Zoology

Animal Magnetism: Do Magnets Affect Regeneration in Planaria?

(from http://sciencebuddies.com/science-fair-projects/project_ideas/Zoo_p018.shtml?fave=no&isb=c2lkOjEsaWE6Wm9vLHA6MyxyaWQ6Mzl5MzU5MQ&from=TSW)

Objective

The goal of this project is to test the hypothesis that magnetic fields can increase the regeneration rate of planaria.

Introduction

Planaria are flatworms (platyhelminthes) that live in freshwater. They are simple organisms with three tissue layers (ectoderm, mesoderm, and endoderm) but no body cavity. They are remarkable for their ability to regenerate.

Figure 1. A *Planaria* flatworm. Note the light-sensitive eyespots on the head. Image courtesy BioMedia Associates.

Anatomical terms are used to describe the procedure for bisecting the planaria, so you will need to understand the following terms in italics. The head end of the planaria (with eyespots) is the *anterior*, and the tail end is the *posterior*. The *dorsal* surface is the one that is normally facing up (the "back" of the planaria). The *ventral* surface is the one that is normally facing down (the "front" of the planaria). The ventral surface contains the pharynx, through which planaria feed.

In this project you will be investigating whether strong magnetic fields have any effect on regeneration in planaria. See the Variations section for additional ideas for experiments on regeneration.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- regeneration,
- anatomical terms:
    - anterior,
    - posterior,
    - dorsal,
    - ventral,
    - pharynx,
    - bisect.

Bibliography

- Wikipedia contributors, 2006. "Planarium," Wikipedia, The Free Encyclopedia [accessed August 2, 2006] http://en.wikipedia.org/w/index.php?title=Planarium&oldid=64512073.
- BioMedia Associates, 2006. "Biology Classics: Planaria," BioMedia Associates [accessed August 2, 2006] http://ebiomedia.com/gall/classics/Plan/plan_about.html.
- K&J Magnetics, 2006. "Neodymium Magnet Safety," [accessed August 2, 2006] http://www.kjmagnetics.com/safety.asp.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- at least 30 live planaria,
  Notes on sources:
    - If you want to try collecting planaria yourself, here are some tips from BioMedia Associates: "It's usually not difficult to find planarians. Shake pond weeds into a pan—flatworms will often be dislodged from their hiding places. Turn over stream rocks and look carefully at the rock surfaces." (BioMedia Associates, 2006) Once you've found them, here is a method for collecting them:
        - "Put a small pellet of canned pet food in an old nylon stocking.
        - "Secure this bag of attractant in the stream or pond bed overnight.

        - "With any luck, in the morning you will find a collection of flatworms crawling over the bag." (BioMedia Associates, 2006)
    - Planaria are also available online from these sources (because availability can vary with the season, be sure to check with them by phone first to make sure that the critters are in stock when you plan to do your project):
        - Carolina Biological http://www.carolina.com;
        - Ward's Natural Science http://wardsci.com/default.asp.
- ice,
- scalpel or razor blade,
- spring water or pond water,
- 6 shallow containers for planaria (e.g., 100 mm diameter Petri dishes),
- 6 pieces of steel sheet metal, each approx. 100 mm square,
- neodymium magnets of same outer dimensions, but increasing strength (3 values), Notes on sources:
    - available online from K&J Magnetics, http://www.kjmagnetics.com;
    - choose magnets with the same outside dimension, but with increasing surface field strength (e.g., part numbers D901, D91, D92);
    - buy at least 21 magnets of the two lower strengths, and 42 of the highest strength (used for two groups of planaria).

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Experimental Procedure

Safety Notes on Neodymium Magnets (K&J Magnetics, 2006).
"The neodymium magnets [used in this project] are extremely strong, and must be handled with care to avoid personal injury and damage to the magnets. Fingers and other body parts can get severely pinched between two attracting magnets. Neodymium magnets are brittle, and can peel, crack or shatter if allowed to slam together. Eye protection should be worn when handling these magnets, because shattering magnets can

