

## 2010 BIO-PROCESS LAB – TRAINING HANDOUT

By Karen L. Lancour

This is a lab-orientated competition involving the fundamental science processes of a **middle school life-science program**.

BE SURE TO CHECK THE RULES for Event Parameters and suggested topics. It will have the year 2010 before the page number at the bottom of the page

### SCIENCE PROCESS SKILLS

#### **Basic Science Process Skills:**

1. **Observing** - using your senses to gather information about an object or event. It is description of what was actually perceived. This information is considered qualitative data.
2. **Measuring** - using standard measures or estimations to describe specific dimensions of an object or event. This information is considered quantitative data.
3. **Inferring** - formulating assumptions or possible explanations based upon observations.
4. **Classifying** - grouping or ordering objects or events into categories based upon characteristics or defined criteria.
5. **Predicting** - guessing the most likely outcome of a future event based upon a pattern of evidence.
6. **Communicating** - using words, symbols, or graphics to describe an object, action or event.

#### **Integrated Science Process Skills:**

1. **Formulating Hypotheses** - stating the proposed solutions or expected outcomes for experiments. These proposed solutions to a problem must be testable.
2. **Identifying of Variables** - stating the changeable factors that can affect an experiment. It is important to change only the variable being tested and keep the rest constant. The one being manipulated is the independent variable; the one being measured to determine its response is the dependent variable; and all being kept constant are constants or controlled variables.
3. **Defining Variables Operationally** - explaining how to measure a variable in an experiment.
4. **Describing Relationships Between Variables** - explain relationships between variables in an experiment such as between the independent and dependant variables.
5. **Designing Investigations** - designing an experiment by identifying materials and describing appropriate steps in a procedure to test a hypothesis.
6. **Experimenting** - carrying out an experiment by carefully following directions of the procedure so the results can be verified by repeating the procedure several times.
7. **Acquiring Data** - collecting qualitative and quantitative data as observations and measurements.
8. **Organizing Data in Tables and Graphs** - making data tables and graphs for data collected.
9. **Analyzing Investigations and Their Data** - interpreting data, identifying errors, evaluating the hypothesis, formulating conclusions, and recommending further testing where necessary.

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**10. Understanding Cause and Effect Relationships** - what caused what to happen and why.

**11. Formulating Models** - recognizing patterns in data and making comparisons to familiar objects or ideas.

**Process Skills and Tasks Which Might Be Tested**

**Lab Safety**

- Distinguishing "safe" behaviors vs. "unsafe" behaviors, identifying safety symbols, evaluating situations -- what to do "if" or what's wrong.
- Identifying the proper techniques to handle lab emergencies.

**Observations**

- Using senses to notice specific features.
- Identifying similarities and differences in features.
- Identifying qualitative and quantitative changes in conditions.
- Using observable properties to classify objects, organisms or events.

**Inferences**

- Formulating assumptions based upon observations.
- Distinguishing between observations and inferences.
- Using observations and inferences to identify testable questions or problems.

**Problem**

- Using observations to propose a topic for experimentation.
- Narrowing the scope of the topic to specific testable aspects.
- Formulate problems within the specific aspects of the topic which are clearly testable.
- Identify which of the problems can be tested with materials available.
- Generalizing variables to be considered in testing the problem such as "The effect of (the independent variable) upon (the dependent variable.)"

**Hypothesis**

- Proposing a hypothesis for a given problem.
- Predicting the effect of the change in the independent variable upon the dependent variable.
- Explaining the relationship or trend that is expected to occur.
- Providing rationale for a hypothesis or prediction.
- Determining the testability of a hypothesis based upon materials provided.
- Evaluating statements presented with a set of data as to their appropriate label.: **1.** logical hypothesis, **2.** illogical hypothesis of contrary to data, **3.** not a hypothesis, but a restatement of data, **4.** reasonable hypothesis, but not based on data

**Predictions**

- Predicting the results for a proposed lab test or setup.
- Selecting predictions based upon previously observed patterns.
- Providing rationale for predictions.

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### Lab Equipment

- Identifying pieces of lab equipment and their function.
- Identifying appropriate pieces of equipment to perform a specific task.
- Selecting and using the appropriate piece(s) of lab equipment for a task.

