EXPERIMENT 17: Plant Reproduction

Read the entire experiment and organize time, materials, and work space before beginning.
Remember to review the safety sections and wear goggles when working with chemicals.
Allow at least 90 minutes for experimenting plus 1 day for soaking fresh pea in Part 2.

Objectives: To observe the structure of a flower and identify the functions of its parts
To observe the parts of a fruit and identify parts important to reproduction.

Materials:

Student Provides:
A fresh pea pod
A large fresh flower such as a lily

From the LabPaq:
Safety goggles
Beaker
Hand magnifying lens
Field microscope
Microscope slides, 3
Microscope slide covers, 3
Scalpel and probes from dissection kit

Discussion and Review: Reproduction in plants takes place in a variety of ways. This laboratory exercise studies the reproduction process in flowering plants that begins with a flower and subsequently produces a seed inside of a fruit. The process of sexual reproduction in flowering plants takes place in the flower which is a complex structure made up of several parts. Some parts of the flower such as the stamens and pistils are directly involved in fertilization and seed production. Other parts such as the petals and sepals are not part of the sexual reproduction process but may be essential to attracting a specific bird, bat, or insect to pollinate the flower.

PROCEDURES:

Part 1 - Parts of a Flower:

Flowers are the reproductive structures of **anthophytes**. The seeds that develop within the flower are then carried within a fruit. Seeds are extremely important form of reproduction in flowering plants. Most flowers have four major organs: **petals**, **sepals**, **stamens**, and **pistils**. Some flowers are incomplete and do not have all four organs. For example the squash plant has separate male and female flowers, with the male flowers having stamens but no pistils and the female flowers having pistils but no stamens. Refer to your textbook for additional information about the life cycle of an anthophyte and the terminology for the many parts and phases of the cycle.

1. Obtain a relatively large open flower that has large, easy to see parts like the lily in the picture to the right.

2. Examine the flower and locate the **petals** and the **sepals**. Observe and record their numbers, size, color, and arrangement on the flower.

3. Remove the petals and sepals by carefully pulling them off of the flower stem.

4. Locate the **stamens**. These are the male organs of the flower. Each is a thin filament with a more bulbous anther on the tip. The **anthers** are filled with pollen. Record the number of stamens.

5. Locate the **pistil**. The **style** is the long thin structure that leads from the **ovary** at the base of the pistil to the **stigma** at the top of the pistil. The stigma may be sticky to help capture the pollen from the anther.

6. With the scalpel, cut an anther from the tip of one of the stamen and examine it with the magnifier as shown in the left photo. Place the anther on a microscope slide. Add several drops of water to the slide. If pollen grains are not visible on the outside of the anther, cut the anther into several pieces with the scalpel to reveal the pollen inside.

7. Examine the slide with the anther under the microscope. The small dot-like particles are pollen grains.

8. With the scalpel, slice the ovary at the base of the style in half lengthwise, from top to bottom. Place one half, cut-side facing up, on a microscope slide. Add a drop of water and place a cover slip on the cut face.

9. Examine the ovary slide with the hand lens. The many small round structures that fill the ovary half are ovules. Each ovule contains an egg cell and is attached to the ovary wall by a tiny stalk. The egg cells will be too small for you to see with the hand lens but you may be able to count the ovules.

10. Next, view the slide under the microscope. Record what details you are able to see.

11. Make a drawing of the flower as you have observed it. Label all of the parts.

Questions:

A. How many stamens are present in your flower? How many pistils are present?

B. How many petals and how many sepals are present in your flower? Would you expect that they would be present in equal numbers?

C. What do you estimate as the number of pollen grains and the number of ovules in your flower? Why do there need to be so many more pollen grains than ovules?