launch pieces at great speeds.
"The strong magnetic fields of neodymium magnets can also damage magnetic media such as floppy disks, credit cards, magnetic I.D. cards, cassette tapes, video tapes or other such devices. They can also damage televisions, VCRs, computer monitors and other CRT displays. Never place neodymium magnets near electronic appliances.
"Children should not be allowed to handle neodymium magnets as they can be dangerous. Small magnets pose a choking hazard and should never be swallowed or inserted into any part of the body.
"Never allow neodymium magnets near a person with a pacemaker or similar medical aid. The strong magnetic fields of the magnet can affect the operation of such devices.
"Neodymium magnets are brittle and prone to chipping and cracking. They do not take kindly to machining.
"Neodymium magnets will lose their magnetic properties if heated above 175° F (80° C).
"Neodymium magnets should never be burned, as burning them will create toxic fumes.
"Like any tool or toy, neodymium magnets can be fun and useful, but must always be treated with care."

1. You will be dividing your planaria into 6 groups, according to the table, below. Groups 1–4 will be bisected (cut in half), and exposed to various magnetic field intensities (weakest = strength 1, strongest = strength 3). Groups 5 and 6 will be unoperated (whole animal) controls. Group 5 is not exposed to an increased magnetic field; group 6 is exposed to the strongest magnetic field (strength 3).

Group #	Condition	Magnet
1	bisected	no magnets (plain sheet metal underneath)
2	bisected	+ magnets, strength 1
3	bisected	+ magnets, strength 2
4	bisected	+ magnets, strength 3
5	untreated	no magnets (plain sheet metal underneath)
6	untreated	+ magnets, strength 3

2. Label the sheet metal squares 1–6.
3. Space the appropriate magnets evenly over a 100 mm circle (i.e., the size of the petri dish) on sheet metal squares 2, 3, 4, and 6 (see table, above). All of the magnets should be arranged with the same pole (either N or S) facing up. The

sheet metal allows you to place the magnets closer together than you would on a non-magnetic surface, and also increases the magnetic field strength.

4. Label the dishes 1–6 and place them on top of the correct sheet metal square.
5. To bisect a planarian, use the following procedure:
    a. Place it on ice to immobilize and anesthetize the animal.
    b. Cut it in half with a scalpel or single-edged razor blade. Make the cut midway between the anterior (head) and posterior (tail) ends of the animal. Take care not to cut yourself!
    c. Immediately place the bisected pieces in the appropriate petri dish containing fresh spring or pond water.
6. For this experiment, you will need to bisect 20 planaria (5 each for groups 1–4, assumes a total of 30 planaria available).
7. Keep the petri dishes covered, and keep all of the dishes at the same temperature, in a place that is not exposed to bright light.
8. Do not feed the planaria during the regeneration period. They are unlikely to feed during this time, so uneaten food will foul the water and the planaria will die.
9. It's a good idea to do a 10% water change every few days. (If the water looks cloudy, change more often and/or change a larger fraction of the water.) Follow the same procedure for all six dishes. Do not use tap water (tap water is generally treated with clorine or chloramine, which would be toxic to the planaria). Use spring water or fresh pond water for the water changes.
10. Observe the planaria daily. For each dish, measure the length of each of the segments and record the results. Also, record the lengths of the whole animals. Note any other observations you make.
11. At the end of two weeks, summarize your results. What is the average amount of regeneration for each experimental group? Is there a systematic difference in regeneration rate with magnetic field strength?
12. Calculate the average amount of regeneration for the head and tail sections separately. Is there any evidence for a difference in regeneration rates of the two segments?

Variations

- What happens if you bisect the planaria in half the other way (along the anterior-posterior axis, instead of across it)? Is the regeneration rate faster, slower, or the same?
- What happens if you cut the planaria into quarters? Which of the segments regenerates fastest?
- How do planaria orient to light? Cover half of the petri dish containing planaria with dark paper and expose the dish to light. Which side of the dish do the planaria prefer? Do you get the same result each time you repeat the

experiment? What happens if you try this with bisected planaria? Do both segments react in the same way? Try this with a group of planaria bisected along the anterior-posterior axis and with a group bisected across the anterior-posterior axis.

Antlion Pits in Open Sand or Under Leaf Cover

(from http://sciencebuddies.com/science-fair-projects/project_ideas/Zoo_p017.shtml?fave=no&isb=c2lkOjEsaWE6Wm9vLHA6MSxyaWQ6Mzl5MzU5MQ&from=TSW)

Objective

The goal of this project is to determine whether antlions prefer to build their pits in open sand or in sand under leaf litter.