### Procedures

- Analyzing procedures for flaws in design.
- Identifying the proper set of equipment for carrying out an experimental procedure.
- Arranging steps of procedures in the appropriate order.
- Determining the repeatability of a procedure.
- Identifying an appropriate procedure to test a problem.

### Design Analysis

- Analyzing designs for experiments relative to problem,
- Evaluating the basic assumptions used in the design of the experiment.
- Identifying components as the independent variable, dependent variable, constants (controlled variables), standard of comparison (control), and time period for the test.
- Evaluating the procedure for repeatability.
- Evaluating the materials and appropriateness of the steps in the procedure.
- Identifying appropriate types of qualitative and quantitative data to be collected.

### Measurement

- Identifying the capacity, range, and increments of measuring devices as a ruler, graduated protractor, caliper, cylinder, pipet, syringe, or thermometer.
- Identifying length, temperature, volume, and mass to the capacity of the instrument.
- Converting units within the metric system.
- Reading the meniscus when measuring liquids in a cylinder.
- Using technology to obtain real world data.

### Balances

- Identifying types of balances as electronic and triple beam.
- Determining the capacity of the balance, its increments, its readability, the types of auxiliary weights, the parts of the balance and their function.
- Determining the mass of an object to the capacity of the instrument.
- Using auxiliary weights to reach the capacity of a triple beam balance.

### Microscopy

- Understanding of parts of microscope & their function, magnification, appearance of images, resolution, changes in field with magnification, types of microscopes and their uses.
- Preparing a wet mount.
- Using a light microscope to perform a requested task.
- Using a dissecting microscope to perform a requested task.

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### Chemical Analysis

- Identifying the appropriate reagents for specific chemical testing.
- Using reagents as pH paper, iodine, glucose test paper, bromthymol blue for chemical analysis.
- Interpreting the results of reagent data.

### Dichotomous Key

- Using observations to formulate a dichotomous/taxonomic key.
- Identifying individuals or objects using a dichotomous key.
- Identifying similarities and differences in characteristics from a dichotomous key.

### Calculations

- Using measurements to determine area, volume, percentages, probabilities, ratios.
- Determine population density of a sample.
- Performing statistical analysis of raw data as mean, median, mode, and range.

### Data Presentation

- Preparing an appropriate data table, chart, diagram, illustration.
- Evaluating the presentation of data.

### Graphing

- Selecting the appropriate graph for a set of data as line, bar, and pie graphs.
- Identifying the title, source, independent variable & dependent variables, and the legend.
- Scaling each axis for a graph.
- Preparing a line, bar or pie graph to represent a set of data.
- Predicting data points not included in a given graph and/or making a best line fit.
- Interpreting a graph and making predictions or inferences based upon the data on a graph.

### Analysis of Data

- Identifying sources of experimental error or human mistakes in the data.
- Determining the validity of results using qualitative and quantitative data.
- Interpreting graphs as well as charts and diagrams as food webs, pedigrees, Punnett squares, food labels, energy and food pyramids, relationships of organisms.
- Identifying data which supports or rejects a hypothesis.
- Identifying discrepancies between stated hypothesis and actual data.
- Understanding cause and effect relationships.

### Errors

- Identifying human mistakes or blunders.
- Identifying experimental errors as systematic errors and random errors.
- Making recommendations for eliminating future mistakes or experimental errors.
- Explaining the effects that human mistakes or experimental errors upon results.

### Conclusions

- Selecting the most logical conclusion for given experimental data.
- Accepting or rejecting hypotheses based upon data analysis.
- Proposing a new hypothesis for rejected hypotheses.
- Formulating models
- Proposing a future test for inconclusive results.

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**STUDENT PREPARATION TIPS**

**Team work skills**

- Use time effectively! Assign tasks and trust your partner's skills.
- Identify and utilize the strengths of each team member.
- Practice working as a team.

**Time limits**

- Practice under competition conditions.
- Practice effective methods of using the strength of each team member to maximize the use of allotted time.
- Make up sample questions and stations to practice completing tasks within an assigned time limit.

**Answering questions**

- Carefully read all questions to determine exactly what is being asked.
- Take a moment to determine if your answer makes sense.
- Be certain that you have completely answered each question.
- Pay attention to details in the questions and in your answers.

