InvestigationWksht01.pdf

02_Measurement_in_Biology_Prep.pdf

Exercise_02.pdf

INVESTIGATION WORKSHEET 1

Name ____________________

How Temperature Affects the Production of CO_2 by Yeast

Observation: Fermentation of nutrients by yeast produces CO_2, and the production-rate of this CO_2 can be used to measure growth of the yeast. In this lab you've already investigated how CO_2 production is affected by different nutrients (i.e., sugar, protein).

Formulate and record a question regarding temperature how it influences CO_2 production by yeast.

____
____
____

Write a your null hypothesis for this experiment:

____
____

Write an alternate hypothesis for this experiment:

____
____

Identify the independent variable:____

Identify the dependent variable:____

Describe your experimental design and procedures. Identify your control and experimental groups. Remember to keep the single variable difference between your control and experimental groups, and specify how you will analyze your data.

What safety procedures should you be sure to incorporate in your methodology?______________________________

____

____

Results:

What would be an appropriate way to graphically represent your data?____

Do your data support your null or alternate hypothesis? ____

Answer your question:____

____

What ideas do you have for experiments that will build on this experiment?_______________________________________

____

____

____

Comments:____

____

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(Exercise 2) Before you arrive for the *Measurements in Biology* lab exercise, please

1. **Read the lab thoroughly. Note all safety guidelines.**

2. **Answer these preparatory questions:**

What safety procedures must you follow during this lab period?

____

____

____

Identify the metric base units for:	State the value of each of these prefixes:
length______________________	centi___________________________
mass________________________	milli___________________________
volume______________________	micro___________________________
temperature__________________	micro___________________________
	nano___________________________

How many liters of cola are left in a 12-ounce can that is half full? Show your work.

You walk 4.5 feet to reach the sink in the lab. How many centimeters did you walk? Show your work.

How is area calculated? ____

What is a meniscus?____

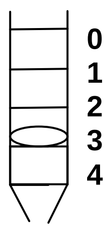
Why is it important to read the volume of a graduated cylinder at eye level?

____

Imagine that you are a biologist who needs to obtain fast and accurate measurements of tadpoles in a natural population. In the field you cannot access an electronic balance, but you do have a graduated cylinder. How could you measure the size of the tadpoles in the field?

____

____



If the meniscus in a 5 mL pipet is at 3 mL, how much liquid is in the pipet? ____

What is the formula for density? ____

Consider these measurements of the lengths of leaves from a plant you are studying in lab:

2.51 cm	**What is the mean?** ________________
1.10 cm	**What is the median?** _______________
5.35 cm	**What is the range?** ________________
0.79 cm	**What is the variance?** ______________
4.95 cm	**What is the standard deviation?** ____
1.32 cm	
1.82 cm	

The mean and median are not identical. What does this tell you about your data? ____

Keeping in mind what you read about significant figures and measurements, you measured the leaves with a 10 cm ruler having 1-mm divisions. What would be the smallest definite (not estimated) measurement that could be read from the instrument used to measure length?

Multiply 10.232 × 44.50342. Record your answer with the correct number of significant digits. Explain your reasoning.

Would it be equally correct and appropriate to represent the number 100 as 100.00? Explain your answer.

Exercise 2

MEASUREMENTS IN BIOLOGY: THE METRIC SYSTEM AND DATA ANALYSIS

This is a simple lab exercise, that includes information about the metric system, but we've found that well over half of our students do not understand the concepts of mean, range, median, and variance. The most critical words to be defined in an introduction to the lab exercise are central tendency and variation. Biology is filled with variation and students must learn not only to document variation, but to view variation as part of natural processes rather than a sign of error. The basic theme of this exercise is that understanding any biological data set begins with measures of central tendency (mean, median, mode) and measures of variation about the mean (range, variance, standard deviation).