Introduction

Antlions (also called doodlebugs) are insect larva that prey on other insects. They dig funnel-shaped traps in sand or soil, and lie in wait at the bottom for victims to stumble in. When an insect tumbles down the loose sand, the waiting antlion grabs it in its mandibles and devours its prey.

Figure 1. Photo of an antlion larva. (Swanson, 2006)

It's interesting to watch an antlion dig its trap. You can even see a video at the Antlion Pit website (Swanson, 2006). They can snap their bodies to throw sand, and can dig a trap in about fifteen minutes. They also make interesting tracks ("doodles") in the sand as they search for a suitable location.

Figure 2. Photo of antlion 'doodles' in the sand. (Swanson, 2006)

When the larva has grown big enough, it pupates. It builds a cocoon around itself, and develops into an adult. When the adult emerges, weeks later, it seeks something to climb, and waits as its wings harden. Later, the females will mate with males, and then lay their eggs in the sand, starting the life cycle over again.

Figure 3. Photo of an antlion adult. (Swanson, 2006)

How does an antlion larva choose a site in which to dig its trap? Do they prefer open sand over sand covered with leaf litter? You can find out by building an artificial antlion habitat with equal areas of each type. Release the antlions in the center and examine where they end up. Do they show a preference for a certain type of habitat? Try to think of other variables you could test with this setup.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- antlion,
- habitat,
- larva,
- pupa.

Questions

- How long do antlions typically remain in the larval stage?
- What do antlion larvae eat?
- How long does metamorphosis take?
- How long do antlion adults survive?

Bibliography

- This site has lots of information on antlions (including QuickTime videos!): Swanson, M., 2006. "The Antlion Pit—A Doodlebug Anthology," [accessed August 1, 2006] http://www.antlionpit.com/index.html.

- This site has pictures of antlions:
  Wikipedia Contributors, 2009. "Antlion," Wikipedia: The Free Encyclopedia [accessed April 29, 2009] http://en.wikipedia.org/w/index.php?title=Antlion&oldid=285741414.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- antlion larvae:
  - can be collected from their natural habitat, or,
  - can be ordered online: http://www.antlionfarms.com/antlions_for_education
- sand or soil (preferably collected from antlion's natural habitat);
- leaf litter (preferably collected from antlion's natural habitat);
- shallow pan;
- ants or other small, crawling insects (to feed antlions).

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Experimental Procedure

1. If you want to collect antlions yourself, they can be found "in sheltered, sandy areas such as wooded dunes, open forest floors, and dry, tree-lined river banks. They can also be found in the sandy soil of flower beds, under hedges or eaves, or in undeveloped city lots." (Swanson, 2005) Note: be sure that you have permission from the landowner before collecting (e.g., it is *not* OK to collect in a National Park).
2. Once you have located antlion pits, here are some tips on capturing the larvae from the Antlion Pit website (Swanson, 2006):

    - "With your hand, a spoon, or a small trowel, scoop out the entire pit with one steady motion, being careful to dig deep enough so as not to crush the antlion.
    - "Let the sand sift through your fingers or pour it into a strainer to expose the animal. The antlion larva may be difficult to spot at first because its gray-brown color often blends in with the soil.
    - "When removing an antlion in this manner you may discover the exposed antlion lying on its back, motionless, and apparently dead. However, it will soon flip over and immediately begin its backward shuffle in an attempt to bury itself once again."
3. Collect sand and leaf litter for constructing an experimental antlion habitat.
4. To make the experimental habitat, fill the shallow pan with sand. Cover half the pan with leaf litter and leave the other half uncovered.
5. Be sure that both sides of the pan have the same temperature and lighting.
6. Release the antlion larvae in the middle of the pan (at the border between open sand and leaf litter).
7. After the antlion traps are established, count how many are in each zone.
8. It's a good idea to observe many trials to make sure that the results are consistent. For more trials, collect the antlions from the pan, smooth out the sand, re-scatter the leaf litter and repeat the experiment.
9. Is there a preference for one side or the other?