**Measurements and Calculations**

- Be sure to analyze the instrument to determine its capacity (range) and increment values to ensure the proper use of the instrument.
- Make measurements to the accuracy of the instrument.
- Select the most appropriate type of instrument for the type of measurement requested.
- Read the increment carefully.
- Be sure to remember any special considerations such as a meniscus.
- Use the same instrument for multiple measurements to improve precision.
- Give your answer in the proper units and be sure to include the units with your answer.
- Be sure calculations are set up and carried out properly.
- Work in a neat organized fashion showing all work where partial credit is possible.
- Be sure your answer makes sense.
- Remember that calculations may be used for breaking ties.

**Reference materials**

- Review the process skills involved in doing life science labs and designing or evaluating investigations.
- Review the identity and appropriate use of common lab equipment.

Use your school's life science textbook and lab manual to help you develop practice lab stations and questions.

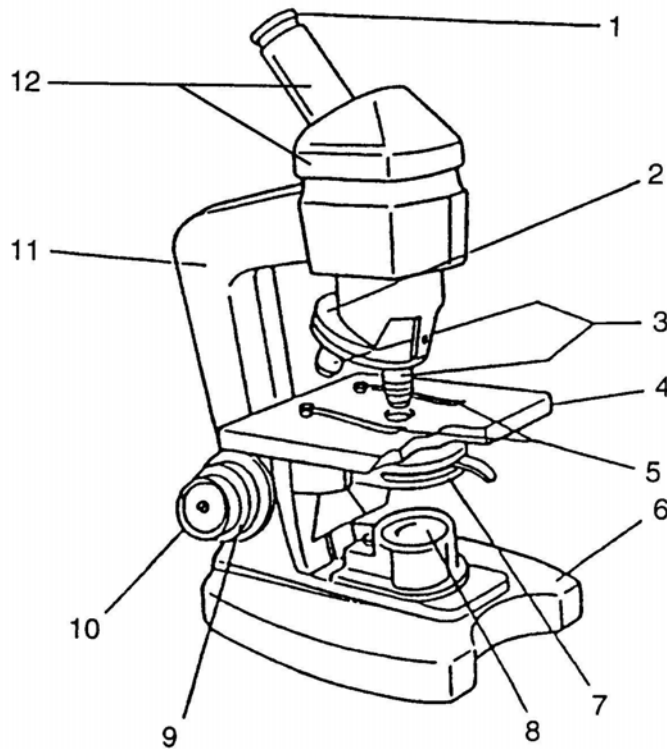
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## Microscopy Review

**I. Parts of the microscope and their function:** The number in front of each part of the microscope represents its number on the diagram.

1. ocular - magnifies the image formed by the objective.
2. nosepiece - holds the objectives.
3. objectives - lenses that receive the light from the field of view and form the first image.
4. stage - supports the slide and the specimen.
5. stage clips - hold the slide in place.
6. base - foundation which supports the scope & keeps it stable.
7. diaphragm - controls the amount of light reaching the specimen.
8. illuminator - source of light.
9. course adjustment - used for initial or low power adjustment.
10. fine adjustment - used for fine tuning & high power focusing.
11. arm - supports the ocular, objectives and body tube.
12. body tube - tube or barrel between the ocular and the objectives.



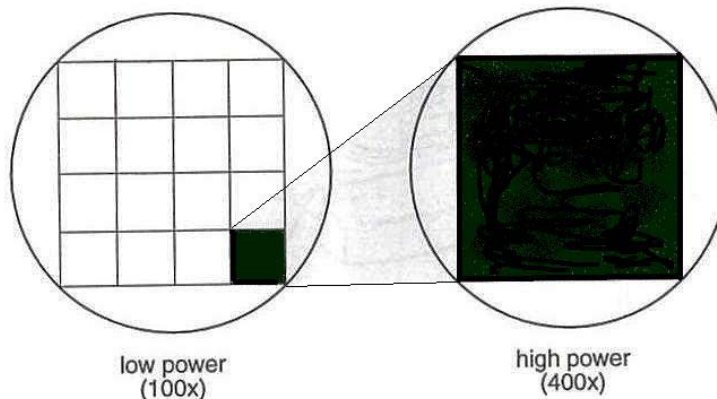
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## Principles of microscopy