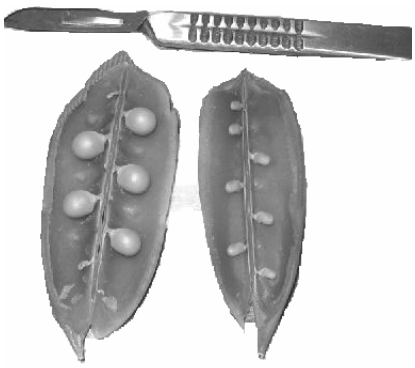
Part 2 - Parts of a Fruit:

After pollination or fertilization occurs, the ovules in the ovary of a flower mature into a fruit containing seeds. Most of the flower parts die and the seeds begin to develop. The wall of the ovule becomes the hard seed coat, which may aid in dispersal and helps to protect the embryo plant until it begins to grow.

As the seeds develop, the surrounding ovary enlarges and becomes the fruit. A fruit is the structure that contains the seeds of an anthophyte. A fruit is as unique to a plant as is its flower; most plants can be identified by examining their fruits. We are most familiar with fleshy, often sweet fruit, such as apples and grapes. But other plants develop dry fruits, such as peanuts and sunflower “seeds.” In dry fruits the ovary surrounding the seeds hardens as the fruit matures. Many foods that we call grains or vegetables are actually fruits.

Anthophytes are classified into **monocotyledons** and **dicotyledons**. **Cotyledons** or ”seed leaves” are contained in the seed along with the plant embryo and absorb food for the embryo. Monocots have only one seed leaf and dicots have two.

A pea pod is actually a fruit, although it is commonly called a vegetable. Peas and their pods are usually consumed before they mature and dry, so people rarely see their natural development. Like all fruits, the pea pod develops from a flower, and parts of the flower can still be identified after pollination and maturation. In this investigation you will observe the features of a pea pod that are flower remnants and study how seeds form and the parts of a fruit that are important to its reproduction. A string bean or lima bean pod may also be used.



1. With a hand lens, first examine the external appearance of the pea pod. Record your observations.

2. Find the stalk that attaches the pod to the plant. Locate the sepals which are the remaining parts from the base of the flower. Record the number of sepals.

3. At the opposite end of the pod, find the remains of the style.

4. Carefully open the pod along the curved edge using the scalpel.

5. Count the number of peas in the pod and note their characteristics. Record the number of peas and your observations of their appearance.

6. Notice the fibers to which the peas are attached by a short stalk. Record the number of fibers you see.

7. Fill a beaker with warm or room temperature water and soak a fresh pea in it for a day.

8. Observe the water soaked fresh pea carefully and locate the scar that shows where the pea was attached to the pod. Use the dissecting needle to carefully remove the seed coat from the pea.

9. Separate the cotyledons. Use a hand lens to observe the embryo plant.

10. Using the scalpel cut a thin slice through a cotyledon and place it on a microscope slide. Place a cover slip on the cut surface and place the slide under the microscope. Observe the parts of the embryo plant. Describe and draw what you observe.

Questions:

A. Based on your observations of the number of sepals and cotyledons present, is the pea a monocot or a dicot?

B. How do you explain any differences among the peas?

C. What is the function of the stalk that attaches the pea to the pod?

D. What reproductive structure does the pod represent?

E. Based on the pea pod's color, can you identify one of the processes it performs?

EXPERIMENT 18: Homeostasis

Read the entire experiment and organize time, materials, and work space before beginning.
Remember to review the safety sections and wear goggles when working with chemicals.
Allow at least 90 minutes to perform this experiment

Objectives: To observe how the human body responds to changes detected in the external environment to maintain homeostasis
To identify the location of some of the body's receptors that detect changes in the external environment.

Materials:

Student Provides:
- An assistant
- Wall mirror
- Paper
- Hot and cold water

From the LabPaq:
- Metric ruler
- Graduated cylinder
- Beaker
- Thermometer
- Wax marker pencil
- Cork
- Pins
- Plastic glasses, 4

Discussion and Review: Homeostasis is the tendency of a body to maintain internal constancy and independence from its surrounding environment. It is a characteristic of life and a process that occurs in all living things. The ability to respond to stimuli in the environment is vitally important to maintaining life. This ability is an obvious characteristic since many of the structures and behaviors of living organisms are specifically adapted to their environment and to maintaining their species' survival.