Variations

- Scientists typically try multiple approaches to test a hypothesis before accepting it. Can you think of addtional ways to test nesting site preference in antlions? The experimental method used in this project relies on captive antlions in a constructed environment. How about conducting a survey of a natural area and counting antlions found in open sand vs. under leaf cover? Be sure that the survey includes equal areas of both kinds of habitat.
- If you plan to perform the experiment with antlions that you collect yourself, here is an interesting variation you might try: consider whether antlions have an innate preference for an open vs. leaf-covered nest site. Separately collect antlions from both types of habitat (label the collection jars so you know which habitat the larvae came from), and test them in separate pans. Do antlions collected from under leaf litter ususally prefer to build their new nests under leaf litter or in open sand? How about antlions collected in open sand?
- Design an experiment to test if leaf cover or temperature is a more important determinant for nesting site preference for antlion larvae. You will need to design an artificial habitat in which you can warm one half while keeping the other at room temperature (e.g., don't use a metal pan, which will conduct heat to both

sides). Conduct trials comparing the four choices summarized in the following table:

Side 1		Side 2	
temperature	surface	temperature	surface
warm	leaf litter	room temp.	open
room temp.	leaf litter	warm	open
warm	leaf litter	warm	open
room temp.	leaf litter	room temp.	open

Dog Toys: What Makes One a Favorite or a Flop to Fido?

(from http://sciencebuddies.com/science-fair-projects/project_ideas/MamBio_p012.shtml?fave=no&isb=c2lkOjEsaWE6TWFtQmlvLHA6MSxyaWQ6MzI5MzU5MQ&from=TSW)

Objective

The goal of this project is to measure canine intelligence with some simple behavioral tests.

Introduction

Dogs have been human companions and helpers for thousands of years. Dogs have been bred and trained for companionship, protection, and many specialized tasks. For example, think of sheep dogs, sniffer dogs, or seeing eye dogs. Dogs can do some pretty clever things, but how smart are they, really? Are there ways to find out what's going on in a dog's mind?

This project has some interesting ideas for assessing the mental capabilities of dogs. Does a dog realize an object still exists even when they can't see it? Can a dog figure out how to get around an obstacle to retrieve a desired object? Choose one or more of the tests and try them out on a large number of dogs. See what you can learn about the mind of a dog.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- animal behavior,
- behavioral testing,
- animal intelligence.

Bibliography

- BBC, 2004. "Test Your Pet," BBC, Science & Nature [accessed August 21, 2006] http://www.bbc.co.uk/nature/animals/pets/testyourpet/flat_alternative.shtml.

- This website has descriptions and calculators for several statistical tests, including the Student's *t*-test that you can use in this project:
  Kirkman, T., date unknown. "Student's *t*-Tests," Department of Physics, College of St. Benedict & St. John's University [accessed February 23, 2006] http://www.physics.csbsju.edu/stats/t-test.html.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- a large number of dogs to test, with owner's cooperation:
  - ideally, try to test somewhere between 50–100,
  - to see why, read the Science Buddies resource, How Many Participants Do I Need?;
- dog treats;
- large can, or shoe box;
- low table or tray (top needs to be above dog's eye level, you can hold a tray above the dog's eye level for large dogs);
- small cushion or towel;
- piece of sturdy string or shoelace, about 1 m in length;
- a couple of chairs.

Experimental Procedure

1. Choose 3–5 of the tests below (click on the links for background on each test and for the test procedure). Try them on a small sample of dogs (your own, and some friends' dogs, for example) so that you have some experience with the tests before trying them on a large number of dogs.
   a. Test 1: Is the Treat Still There?,
   b. Test 2: Spatial Perception,
   c. Test 3: Obstacle Course,
   d. Test 4: Spoken Commands,
   e. Test 5: Pull the String.
   f. Note: test procedures and images are from the BBC (BBC, 2004).
2. Find dogs to test. For example, you could bring your test materials to a local park where dog owners gather and do the tests there.
3. Keep track of the test results in your lab notebook. For each dog you test, get the dog's gender, breed, age, and number of years with the current owner.
4. For each of the tests, make sure that you have permission of the dog's owner. It will be best if you have their active assistance as well. The dog is likely to respond best if the owner gives the commands for the tests.