- A. Appearance of objects
1. Inverted and reversed (upside-down & backwards)
  2. If an "e" is placed in the stage in its normal position, it will appear as an "ə".
  3. Only a thin layer of the specimen is in focus at any level (depth of focus).
- B. Movement of specimens
1. Actual movement is opposite to appeared direction of movement.
  2. If an organism is actually moving (↗), it will appear to be moving (↙).
- C. Total magnification
1. Multiply ocular magnification times objective magnification.
  2. Oculars are normally 10X or 12X.
  3. Objectives are typically as follows:
    - a. scanning power - 4X or 5X or 6X
    - b. low power - 10X or 12X
    - c. high power - 40X or 43X or 45X
  4. Sample problem: If the ocular is 10X and the objective is 43X, the total magnification is 430.
- D. Changing objectives
1. When changing objectives from scanning power to lower power to high power, the following changes will occur:
    - a. the size of the field of view decreases.
    - b. the field of view is darker.
    - c. the size of the image increases..
    - d. the resolution (ability to separate small details) increases.
    - e. the working distance (distance between coverslip & objective) decreases.
    - f. the depth of focus (thickness of the specimen which may be seen in focus) is reduced.
  2. The relationships of magnification and the fields of view diameter and area ratios are approximately (10 X ocular and listed objective)

<i>objective</i>	<i>total magnification</i>	<i>diameter</i>	<i>area</i>
scanning 5X	50	-	-
low 10X	100	1/2 scanning	1/4 scanning
high 40X	400	1/4 low	1/16 low



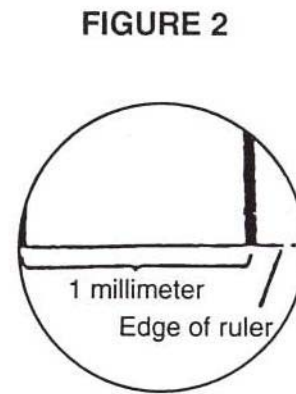
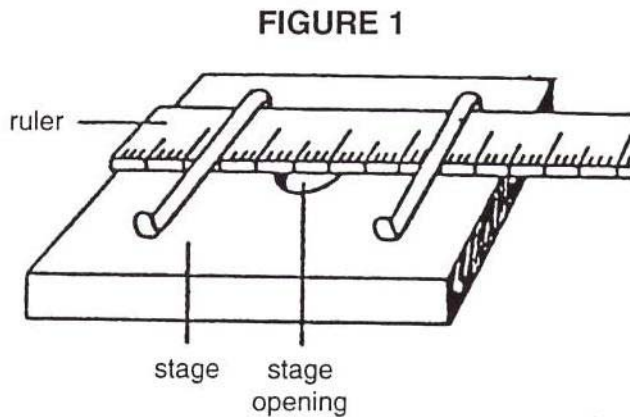
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### Principles of advanced microscopy

#### A. Measuring the diameter of the field of view.

1. Place a transparent millimeter ruler on the stage, hold it down with the stage clips, and observe the ruler in the desired field of view - scanning or low. (See Fig. 1)
2. Focus on the metric edge of the ruler. Hint: applying gentle pressure to the free end of the ruler will help adjust for the thin ruler and allow for better focus.
3. Place the center of one millimeter marking at the left edge of the field of view (see Figure 2) and measure the diameter of the field in millimeters. For reference: Scanning power (50X) is about 3.0 to 3.2 mm and low power (100X) is about 1.5 to 1.6 mm. Sizes will vary with changes in magnification and manufacturer.



4. Convert the measurement in millimeters to micrometers by multiplying by 1000.

Samples:

low power field      1.6 mm X  $\mu\text{m}/\text{mm}$  = 1600  $\mu\text{m}$  or mcm

scanning power field      3.2 mm X 1000  $\mu\text{m}/\text{mm}$  = 3200  $\mu\text{m}$  or mcm

5. The diameter of the high power field is less than one millimeter. It can be calculated from the diameter of the low power field by using the following formula:

$$\frac{\text{high power field diameter}}{\text{lower power field diameter}} = \frac{\text{low power magnification}}{\text{high power magnification}}$$

Sample:

$$\frac{\text{h.p. field}}{1600 \mu\text{m}} = \frac{100}{400} \quad \text{to} \quad \text{h.p. field} = \frac{100 \times 1600}{400} = 400 \mu\text{m or mcm}$$

#### B. Estimating the size of an object.

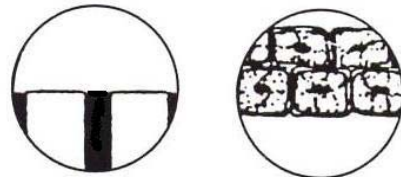
1. Determine the number of cells or objects that would fit across the diameter of the field of view.
2. Estimate the size of the object by dividing the diameter of the field by the number of the objects that would fit across the field.