In addition to responding to external stimuli, living things also respond to internal changes. Organisms must make constant internal adjustments to maintain a proper body temperature and to keep the correct amount of water and minerals in their cells. Such responses require the controlled use of energy within the organism's cells. Changes in the internal environment must be stabilized by the physiological mechanisms of homeostasis. Internal changes arise from two basic sources:

1. **The External Environment:** An organism's internal environment responds to changes in its external environment, such as temperature, pressure, or chemical assault.

2. **Metabolic Activities:** All metabolic activities require a constant supply of oxygen, nutrients, salt, and other minerals that cells withdraw from their environment and that must be replaced.

Homeostasis is maintained by the coordinated activities of the nervous, circulatory, and endocrine systems, and especially by organs such as the lungs, skin, eyes, ears, and digestive tract. These are all specific sites where materials and/or stimuli exchange with the external environment.

PROCEDURES: Part 1 – Vision:

The eyes are a primary organ for warning the body of any assault from the external environment. Our body reacts reflexively to danger perceived by the eyes rather than waiting to make a conscious thought or decision. The eyes themselves react to the amount of light striking them by changing the diameter of the pupil through which light reaches the eyes' sensors. This protects the eyes from too much light and makes them more sensitive in the dark.

1. Make several small balls of any kind of crumpled paper, notebook, newspaper, etc.

2. Put on your safety goggles and stand facing a wall mirror in a well lit room. If you do not have a wall mirror, stand in front of a glass window at night when it is dark outside; when you turn on bright light in the room, the window will act as a mirror and reflect your image. Stand about three feet from the mirror or window.

3. Have an assistant stand behind and a little to one side of you, and throw the paper balls, one at a time, at the image of your face in the mirror. Describe how you feel as your eyes respond. Ask your partner to describe how your eyes responded. Record these observations.

4. Still facing the mirror or window, have your partner pinch the skin at the back of your neck. Describe how you feel as your eyes respond. Ask your partner to describe how your eyes responded. Record these observations.

5. Stand one foot from the mirror. Observe the diameter of the pupils of your eyes.

6. Cover one eye with your hand for one minute, leaving the other eye open. Remove your hand and quickly observe the diameter of the pupils in both eyes. Repeat the same procedure with the other eye. Record these observations.

7. Close both eyes for one minute and have your assistant observe the size of the pupils of your eyes when you open them. Have the assistant continue to observe for one minute and describe any changes in the diameter of the pupils of your eyes. Record these observations.

8. Have your assistant slice open an onion a few feet in front of you while watching your eyes. Describe how you feel as your eyes respond. Ask your partner to describe how your eyes responded. Record these observations.

Questions:

A. Did any of the responses of your eyes require conscious thought?

B. Do you think that you could have controlled or prevented any of the reactions?

C. In seeing the onion cut what is your body anticipating?

D. What are the four basic reactions that you have observed in the experiment? For each of the four describe how this reaction or reflex is a defensive mechanism for your body and how it maintains homeostasis.

Part 2 – Touch:

There are sense receptors in your skin that warn your body if it is being touched by something in the external environment. The concentration of the skin's receptors varies in different parts of the body. Some areas like fingertips have a very high concentration of receptors and are used to feeling and determining the shapes of objects, but other skin surfaces may have only enough sensors to detect larger objects. When two separate points are simultaneously touched to the skin, the minimum distance apart at which they are sensed as two separate and distinct points is the same distance apart that that the receptors are located in that area of skin.

