

Vitruvian Man Meets the Scientific Method

Writing and Testing Appropriate Hypotheses

About this Lesson

This is an excellent introductory lesson on testing hypothesis and taking accurate measurements.

This lesson is included in the Biology Module 5.

Objectives

Students will:

- Devise and test a hypothesis regarding Vitruvius' human proportions theory.
- Devise and test a hypothesis regarding the relationship between foot and forearm lengths.
- Gather data from other students in the classroom to increase sample size.

Level

Biology

Common Core State Standards for Science Content

LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, *Framework for K–12 Science Education*, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

Code	Standard	Level of Thinking	Depth of Knowledge
(LITERACY) RST.9-10.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.	Apply	II

CONNECTIONS TO AP*

AP Biology: This lesson addresses concepts contained in Science Practices 4 and 5 in the revised AP Biology curriculum.

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Materials

Each lab group will need the following:

calculator, TI[®] graphing
meter stick
string

Assessments

The following types of formative assessments are embedded in this lesson:

- Visual assessment of measuring techniques used within the lesson
- Sharing class data

Teaching suggestions

Students find hypothesis writing to be impersonal at times. This activity has students design hypotheses that can be accepted or rejected based on data from their own body. Have students measure across the back to avoid boy/girl problems.

REFERENCES

Miller, Kenneth and Levine, Joseph. *Biology*. Pearson Education, Inc. pp. 8–10

Greenberg, John, Revision editor. *BSCS Biology, A Molecular Approach*. Chicago: Everyday Learning, 2001. pp. 8-9

Answer Key**Data and Observations**

The data for Table 1, Table 2, and Table 3 will vary from class to class. The data typically do not support Vitruvius' theory.

Table 1. Lab Partner Data			
	Arm Span (cm)	Height (cm)	Difference (cm)
Your measurements	165.1	167.6	2.5
Your partner's measurements	167.5	157.4	10.1

Table 2. Class Data			
Person (M/F)	Arm Span (cm)	Height (cm)	Difference (cm)
Tanica (F)	163.4	164.4	1.0
Jackie (F)	158.6	160.6	2.0
Ryan (M)	170.5	168.7	1.8
Marilyn (F)	165.0	154.9	11.1
Labrisa (F)	167.1	159.0	8.0
Derk (M)	170.3	173.4	3.1
Sandy (M)	164.2	165.8	1.6
Jamie (F)	159.4	159.3	0.1
Hector (M)	166.6	170.1	3.5
Paige (F)	152.4	150.6	1.8

Answer Key (continued)

Person (M/F)	Length of Foot (cm)	Length of Forearm (cm)	Difference (cm)
Carolyn (F)	22.0	26.6	4.6
Denise (F)	25.4	27.9	2.5
Fred (M)	25.5	25.1	0.4
Kirbo (F)	24.8	28.4	3.6
Shonda (F)	20.5	24.2	3.7

Answer Key (continued)

Conclusion Questions

1. Answers will vary based on student measurements.

The example data varies. There was a difference of 2.5 cm in the student's measurements and a difference of 10.1 cm in their partner's data.

2. Answers will vary based on student measurements.

The lab group data for the example varies, and so does the rest of the groups' data.

3. Answers will vary based on student measurements but the data typically do not support Vitruvius' theory.

The example data does not support Vitruvius' hypotheses because every person's data shows variation.

4. Answers will vary based on student measurements.

Males in this example class have less variation in the measurements than do females.

5. Students should indicate whether or not the hypothesis is supported or not supported by the data collected. The data collected in this investigation does not support Vitruvius' theory.

6. Answers will vary based on student measurements.

In the example data, there was a 2.5 cm and 4.6 cm difference in the measurements when comparing foot measurements to forearm lengths.

7. Sample size is important to add validity to the conclusions drawn from the data.

8. There is not a direct correlation between the length of the forearm and foot length.

Students should indicate whether or not the hypothesis is supported or not supported by the data collected.

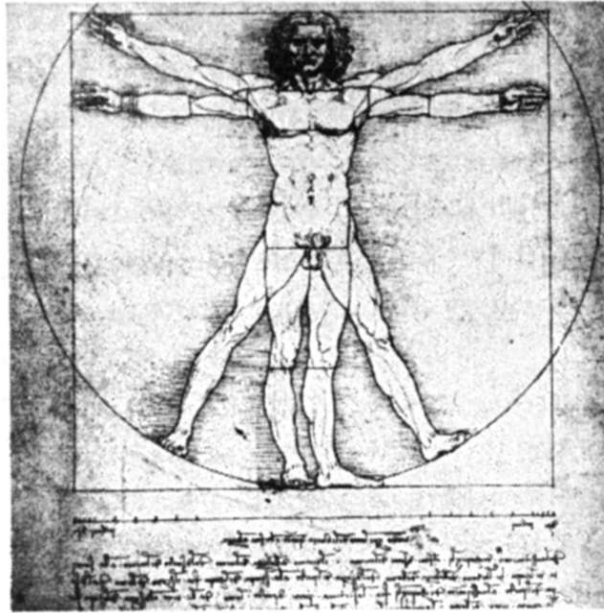
Extension

The independent variable should be the range of heights in 10-cm increments and the dependent variable should be the number of students within that range.