**Sample:** a. diameter of the field is

$$2 \text{ mm} \times 1000 \mu\text{m}/\text{mm} = 2000 \mu\text{m}$$

b. length of cell "x" is

$$2000 \mu\text{m} / 3 \text{ cells} = 660 \mu\text{m}/\text{cell}$$



A

B

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**Stereomicroscope or Dissecting Microscope**



Dissecting microscopes are stereomicroscopes, instruments that are used for obtaining a three-dimensional view of a specimen. (Stereoscopy is simultaneous vision with two eyes producing a unique vision in which the observer can perceive the relative distances of objects in space.) Stereomicroscopes are essentially two compound microscopes that are both trained on the same sample. Each microscope consists of an objective, a prism-erecting system (which erects the image, and an eyepiece). The angle between the two chambers of the microscope is usually about 10 degrees.

Stereoscopic microscopy has advantages and disadvantages to other microscopes. An obvious advantage is that stereomicroscopes produce a truly three-dimensional image, which can be useful in determining the exact location of objects. For this reason, having a three-dimensional image is important in micro-dissection. Also, stereomicroscopes have a favorable depth of field. Another advantage of stereomicroscopes is that they can be fitted with a fluorescent lamp. Another characteristic of stereomicroscopes is that they have a much lower magnification limit than other microscopes, such as the compound microscope, for instance. The stereomicroscope can magnify an image 100-150 times, while normal compound microscopes can magnify an image 1000-1500 times. This can be a disadvantage of stereomicroscopes, because not as much detail of the image is seen. However, having a lower magnification limit can also be favorable. For example, a lower magnification can allow one to see more of the object than a higher magnification, which makes the object interpreted more easily.

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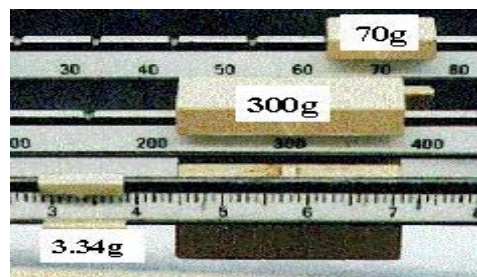
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### Balance Review

**Electronic Balances** – With the electronic balance, an object is placed on the balance pan and the measurement can be read on the display to tenth or hundredths of a gram depending on the incrementation of the balance. The Zero button or tare button on the front of the balance resets the balance to Zero. If a container is placed on the pan, hitting the Tare or Zero button will reset to zero and ignore the mass of the container. The substance to be weighed can now be placed into the container and the balance will show only the mass of the substance. When the container is removed from the balance, the display will go into negative numbers until the **Tare or Zero** button is pressed again. Some electronic balances have a Unit button on the front which allows the units to be changed. These balances usually have both metric grams and English ounces available. If an object is placed on the pan that goes beyond the capacity of the balance, an ERR message will be displayed.



**Triple Beam Balances** - The balance is named for its three "beams". An object is placed on the pan of the balance and tares on the beams are moved to balance the mass. As you face the balance, the back beam is graduated in 10 gram increments and the middle beam is graduated in 100 gram increments. It is very important that the tares on these two beams are in the notch for the whole number of grams and not in between notches. The front beam is a sliding scale graduated in grams. The tare on this beam can be positioned anywhere on the scale. Masses on a triple-beam balance can be read to tenths of a gram and estimated to hundredths.