1. Insert two dissection pins into a cork so that the heads are 0.5 cm apart. Gently touch the heads of the pins to your forearm, to the back of your hand, to your palm, to a fingertip, to your cheek, and to your lip. For each touch note if it feels like two points or one. Set up a data table of touch points by distance between points like the one below to record your observations. Feel free to add other skin location columns such as stomach, thigh, etc.

Pin Point	Nerve Receptor Concentration Test					
Distance	Forearm	Hand Back	Palm	Fingertip	Cheek	Lip
0.5 cm						
1.0 cm						
1.5 cm						
2.0 cm						
.... etc.						

2. Rearrange the pins so that the heads are 1 cm apart. Repeat the process of touching the same areas and observe for each if it feels like one point or two. Record your observations.

3. Repeat the process increasing the distance between the points by 0.5 cm each time until all skin location contacts distinctly feel the two points.

Questions:

A. Which areas touched recognized the two points as two points from the least distance apart?

B. Would these areas coincide with areas of skin that you consider generally more sensitive?

C. What role does the greater sensitivity of these areas play in defending the body against external contact?

D. How does this defense sustain homeostasis?

Part 3 – Temperature:

Detection of temperature is another critical defense of the body. Homeostasis demands that the human body reflexively avoid objects or environments that are significantly warmer or cooler than the core body temperature of about 37 degrees C (98.6 degrees F). Receptors in our skin are constantly telling the body that the environment is too hot or too cool, and that the body is therefore gaining or losing thermal energy. Homeostasis continually causes our bodies to try to adjust this imbalance through changes in our behavior and/or in our metabolic rate.

Temperature senses can be unreliable, sometimes sensing the wrong imbalance because of contrast to another sensation or because the sensors have been desensitized or super sensitized. However, this is complicated by the fact that in sensing contrasts, the skin sensors are also defending the body not only against imbalance of temperature but also against abrupt changes of temperature. The following will demonstrate such deceptions.

1. Prepare four glasses of tap water at different temperatures. Use combinations of hot and cold water from the faucet and some crushed ice achieve temperatures of approximately 10°C, 20°C, 30°C, and 45°C respectively in the four glasses. Use the wax pencil to write the temperature on each glass.

2. Place the index finger from one hand into the 45°C water and the index finger from the other hand into the 20°C water; hold them there for 30 seconds.

3. After the 30 seconds place both fingers in the glass of 30°C water. Note the sensation in each finger. Dry your hands and record your observations.

4. Place the index finger from one hand into the 45°C water and the index finger from the other hand into the 30°C water; hold them there for 30 seconds.

5. After the 30 seconds place both fingers in the glass of 10°C water. Note the sensation in each finger. Dry your hands and record your observations.

Questions:

A. In what conditions were the sensations of temperature false? That is, where did you sense heat or cold when the water contacted was not actually hotter or colder respectively, than core body temperature? Why do you think this happens?

B. How is the sense of temperature important to homeostasis?

C. How can the false senses of temperature be also important in homeostasis?

EXPERIMENT 20: Functions of Bones

Read the entire experiment and organize time, materials, and work space before beginning.
Remember to review the safety sections and wear goggles when working with chemicals.
Allow 2 days to boil, clean and dry bones for this experiment.

Objectives: To hypothesize which bones will be more dense, those of birds or mammals,
To calculate the densities of bird and mammal bones,
To explain the reason for differences in the densities of bird and mammal bones.

Materials:

Student Provides:
- Leg and wing bones from chicken or other fowl
- Small rib bone from cow or pig
- Pliers or nut cracker
- Thread

From the LabPaq:
- Graduated cylinder, 50-mL
- Hand magnifying lens
- Spring scale, 10-gm
- Scalpel and probe from dissection kit

Discussion and Review: Mammals and birds have **skeletons** that are surprisingly similar, both having roughly the same parts of **skulls, backbones, ribs, pectoral** and **pelvic girdles**, plus four limbs. However, the function of the individual bones may be somewhat different. The skeletons of mammals and birds are required to provide differing amounts of support, structural strength, and flexibility to the body, depending on the life style of the animal.