SUGGESTED ELEMENTS FOR AN INTRODUCTORY LECTURE

- Quantification of data is essential for good science.
- The natural world, especially the life sciences, is filled with variation.
- Natural variation often makes simple observation inadequate for study of living processes.
- To deal with variation, biologists employ the scientific method and careful quantification of data.
- The most conventional and widely used tool to express scientific data is the metric system.
- The metric system need not replace the English system in all walks of life. But, it is a powerful and efficient tool for calculation-intensive sciences.
- Scientists rarely convert from one system to the other. Instead, they work within the metric system. Learning to do conversions within the metric system is more important than conversions between systems.
- Metric units include measures of length, volume, mass, and temperature, and are based on multiples of ten.
- The initial and most fundamentally important analysis of a data set is to determine the central tendency (mean, mode, and median) and the variation (range, variance, standard deviation) inherent in the data.

INVESTIGATIVE PROCEDURE

- Inventory/survey class on what supplies are needed for this procedure:

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____

____

____

ACTIVITIES

1. Make metric measurements of length, width, volume, mass, and temperature for common objects.
2. Calculate mean, median, range, variance, and standard deviation for example data.
3. Gather and statistically summarize a data set of student heights.

VOCABULARY

density	kilogram	mean
median	meniscus	meter
metric system	range	standard deviation
statistics	sum of squared deviations	variance
volume		

MATERIALS FOR ALL PROCEDURES

Number of lab sections ___________ Total work groups ___________

Work groups per section ___________ Students per work group ___________

TIME LINE FOR LABORATORY PREPARATION

Beginning of the semester:

Determine the number of sections, work groups, and students in the course.
Inventory supplies and, if necessary, reorder supplies.
After the supply of each material is verified, check off the supply in the spaces in the list(s) below.

Two weeks before lab:

Determine how many work groups you will have.
Verify that the needed quantities of disposable supplies are available.

One–Three days before lab:

Place beaker of tap water in refrigerator.
Distribute materials to each work station.

One hour before the lab:

Fill the ice chest with crushed ice.
Heat water if hot tap water is not available. A large flask of water should be fine for the entire class.

		Quantity Needed		
√	**Materials**	**Total**	**Per Group**	**Catalog Number**
	Equipment			
___	triple beam balance	________	_______	15 W 6057
___	refrigerator	________	_______	
___	calculator or computer	________	_______	

___ small open-topped ice chest	_______	______	
Supplies: one set per group			
___ meter stick or metric tape measure	_______	_______	
___ common items to measure (coffee cup, book, nickel, paper clip, golf ball)	_______	_______	
___ 10-ml graduated cylinder	_______	_______	18 W 1705
___ 100-ml graduated cylinder	_______	_______	18 W 1730
___ 100-ml beaker	_______	_______	17 W 4020
___ 10-ml pipet	_______	_______	17 W 1308
___ 5-ml pipet	_______	_______	17 W 1307
___ pipet dispensing bulb	_______	_______	15 W 0511
___ gallon jug (milk jug)	_______	_______	
___ eye dropper	_______	_______	
___ centigrade thermometer	_______	_______	
___ pencil	_______	_______	
___ marble	_______	_______	
___ small rock (1”)	_______	_______	
Solutions			
___ hot, cold, and refrigerated tap water	_______	______	

Comments on Procedures

- A guide to the metric system and conversions may be helpful in addition to the information provided in the lab manual.
- We also provide a few objects of unknown mass, volume, and dimensions for the students to measure. The class results are put on the board, collated, and the variation is discussed.
- Unless otherwise noted, all catalog numbers are Ward’s Natural Science. Comparison shopping at the following scientific companies might save you money on some supplies:
    - Carolina Biological Supply Company, www.carolina.com
    - Fisher Scientific, www.fishersci.com
- Safety first: Be sure and cover any safety issues that may be specifically related to this lab procedure.

Answers to Questions

1. a**.** Can measurements be accurate but not precise? Explain.
Yes, if the mean of the values is “true”, but the variation is high and scattered.

b. Can measurements be precise but not accurate? Explain.
Yes, if the measurements are all similar (low variation), but the mean of those measurements is far from the "true" value.

