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2017

Investigating Patterns Using Analyzing Digital Images (ADI) Software

Jennifer Welborn

Amherst Regional Middle School, welbornj@arps.org

Wayne Kermenski

Hawlemont Regional School, wkermenski@gmail.com

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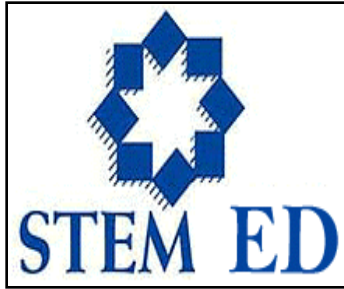


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Welborn, Jennifer and Kermenski, Wayne, "Investigating Patterns Using Analyzing Digital Images (ADI) Software" (2017). *Patterns Around Us*. 6.

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ADI Investigations

1: Analyzing patterns of variation in populations

NGSS:

- MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
- HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

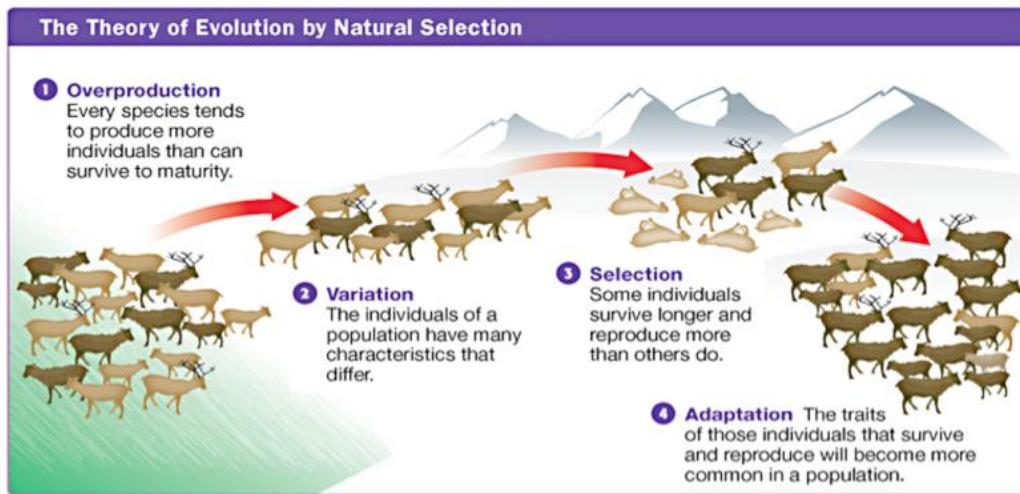
Introduction:

Means and Variation in a Population

A population of organisms almost never consists of individuals that are all exactly alike. For example, you have probably noticed quite a bit of variation in the size, shape, color and firmness of apples in a grocery store bin. Nevertheless, if you were to describe apples, you might describe one that had a size, shape, color and firmness that were not particularly extreme but which you felt best represented apples in general. Such an apple would be an average, or mean, with respect to the particular traits you used to describe it. In biology, the mean value is useful for a number of reasons. It helps naturalists describing and classify organisms. Second, the mean can be used for comparing populations or samples.

However, despite our tendency to think about average organisms, for some traits there remain considerable variation among individuals in a population and this variation is very important to the evolution of species. Darwin was the first to understand the importance of such variation in organisms that is an important component of natural selection.

The mean and variation of a population are easily seen by graphing the number of individuals that have a trait of a given value. In this experiment, we will investigate color variation found in a mealworm population using ADI.



Pre-lab question.

In the natural selection diagram presented, identify why it is beneficial for a population to have variation in traits.

Purpose:

Using ADI, we will examine whether there is variation in the color of a small population of mealworms.

Materials:

- Camera
- 20 mealworms
- Area with good lighting in order to take good pictures
- Computer with ADI program
- ADI Manual

Procedure for taking a picture of a mealworm population:

1. Designate an area with good lighting in order to take pictures of your mealworm population.
2. Place 20 mealworms in a petri dish.
3. Take a picture 30 cm from the mealworms. Make sure the picture is clear.
4. Use ADI program to assess the average color for each mealworm found in your population. In order to accomplish this, follow the instructions outlined in the ADI manual. Record the average color for each mealworm in the table below.

Data:

Mealworm	Average Color
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Mealworm	Average Color
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Results:

Identify the range for the average color value for your population. Recall range can be calculated by subtracting the smallest value from the largest value.