**373.34 grams**

**Auxillary Weights** – Triple beam balances are designed to be used with auxillary weights. They come in a set of two 1000g equivalent and one 500g equivalent weights. The set of weights extends the capacity of the balance from 610 grams to 2610 grams. The actual mass of each auxillary weight is printed on the top of the weight in grams. They are placed at the end of the beams

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### Measurement Tips

**Accuracy** - The closeness of a measurement to the true value of what is being measured.

The accuracy depends upon the quality of the instrument being used.

**Instruments** are supplied with the following information.

**Capacity** - the amount that can be measured with the instrument.

**Range** - the high value up to the low value. (Used where zero is not the low value.)

**Numbered increments or graduations** - the value represented by the numbered graduations or increments on the instrument. Some instruments such as balances may have more than one set of numbered increments.

**Unnumbered increments or graduations** - the value represented by the unnumbered graduations or increments on the instrument.

**Readability** - the smallest unnumbered increment on the instrument.

The readability is listed on some instruments as balances. It is always listed in the supply catalogs with a description of each instrument.

**Vernier scale** - a gliding scale to increase the accuracy of the estimation.

It is often found on vernier calipers, micrometers, barometers and balances.

### Tips for measurement

- \* Choose the appropriate instrument.

Be sure to identify the value of the numbered and unnumbered increments as well as the readability of the instrument before beginning the measurement.

- \* When measuring liquids in a cylinder or pipet, remember to read the bottom of the meniscus curve.

- \* When measuring with a metric ruler, be sure that the first increment is present. In some cheap rulers it may not be present or may not be at the very end of the ruler. In this case, begin measuring at 1.0 cm. and subtract 1.0 cm from your reading. *Remember* that the numbered increment of a metric ruler are in cm and the unnumbered increment is mm.

- \* Remember that beakers are designed to hold liquids and estimate amounts. They were not intended for use as a measurement device.

- \* When making several measurements, use the same instrument each time for more reproducible results.

- \* On instruments that have sufficient space between the unnumbered increments, it is customary to record the answer one place beyond the value of the readability by estimating the last value.

Measuring device examples	smallest increment	record to nearest
metric ruler	1 mm	0.1 mm
grad. cylinder	1 mL	0.1 mL
grad. cylinder	0.2 mL	0.1 mL
grad. cylinder	0.1 mL	0.01 mL
Celsius thermometer	2° C	1° C
balance	0.1 g	0.01 g

- \* For electronic balance, there is no way to estimate the last value so the answer must be recorded as presented by the balance.

- \* Be sure to read the instrument carefully to avoid human experimental errors.

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### HUMAN MISTAKES VS. EXPERIMENTAL ERRORS

**Human Mistakes** are mistakes or blunders made by the person performing the procedure due to carelessness or individual bias. Examples of human mistakes are misreading directions, incorrectly reading a measuring device, using incorrect chemicals or forgetting to include a component, incorrectly measuring chemicals, spilling or contaminating solutions, breaking equipment or using unclean equipment, recording measurements incorrectly or doing calculations incorrectly. Data derived as a result of human mistakes is not valid. If you know you have made a human mistake, the results should not be used.

**Many problems in competition result from human mistakes. Human mistakes can be avoided by care and attention to detail when performing a task.**

**Experimental Errors** are errors resulting from instrument variation or the techniques used to conduct an experiment. There are two types of experimental errors – **systematic errors** and **random errors**.

**Random Errors** are chance variations due to variations in individual test specimens, difference measuring devices or pieces of equipment, environmental variations, or different persons performing the experiment. These errors will have an equal chance of having results that are too high or too low. If sufficient numbers of measurements are made the low values will cancel out the high. Examples of chance variations or random errors include variation in eye level when reading an instrument, variations in calibration from one instrument to another of the same type, variations in different pieces of equipment of the same type, slight variations in environmental conditions. **The experimenter has little or no control over random errors.**

**Systematic Errors** are the result of the way in which the experiment was conducted or the design of the system. These errors result in values that are consistently too high or too low. Examples of systematic errors are miscalibrated measuring instruments, improperly adjusted instruments, not noticing a ruler with rounded ends, a clock with runs too fast or too slow, reading the top instead of bottom of a meniscus. **Reducing systematic errors comes with increased skill of the experimenter in refining techniques and checking the calibration of instruments, recognizing and eliminating sources of systematic errors.**

### BASIC STATISTICAL ANALYSIS

**Mean** is the average. It is found by adding all of the values and dividing by the total number of values. The mean is used to analyze random error.