One would expect the skeletons of birds to be adapted for flight, whereas those of most mammals to be adapted for walking on the ground. Flying capabilities are enhanced when the body, including the bones, is lightweight. Reduced skeletal mass results if the skeleton has fewer and lighter bones. Consequently, birds have fewer vertebrae in the back and less bones at the ends of limbs, plus the density of their bones is less than that of mammals.

PROCEDURES:

1. Secure one leg bone plus two wing bones of a chicken, duck, or other flying fowl. These can be left over from a meal or obtained from a butcher. Clean the meat off of the bones and then boil them for 20 to 30 minutes. Remove any remaining meat and cartilage from the bones.

2. While the leg bone is still soft from boiling make sure it will completely fit inside the graduated cylinder with its top below the 50-mL measurement line. If the bone is too long or its ends are too wide, carefully use the scalpel to slice off bits of bone until it properly fits inside the cylinder. If the bone is unusually large, you may have to crush one end with the pliers to remove enough bone to allow it to fit.

3. Allow the bones to dry completely; this will take at least one full day.

4. When the bones are dry, weigh the leg bone with the 10-g scale. If the bone's weight exceeds the scale's 10-g limit, then carefully trim the bone until it is less than 10 g and can be accurately weighed. If it is an unusually large bone you may have to crush one end with pliers to remove enough bone to bring the weight under 10 g. Record the final weight of the leg bone specimen and separately record the combined weight of the two wing bones, all to the nearest 0.1 g.

5. Obtain a small pork or beef rib bone. This may also be left over from a meal or obtained from the meat department of your local supermarket. Most meat departments have bone scraps and are happy to help when you explain what you are doing. Take the 50-mL graduated cylinder with you and explain that you need a narrow rib bone fragment to fit inside of the cylinder and to be about half to three-quarters of its height. The butcher will have the proper tools to easily split and cut a rib bone to the right size for you.

6. Boil the rib bone for 20 to 30 minutes. Remove all remaining meat and cartilage from it and allow the bone to dry completely; this will take at least one full day.

7. When the bone is dry, weigh it with the 10-gm scale. If the weight exceeds the scale's limit, then carefully trim the bone until it is less than 10 g and can be accurately weighed. You can possibly shave off sufficient bone with a scalpel or crush one end with pliers to remove enough bone to bring the weight under 10 g. Weigh the final bone specimen and record the weight to the nearest 0.1 g.

8. Tie a piece of thread around one end of the chicken leg bone and place it inside of the empty graduated cylinder. Add water until the bone is completely covered. If the bone floats, use a probe from the dissection kit to hold the bone below the surface of the water. Read the level of the water in the graduated cylinder and record it in mL, estimating to the nearest 0.1 mL. Note if the bone floats or sinks in the water.

9. Remove the bone with the thread and hold the bone over the cylinder long enough for the water to drip off and back into the cylinder. Read the level of the water in the cylinder. Record the level in mL, estimating to the nearest 0.1 mL.

10. Subtract the water level without the bone from the water level with the bone fully submerged. The difference is the volume of the bone in mL. Remember that a mL of liquid occupies one cubic centimeter, so mL = cc. Divide the weight of the bone in

g by the volume of the bone in cc; the result is the density of the bone in g/cc. Record the density.

11. Repeat the above steps 8, 9, and 10 for the two chicken wing bones, tied together by the thread.

12. Repeat the above Steps 8, 9, and 10 for the pork or beef bone.

13. Cut or break open each of the bones and examine the texture of the interiors with the hand magnifying lens. Look for honeycomb structure or air pockets in the bones. Record what you observe for each of the bones.

Questions:

A. What are the densities of the three types of bones used in the experiment?

B. Are the chicken wing bones and leg bones the same density? If not, what would you hypothesize as the reason for the difference based on function? Of what value is there to a bird if the wing bones are more or less dense than other bones?

