values of a cell are known, then the displacement of the cell and the time can be predicted using the kinematic equations.

The four kinematic equations that describe an object's motion are:

$$d = v_i\, t + \frac{1}{2}\, a\, t^2$$

$$v_f^2 = v_i^2 + 2\, a\, t$$

$$v_f = v_i + a\,t$$

$$d = \frac{v_i + v_f}{2}\,t$$

There are a variety of symbols used in the above equations. Each symbol has its own specific meaning. The symbol ***d*** stands for the ***displacement*** of the object. The symbol ***t*** stands for the ***time*** for which the object moved. The symbol ***a*** stands for the ***acceleration*** of the object. And the symbol ***v*** stands for the ***velocity*** of the object; a subscript ***i*** of the ***v*** indicates that the velocity value is the ***initial velocity*** and a subscript ***f*** indicates that the final velocity value is the ***final velocity.***

Vocabulary / Definitions

Word	Definition

Associated Activities

Modeling Immune System Cell 2-Dimensional Motion

Lesson Closure

Assessment

Quiz on kinematics: See attachments.

Lesson Extension Activities

Additional Multimedia Support

References

Immune cell movies: Von Andrian Lab, CBR Institute Harvard Medical School, http://labs.idi.harvard.edu/vonandrian/Pages/Henricksonvideos-NI.htm

Killer T-cell attacking Cancer cell movie: http://www.youtube.com/watch?v=jgJKaP0Sj5U

Attachments

Modeling Immune System Cell 2-Dimensional Motion (doc)

Quiz on kinematics (doc)

Other

None

Redirect URL

None

Contributors

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Supporting Program