Once the range has been identified, create interval values for the data that will best represent the pattern of variation. For example, if the range was 20, a good interval may be 4; 30-34, 34-38, 38-42, 42-46, and 46-50. However, you will have to use your judgment on this one.

Conclusion:**Examining the results from your graph.**

1. Did you find color variation in the mealworm population?
2. How does variation of a trait within a population relate to the theory of natural selection? Please use the mealworm population as an example.

ADI Investigation 2: Branching pattern in the small intestines

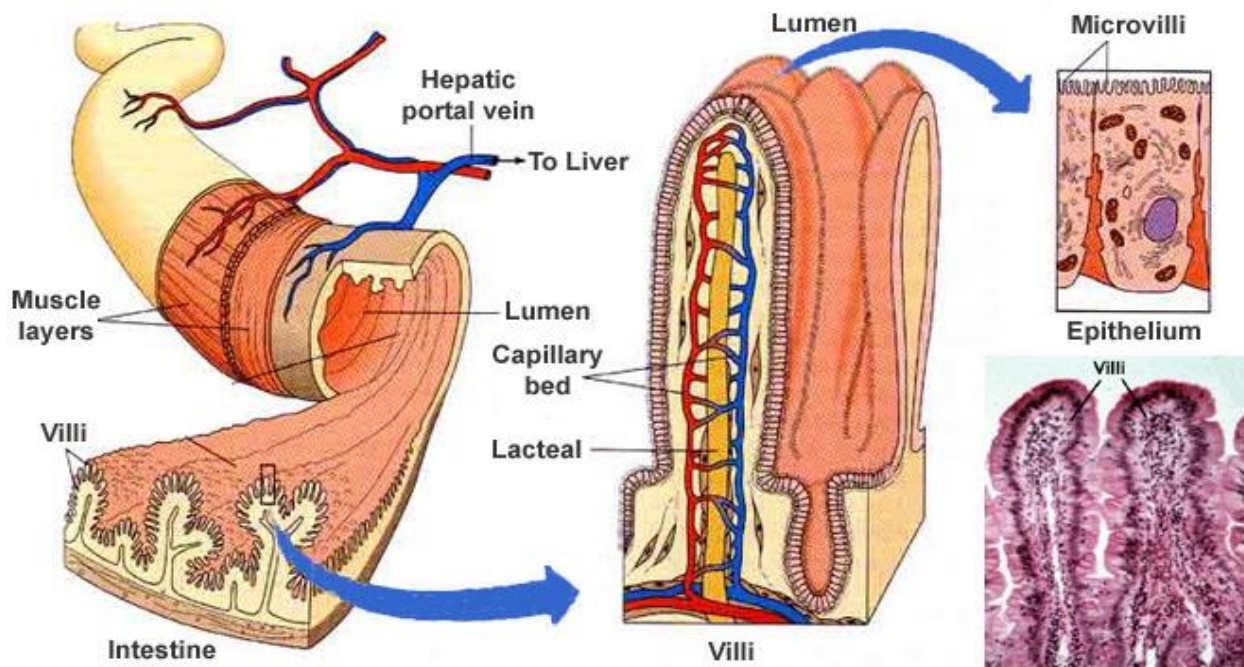
NGSS

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Introduction:

The main function of the digestive track is to absorb nutrients from the food organisms eat. One mechanism by which the digestive system accomplishes this is by increasing the surface area of the intestines. Let's use a sponge as an example. If you spilled milk on the floor, the best way would be to get as much surface area of the sponge in contact with the milk. In doing so, you will be able to soak up the milk more efficiently. How your digestive tract improves its surface area is by folding the outer surface many times over similar to a wave pattern. These folds are referred to as villi and microvilli. Please refer to the picture below.



Purpose:

In this investigation, we will use digital images and ADI to measure the increased surface area created by villi located in the small intestines.

Name: _____

Assignment: ADI Pattern investigations

Materials:

- Computer with ADI
- Real picture of villi tissue

Procedure:

1. Download a real picture of villi from the google images and save it to your desktop.
2. Refer to the ADI manual for importing and measuring images.
3. Using the measuring tool, measure the distance of the villi image from one end to the other.
4. Using the measuring tool, measure the surface length of the villi.

Data:

Length of the image from one side to the other: _____

Length of the villi surface: _____

Results:

By how many times more do villi increase the surface area of the small intestines?