C. Is the average density of the chicken bones different from the density of the beef or pork bone? If there is a difference, what would you hypothesize as the reason for the difference based on function?

D. Did both the chicken and the beef or pork bones float? What does this tell you immediately about the density of a bone? Remember the density of water is 1 g/cc.

E. What did you observe about the texture or structure of the interior of the bones? Would air pockets make the bone more or less dense? In which bones would you expect to find such pockets or honeycomb structures?

EXPERIMENT 21: Human Behavior

Read the entire experiment and organize time, materials, and work space before beginning.
Remember to review the safety sections and wear goggles when working with chemicals.
One hour of observation time in addition to travel and analysis time is required

Objectives: To hypothesize different behaviors for different groups of subjects
To observe, record, and analyze observations of human behavior
To identify instinctive versus learned behavior.

Materials: Student Provides: Timer or clock
A mixed group of at least 12 people

Discussion and Review: Human behavior is complex and varied. Some things we do by **instinct** such as duck or blink our eyes when an object is thrown at us. Other things we do represent **learned behaviors** such as skipping rope, combing hair, or deciding how to spend time. However, almost everything we do is in some way a complex mixture of instinctive and learned behavior. In this experiment, you will observe people going about their normal activities and record their actions. From these observations you will then draw conclusions about different types of people and the behaviors they are more likely to exhibit. Your objective is to classify the types of behaviors the subjects you observe exhibit.

PROCEDURES:

1. Choose a site where there are lots of people about. Good possibilities include a playground, a beach, a park, a food court at the shopping mall, a party, or a sporting event where you can observe the spectators, not the participants.

2. Choose boundaries for your study area. The area should be large enough that it is usually occupied by an average of 12 or more subjects. It could be a specific area at the playground, within only the seating section at Burger King®, etc. You will record the behaviors of subjects only within this defined boundary. If a subject leaves, then do not further record his/her behavior. If a new subject enters this boundary, then begin recording his/her behavior.

3. Watch the **population** of human **subjects** within your boundary area for a few minutes and identify several types of the behaviors they exhibit. From these observations, make a list of the behaviors you now might expect to see within the boundary area and record them in a chart like the example that follows

4. Choose a factor by which to compare the subjects in the population. For example, you may want to contrast males versus females, or older versus younger people, or tall versus short people, or blond versus brunettes and red headed people. Create a code for each factor such as: M vs. F for males/females; or Y vs. O for young/old. Based on this contrast factor, write a hypothesis you wish to test with your data.

5. Note the beginning time and set a timer to remind you to record observations every 5 minutes. The initial observation is at time = 0. That time will be followed by observations every 5 minutes, for a total of 13 sets of observations over a full hour.

6. For each observation, record the total number of subjects within the boundary area by each of the contrast factor codes identified in step 4 above. Then tally and record the number of subjects per factor code engaged in each of your identified behaviors. The following example illustrates how activities are recorded.

Example Data: Study area = park playground; contrast = males, M, vs. females, F.
Hypothesis: males and females equally perform the same activities at the playground.

Time (minutes)	Total # Subjects	Swinging	Playing on "Monkey Bars"	Talking	Pushing Swings	Playing on Slide
0	6M; 6F	2M; 1F	3M; 0F	0M; 4F	1M; 1F	0M; 0F
5		2M; 1F	2M; 0F	0M; 5F	1M; 0F	1M; 0F
10		0M; 1F	2M; 0F	0M; 5F	1M; 0F	3M; 0F
15		0M; 1F	0M; 0F	0M; 5F	1M; 0F	5M; 0F
…						
60	3M; 8F	1M; 2F	0M; 3F	1M; 1F	0M; 2F	1M; 0F

Questions:

A. How many subjects were in your study area at the beginning of the study, time=0, and at the end, time=60? Where there more subjects at the beginning or the end of the study?

