Let's All Do The Wave!

Video Title:
Arthropod Locomotion: Engineering

Activity Subject: Evaluating how the movement wavelength of various animals relates to relative speed
Grade Level: 9 – 12 grades

Introduction
This lesson consists of a cross disciplinary activity incorporating aspects of wave characteristics from Physics, movement traits from Biology, and evaluating locomotion design from Engineering. Students can be introduced to the idea by showing the video *Arthropod Locomotion: Engineering* from the shapeoflife.org or other videos of animals that exhibit wave-like characteristics during motion. Class discussion can begin by analyzing the necessity to move efficiently and how moving in a wave-like manner could be beneficial. Students then discuss how this motion can be compared to the relative speeds of the animals. This can be done through researching the body length, l, of each animal, the top speed, v, and the "wavelength," λ, of their motion. The wavelength can be estimated by counting the number of wavelengths present and dividing the body length by this number. Students can then decide which values or ratios to plot against each other to properly represent the relationship (ex. the ratios $\frac{\lambda}{l}$ vs. $\frac{v}{l}$). The resulting graphical relationship of this data can be analyzed to determine which animals have evolved this trait the best and how this characteristic may be developed in locomotion of machines.

Assessments
Written and Oral

Time
60+ minute lesson

Group Size
Varies: single student, small group, or the whole class

Next Generation Science Standards
Performance Expectations:

Physics
HS-PS4-1. – Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Biology
HS-LS4-2. – Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

Engineering
HS-ETS1-2. – Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Learning Objective:
Students use research, mathematical modeling, and analysis skills to evaluate the effectiveness and engineering advantages of wave-like motion characteristics in various animal species

Let's All Do The Wave! Teacher's Edition

Materials, Preparation, and Procedures

Materials and Preparation:

- Access to the Internet. You will be referencing at least one video: *Arthropod Locomotion: Engineering* [Under Topics click on Other Topics, click on Arthropod Locomotion: Engineering. (7:15 minutes)]
- Access to graph paper or even better a white board or set of white boards.

Procedure:

1. Have students watch the video *Arthropod Locomotion: Engineering* (or other video showing wave-like motion in animals) either by themselves, pairs, or as a whole class.
    a. As they watch have students take notes about interesting aspects about the motion of the animals.
2. Students get into small groups to discuss benefits of this type of motion from an evolution and survivability standpoint.
    a. Come together as a class to list ideas
3. As a class, come up with characteristics to compare and analyze the motion of animals.
    a. Since animals vary largely in size, a good comparison would be the ratio of wavelength to body length, $\frac{\lambda}{l}$, versus the ratio of top speed to body length, $\frac{v}{l}$. This relates the relative size of motion to the relative rate of motion.
4. Groups then decide on animal types they want to analyze (ex. up down motion of inchworms, slithering of snakes, etc.)
    a. Combining motion of two different types offers extra challenges for comparison due to an increase in variables (ex. travelling through water or on land). This is a good chance to discuss experimental and analytical constants.
5. Groups research the characteristics of the various species of the chosen type.
6. Students calculate ratios (or chosen comparison characteristics) and represent them on a data table.
7. Groups plot data on white boards and present findings to the class.
8. New small groups can then analyze the plotted results and come together as a class to determine if there is a correlation between the comparison characteristics.
9. Lesson ends with a discussion about the possible uses of this analysis in the creation of technology that requires locomotion.

Let's All Do The Wave! Student's Edition

Materials, Preparation, and Procedures

Materials and Preparation:

- Access to the internet. You will be referencing at least one video: *Arthropod Locomotion: Engineering* [Under Topics click on Other Topics, click on Arthropod Locomotion: Engineering. (7:15 minutes)]
- Access to graph paper or even better a white board or set of white boards.

Procedure:

1. Watch the video *Arthropod Locomotion: Engineering* (or other video showing wave-like motion in animals).
2. Get into small groups to discuss benefits of this type of motion from an evolution and survivability standpoint.
3. Come up with characteristics to compare and analyze the motion of animals and share with the class.
4. Decide as a group what type of animal you want to analyze (example: up down motion of inchworms, slithering of snakes, etc.).
5. Research the characteristics of one animal of the chosen movement type.
6. Calculate chosen comparison characteristics and post data onto a data table.
7. Plot the data on a piece of graph paper and on a whiteboard to display for the class.
8. Analyze the plotted results and come together as a class to determine if there is a correlation between the comparison characteristics.
9. Discuss the possible uses of this analysis in the creation of technology that requires locomotion.