Conclusion:

1. What effect do you think microvilli have on the surface area of your small intestines?
2. Look up how much surface area of an average person's small intestine. Before you do that, what do you think the area is? _____ Were you close? _____
3. Review: What is the main purpose of the digestive tract? In a few sentences, explain how our body has evolved to make this function possible?

ADI Investigation 3: Buckling and tree height patterns

NGSS:

- MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
- HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
- HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

Introduction:

Buckling Strength

The maximum height of a vertical column can be determined by Young's modulus of the material and the radius. This can be calculated by the formula below:

$$I_{cr} = cr^{2/3}$$

l = height of the column
 c = constant of a material
 r = radius of the column

Buckling Strength and Structural Design in Nature

It is a competitive advantage for trees to grow tall and capture as much sunlight as possible. But, is there a limit to how tall a tree can grow? What determines how tall a tree can grow?

Following the principles of natural selection, trees that have the trait for tallness but do not have the ability to handle the force created by this trait could buckle, die and not pass on their tallness trait to the next generation. Therefore, there may be a relationship between tallness and trunk diameter for trees. In this Investigation, we will examine whether there is a limit to how tall a tree can grow given its trunk diameter.

Using analyzing digital images (ADI) one can take a picture of a tree and measure various tree dimensions. In order to accomplish this, the picture needs to have a known length within the picture as a reference and the picture should be taken on relatively flat ground.

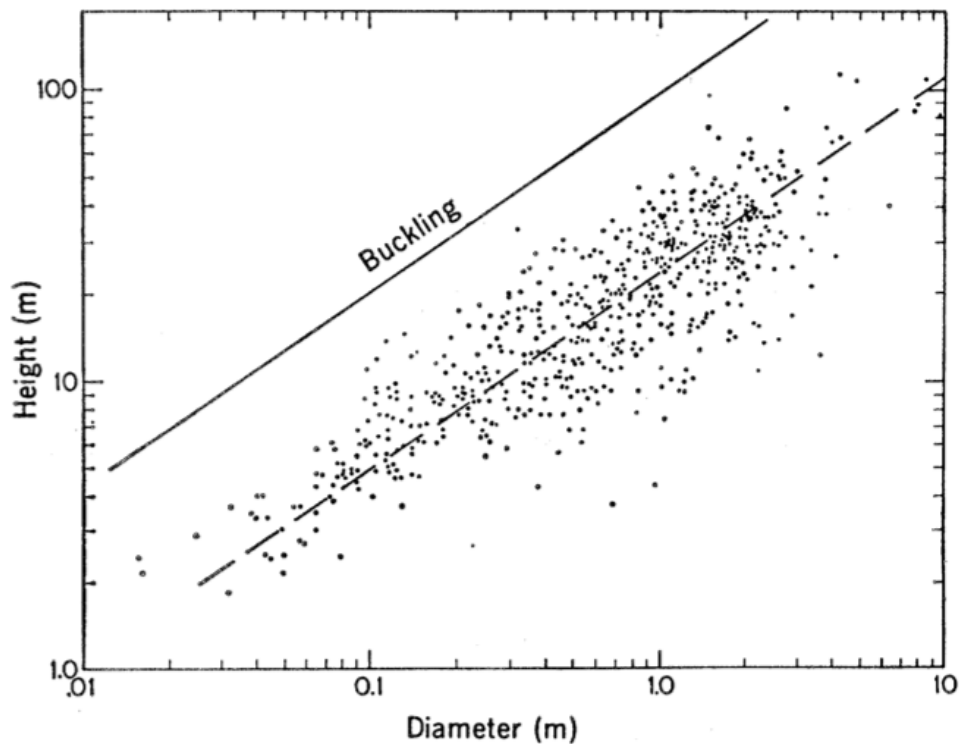
Results:

In the final column of the data table, please solve for “c” using each group’s measurements. Please attach a separate piece of paper showing your calculations.

Conclusion:

1. Was the constant “c” consistent for each tree? Why? Why not?
2. Research has shown (MCMAHON, T.A. 1973. Size and shape in biology. Science 179: 1201-1204.) that $c = 34.9 \text{ m}^{1/3}$. Was the mean for the class result similar to the previous result?

McMahon’s data on tree buckling is shown below.



3. Do you think trees abide by physical principles in regards to their height?
4. Could the correlation between height and trunk diameter be an evolutionary adaptation?