2. Make the following conversions.
1 meter = 100 centimeters = 1000 millimeters; 92.4 millimeters = 0.0924 meters = 9.24 centimeters; 10 kilometers = 10,000 meters = 100,000 decimeters; 82 centimeters = 0.82 meters = 820 millimeters; 3.1 kilograms = 3,100 grams = 3,100,000 milligrams; 281 milliliters = 0.281 liters = 2.81 deciliters; 35 millimeters = 3.5 centimeters 0.035 meters

3. What are some potential sources of error in your measurements?
angle of vision, building, posture when measuring height, variation in dimensions of a page, table, room, ceiling, mistakes in reading the ruler, etc.

4. What volume of liquid did you measure?
Variable

5. **a**. Density is mass per unit volume. Use data that you've gathered to determine the density of water at room temperature.
Density of water = (mass/volume = 1 gram / 1 milliliter)

b. What is the density of the wooden pencil? Does it float? Why?
Because wood is less dense than water, the pencil will float. The density of the pencil will vary.

c. What is the density of the rock? Does it sink? Why?
Because the rock has a higher density than water, it will sink. The exact density of the rock will vary.

6. **a.** Does the mean always describe the "typical" measurement? Why or Why not?
No, because the mean can be dramatically affected by a single, extreme atypical measurement. And, the mean may be calculated to a portion of a single unit; i.e., the mean number of children per family is 2.3, but no family actually has 2.3 children.

b. What information about a sample does a mean *not* provide?
It does not provide information about variation, range, and extremes on either side of the mean.

7. **a.** What is responsible for this difference between the mean and median?
The distribution of numbers throughout the range is uneven.

b. How would the median change if the 9-mm-long leaf was not in the sample?
The median would not change.

c. How would the mean change if the 9-mm-long leaf was not in the sample?
The mean would change from 58.6 to 62.4.

d. Consider these samples. What is the mean for sample 1? Sample 2?
Both means = 30.

8. **a.** Could two samples have the same mean but different ranges? Explain.
Yes, the mean does not reflect the distribution of sample values.

b. Could two samples have the same range but different means? Explain.
Yes, uneven distributions of numbers within the same range could produce different means.

9. **a**. What does your calculation tell you?
Conclusions vary (males usually taller than females, range for males usually greater than range for females, etc.).
b. What are the limitations of your sample?

There can be great variation in small sample sizes.

Questions for Further Thought and Study

1. What are the advantages and disadvantages of using the metric system of measurements?
   Base 10 of units, easy to convert between scales.
   Unfortunately many scientists and businesses are in countries using the English standards of units and measurement scales.
2. Why is it important for all scientists to use a standard system of measures rather than the system that may be most popular in their home country or region?
   Good science must be repeatable.
   Standards assist scientists from different countries who are working together to repeat investigations. Their cooperative effort and repetition of the experiments strengthen the validation of the results.
3. Do you lose or gain information when you use statistics to reduce a population to a few characteristic numbers? Explain your answer.
   Fewer examples in regulation, greater the rise of detecting a difference when none really exists.
   One loses information. A few "characteristic numbers" cannot fully describe the variation among all members of a population.
4. Suppose that you made repeated measurements of your height. If you used good technique, would you expect the range to be large or small? Explain your answer.
   Small. Repeated measures improve technique and thus improve precision and accuracy.
5. Suppose that a biologist states that the average height of undergraduate students at your university is 205 cm plus or minus a standard deviation of 17 cm. What does this mean?
   The mean value is 205 cm. 68% of students range between 188cm – 222cm
6. What does a small standard deviation signify? What does a large standard deviation signify?
   low variation in the data set
   high variation in the data set
7. Is it possible to make a perfectly precise measurement? Explain.
   No, only in theory. Uncertainty in all measurements.
8. When in our everyday lives do we *not* want precise measurements?
   Late for work, utilities rates, physical attributes, age.

ADDITIONAL OUTSIDE RESOURCES

- Measurements in Science (PowerPoint), www.insight-media.com, order no. BAS3650