B. How many subjects were there in each contrast factor code category at the beginning of your study, time=0, and at the end of the study, time=60? How did the distribution change during the study?

C. Which of the behaviors was most common overall? Which was least common overall? Was there a difference in behaviors for your contrast factors? Did one factor perform certain behaviors more than another?

D. Based on the observations recorded in your data chart, draw conclusions about the subjects in your study area and compare them to your hypothesis. For the example given above, the data reflects that boys and girls do not equally perform the same

activities at the playground and that boys tend to slide more while girls tend to swing more.

E. If you were going to do another study in this area, what other factors would you examine? Are there other behaviors you would include in your chart? Are there behaviors you would leave off of your chart? Would you change your time interval or the total time of your study?

F. For each of the behaviors on your chart, identify if you believe that behavior is instinctive or learned, or a mixture, and why.

EXPERIMENT 22: Muscle Fatigue

Read the entire experiment and organize time, materials, and work space before beginning.
Remember to review the safety sections and wear goggles when working with chemicals.
Allow at least one hour to perform this experiment

Objectives: To observe how fatigue affects the number of repetitions of an exercise one can accomplish and
To hypothesize how this relates to muscle function.

Materials: Student Provides: Timer or clock
Exercise equipment (optional)
Partner (optional but preferable)

Discussion and Review: Nearly half of normal body mass is muscle; the contraction and relaxation of those muscles produce the movement of body parts. In this process, muscles use up energy in the form of **ATP, adenosine triphosphate**. ATP is produced from aerobic and anaerobic cellular respiration in the muscles. The aerobic respiration dominates when adequate oxygen is delivered to the muscle cells if a muscle is at rest or during moderate activity. But when an adequate supply of oxygen cannot be maintained during vigorous activity, anaerobic respiration, specifically the process of lactic acid fermentation, becomes the primary source of ATP production.

As you continue to exercise, at some point your muscles are unable to get oxygen fast enough to sustain the anaerobic respiration. ATP becomes in short supply. As the anaerobic process becomes dominant, lactic acid builds up in your muscles. As excess lactic acid passes into the blood stream, the blood becomes more acidic. Rapid breathing occurs as your system tries to capture more oxygen for aerobic respiration. Cramping can occur in the muscles from the excess lactic acid, and you experience fatigue. As you catch your breath following exercise, more oxygen is supplied to your muscles and the lactic acid is broken down. Regular exercise can result in improved efficiency of your lungs and in improved maintenance of aerobic cellular respiration in your muscles.

PROCEDURES:

1. Select a form of repetitive exercise that will work one set of muscles. Make sure you can count single repetitions of the exercise over time such as one jumping jack, push up, sit up, or free weight lift. Describe the exercise.

2. The purpose of the exercise is to count how many repetitions you can accomplish within a set amount of time. You will repeat this process 5 times for 5 trials. Create a data table to record the number of repetitions completed for each trial.

3. This exercise can be done alone but it is much easier and perhaps more accurate to do it with a partner. Agree on a fixed amount of time for each trial such as 30 seconds or 1 minute. While your partner records your time, begin your exercise. Count and record the number of repetitions within each trial period.

4. Take a one minute rest and repeat the exercise. Repeat at the same rest intervals until you have completed five trials.

5. Record your results in a graph; plot the number of repetitions on the y-axis and the trial number on the x-axis. Connect the points on your graph with a line.

6. Calculate the slope of the line in the graph for the overall sum of the set of trials and between each set of points (i.e., between each pair of trials). To calculate the slope of a line, divide the distance between the points along the *y*-axis by the distance between the same points along the *x*-axis. The formula for this is $(y_2-y_1)/(x_2-x_1)$ where y_1 x_1 are the coordinates of one trial data point and y_2 x_2 are the coordinates for another.