**Median** is the middle value. It is found by arranging all of the values in increasing or decreasing value or magnitude and finding the middle.

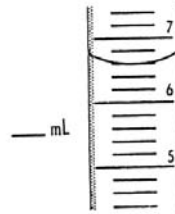
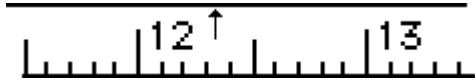
**Mode** is the value that occurs most frequently or often.

**Range** is the difference between the high value and the low value.

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**PRACTICE TASKS**



Type of instrument \_\_\_\_\_ (metric)  
 Capacity \_\_\_\_\_  
 Numbered increments \_\_\_\_\_  
 Unnumbered increments \_\_\_\_\_  
 It's reading is \_\_\_\_\_ c m  
 List possible errors or mistakes:

Type of instrument \_\_\_\_\_  
 Capacity \_\_\_\_\_  
 Numbered increments \_\_\_\_\_  
 Unnumbered increments \_\_\_\_\_  
 It's reading is \_\_\_\_\_  
 List possible errors or mistakes:

**Yeast Fermentation – 24 Hours Old Culture**  
**Team Number                  Length of CO<sub>2</sub> Bubble**

<b>1</b>	<b>58 mm</b>
<b>2</b>	<b>63 mm</b>
<b>3</b>	<b>55 mm</b>
<b>4</b>	<b>80 mm</b>
<b>5</b>	<b>65 mm</b>
<b>6</b>	<b>0 mm</b>
<b>7</b>	<b>50 mm</b>
<b>8</b>	<b>30 mm</b>

**Note:** 2 drop of yeast were placed in a fermentation tubes containing the same same amount of a 10% molasses solution. The diameter of all tubes were the same.

**Identify any possible human errors or systematic errors in the data.**

Determine the mean for the length of the carbon dioxide bubble. Show your work.

Determine the median for the length of the carbon dioxide bubble. Show your work.

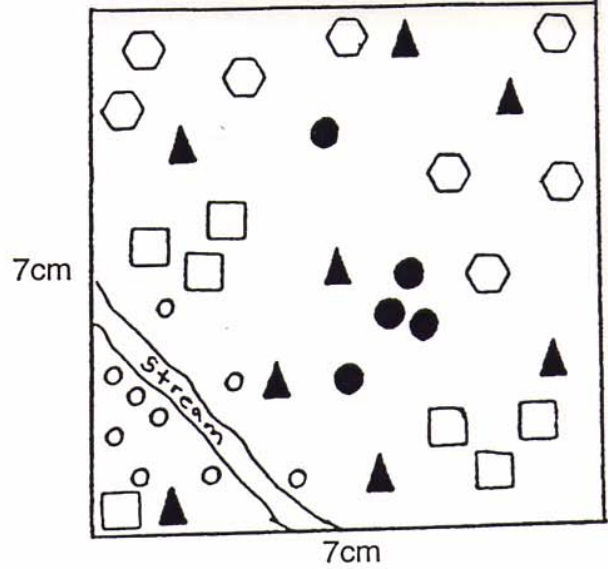
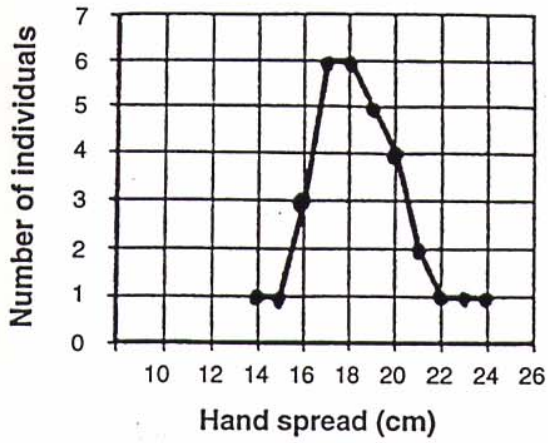
Determine the mode for the length of the carbon dioxide bubble. Show your work.

Determine the range for the length of the carbon dioxide bubble. Show your work.

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**SAMPLE EXERCISES**

**Variation in hand sizes  
within a class of students**



7cm = 70mm = .07m