***Vitruvian Man* Meets the Scientific Method**

Writing and Testing Appropriate Hypotheses

Leonardo da Vinci's drawing *Vitruvian Man* shows how the proportions of the human body fit perfectly into a circle or a square. This diagram by Leonardo da Vinci is an illustration of Vitruvius' theory. According to Vitruvius' theory the distance from fingertip to fingertip (arm span) should be equal to the distance from head to heel (height). In this activity you will explore the legitimacy of Vitruvius' theory by developing a hypothesis regarding *Vitruvian Man*.



A hypothesis is a possible explanation for a set of observations or an answer to a scientific question. A hypothesis is useful only if it can be tested. Testable hypotheses are generally written in a formalized format using an *if-then* statement. For example;

- If my car does not start because the battery is dead, then when I replace the old battery with a new one, it will start.
- If increasing physical activity causes a person to burn calories and lose weight, then I should lose weight when I run 2 miles a day.

Formalized hypotheses contain both a dependent and an independent variable. The independent variable is the one that you change and the dependent variable is the one you observe and measure to collect data. Consider a hypothesis that says "If the temperature is decreased, then the lizard will take longer to travel from point A to point B". In this example, temperature is the independent variable because the experimenter controls it and time is the dependent variable because the time required for movement is being measured. Using the *if-then* format forces the scientist to think about what results are expected.

PURPOSE

In this activity you will devise and test a hypothesis regarding Vitruvius' theory on human proportions. In Part II, you will devise and test a hypothesis concerning the relationship between foot and forearm lengths.

MATERIALS

Each lab group will need the following:

calculator, TI[®] graphing
meter stick
string

PROCEDURE

PART I

1. Write an *if-then* hypothesis based on Vitruvius' theory relating arm span and height. Record your hypothesis on your student answer page in the space labeled Hypothesis #1.
2. Working with a partner, measure your arm span by standing against a flat surface and spreading your arms out as far as possible. Using the string, have your partner measure the distance from the longest finger on one hand to the tip of the longest finger on the other hand across your back. Measure this length on the meter stick. Record your measurements in Data Table 1.
3. Repeat step two on your partner.
4. Remove your shoes and have your partner measure your height as you stand against a flat surface. Measure the distance from the top of your head to the floor with the string. Measure this length with the meter stick. Record your measurements in Data Table 1.
5. Repeat step 4 on your partner.
6. Calculate the difference between your arm span and your height (arm span – height). Record your calculations in Data Table 1.
7. Gather data from 10 additional students in the classroom. Record the students' name, gender and data in Data Table 2.

PART II

1. Some people have observed that the length of their foot is the same as the length of their forearm. Others disagree saying there is no relationship between the two. You have been assigned to investigate this phenomenon. As a good scientist, you know that the first thing you need to do is write a hypothesis. Is there a direct relationship between the length of a person's foot and the length of their forearm? Write an *if-then* hypothesis for this relationship on your student answer page in the space labeled Hypothesis #2.
2. Collect foot-forearm data from five people and record the measurements in Data Table 3.

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HYPOTHESIS #1

HYPOTHESIS #2

DATA AND OBSERVATIONS

Data Table 1: Lab Partner Data (cm)			
	Arm Span	Height	Difference
Your measurements			
Your partner's measurements			

Data Table 2: Class Data (cm)			
Person (M/F)	Arm Span	Height	Difference

Data Table 3: Foot Length/Forearm Length Comparison (cm)			
Person (M/F)	Length of Foot	Length of Forearm	Difference

CONCLUSION QUESTIONS

1. Does your individual data for height and arm span support Vitruvius' theory? Why or why not?

2. How do your height and arm span results compare to other groups in the class? Explain.

3. Does the class height and arm span data support Vitruvius' theory? Why or why not?

4. When comparing males and females, does one group fit Vitruvius' theory more closely than the other? Explain your answer.

5. Write a conclusion statement based on the data that you have collected for Hypothesis #1.

6. Based on the data that you have collected is there a correlation between the length of the forearm and the length of the foot? Explain your answer.

7. Why was it necessary to collect data from other students in the class?

8. Write a conclusion statement based on the data that you have collected for Hypothesis #2.

EXTENSION

Construct a histogram of the heights of the students in your classroom.