Questions:

A. What effect did repeating the exercise over time have on the muscle group?

B. As you repeated the exercise over time, how did your muscles feel?

C. Reflect on how your muscles work. What physiological factors are responsible for fatigue?

D. How well do you think your fatigued muscles would work after 30 minutes of rest?

E. What can you learn form the slope of the line in your graph? How does the slope change as you become more tired? What does a steeper or flatter slope mean?

6. Repeat the above step four more times. Calculate the average of the five measures of the balloon's circumference.

7. Calculate the average radius of the balloon by dividing the average circumference by 6.28 which is approximately equal to 2 π.

8. Calculate the average volume of the balloon as $\frac{4 \pi r^3}{3}$. This is the tidal volume of one average breath in cm^3 or cc, also in mL.

9. Multiply the average tidal volume in mL by the average number of breaths you take per minute. Divide the product by 1000 to get the tidal volume per minute in liters. Record your calculations and results.

10. Repeat the procedures above with an assistant. Compare and contrast the results.

Questions:

A. How do your average number of breaths and your tidal volume per minute compare with the measurements for your assistant? Can you account for differences by the size of the person or their physical condition?

B. An average adult inhales 6 liters of air per minute. How does this compare to your tidal volume and that of your partner?

C. What do you think would happen to your number of breaths and your tidal volume just after exercising? Why?

EXPERIMENT 24: Respiration

Read the entire experiment and organize time, materials, and work space before beginning.
Remember to review the safety sections and wear goggles when working with chemicals.
Allow at least 45 minutes to perform this experiment

Objectives: To measure the resting breathing rate,
To estimate the amount of air inhaled per minute.

Materials:

Student Provides:
- Timer or clock
- An assistant

From the LabPaq:
- Balloon
- String
- Metric ruler from dissection kit

Discussion and Review: In **external respiration**, air is drawn into the lungs where the oxygen in the air is exchanged for carbon dioxide that is then exhaled. External respiration should not be confused with cellular respiration in which chemical reactions take place within the cell to provide energy. In the doctor's office, the volume of air that moves in and out of the lungs is measured by use of an instrument called a **spirometer**. This volume of air can also be measured, though less accurately, using a balloon.

PROCEDURES:

1. Sit at rest. Watch the second hand on a clock and count the number of times you breathe in 30 seconds. Count one complete cycle of inhaling and exhaling as one breath. Record the number of breaths.

2. Repeat Step 1 two more times, recording the number of breaths each time.

3. Calculate the average number of breaths you take in 30 seconds. Multiply this average by 2 to get your average resting breathing rate per minute.

4. Stretch the balloon you'll be using and blow it up once or twice to make it flexible before beginning the next part of the experiment.

5. Take a regular breath and exhale normally into the balloon. With one hand, squeeze the balloon neck and hold it tightly closed so that air does not escape. With the other hand, wrap a string around the balloon at its widest point and grasp the string where it marks the balloon's circumference. Release the neck of the balloon. Measure the length of the string in cm from its tip to where you grasped it. Record this length as the circumference of the balloon.

6. Repeat the above step four more times. Calculate the average of the five measures of the balloon's circumference.

7. Calculate the average radius of the balloon by dividing the average circumference by 6.28 which is approximately equal to 2 π.

8. Calculate the average volume of the balloon as $\frac{4 \pi r^3}{3}$. This is the tidal volume of one average breath in cm^3 or cc, also in mL.

9. Multiply the average tidal volume in mL by the average number of breaths you take per minute. Divide the product by 1000 to get the tidal volume per minute in liters. Record your calculations and results.

10. Repeat the procedures above with an assistant. Compare and contrast the results.

Questions:

A. How do your average number of breaths and your tidal volume per minute compare with the measurements for your assistant? Can you account for differences by the size of the person or their physical condition?

B. An average adult inhales 6 liters of air per minute. How does this compare to your tidal volume and that of your partner?

C. What do you think would happen to your number of breaths and your tidal volume just after exercising? Why?