5. Also remember the following:
    a. Don't force a dog to do any of the tests. If a dog is unwilling to take part, try again later.
    b. Do give each dog the time, space, and quiet that it needs to have a good go at the test.
    c. Make sure an adult is present when you test your pet.
6. We suggest the following steps for analyzing the results:
    a. Scoring the tests:
        A = 3 points
        B = 2 points
        C = 1 point
    b. A good way to examine the results of each test is to make a histogram of all of the individual scores. Look at the outline of the histogram. Are the results normally distributed (i.e., in a bell-shaped curve)? What are the mean, median, mode, and standard deviation for each test?
    c. Normalizing the scores will make it easier to compare the results between dogs. The following equation shows one way to calculate a normalized score for each test for each individual dog:

$$\text{normalized score} = \frac{(\text{individual score} - \text{mean score})}{\text{mean score}}$$

    d. With this equation, dogs scoring below the mean will have a negative normalized score, and dogs scoring above the mean will have a positive normalized score.
7. Which dogs scored highest? Lowest?
8. Which test had the widest variation in scores? Which test had the narrowest variation in scores?

Test 1: Is the Treat Still There?

This test can give you a glimpse of how a dog understands the world around itself. To do well on this test, the dog must be able to understand that an object continues to exist, even if it can no longer be seen. Note that the treat or toy used for this test should not have a strong smell, which the dog could use to confirm that the object is still there.

Procedure for Test 1

1. The owner should have the dog sit, and let it see the treat or toy as it is placed on the floor.

Figure 1. Let the dog see a treat or toy as it is placed on the floor. (BBC, 2004)

2. Place the can or box over the treat or toy.

Figure 2. Cover the treat or toy. (BBC, 2004)

3. The owner should release the dog from sitting, with an "OK," or similar neutral command.
4. How does the dog react?

Figure 3. How does the dog react? (BBC, 2004)

5. Interpreting the results:
    A. Dog flips the can/box over.
    B. Dog shows an interest in the can/box, but gives up.
    C. Dog completely ignores can/box.
    - If option A - The dog understands what psychologists call "object permanence". It realises that objects continue to exist even after they have disappeared from view. This is cleverer than you may imagine. To understand this, it must have a representation of the world that goes beyond what it can immediately perceive.
    - If option B - The dog shows signs that it understands that the treat still exists under the cover. This could be because it can still smell the treat, or it could be because it still imagines it to be there. The latter takes some thought and the dog is being fairly smart. You might also consider trying the test with another vessel or on another surface in case it was just too difficult to flip over.
    - If option C - The dog has shown that it doesn't understand the idea that an object exists when it isn't perceived. For many dogs this is a natural response; it takes a leap of imagination to picture a world beyond the one that we see in front of us. We humans act the same way until we are about 9 months old.

Test 2: Spatial Perception

This test can show how well the dog understands spatial relationships between objects, especially horizontal objects. Dogs that move about more in 3 dimensions should do better at this than those that move only on the ground.

Procedure for Test 2

1. The owner should have the dog sit in front of the table, or should hold the tray, so that the surface is above the dog's eye level.

Figure 4. (BBC, 2004)

2. Place a cushion or folded towel on the table or tray. This is so that treat or toy will not make much sound when it is dropped.

Figure 5. (BBC, 2004)

3. Stand on the opposite side of the table or tray from the dog. Hold the treat above the table or tray, and, when the dog is watching it, drop the treat onto the cushion.

Figure 6. (BBC, 2004)

4. How does the dog react? (You'll have to keep a sharp eye on the dog for this one.)

Figure 7. (BBC, 2004)

5. Interpreting the results:
    A. Dog looks at the table top or tray.
    B. Dog looks at the floor, then back up at the table or tray.

C. Dog looks on the floor for the treat.

- If option A - The dog understands the way that horizontal objects relate to each other. This may not seem like much, but many animals have difficulty with this test.
- If option B - The dog was surprised that the treat didn't hit the floor, but quickly worked out where it was likely to be. Many animals have trouble with this test.
- If option C - The dog expected the treat to fall to the floor. This shows that the dog hasn't grasped the way in which horizontal objects relate to the other objects in their world.

Test 3: Obstacle Course

This is both a spatial perception and a problem-solving test. First the dog has to work out a route to the reward, and then it has to walk *away* from the treat in order to get it.

Procedure for Test 3

1. Arrange the two chairs so that they face each other. Lay them on their sides, so that their bases make a V-shaped barrier with a gap in the middle that is too small for the dog to fit through.

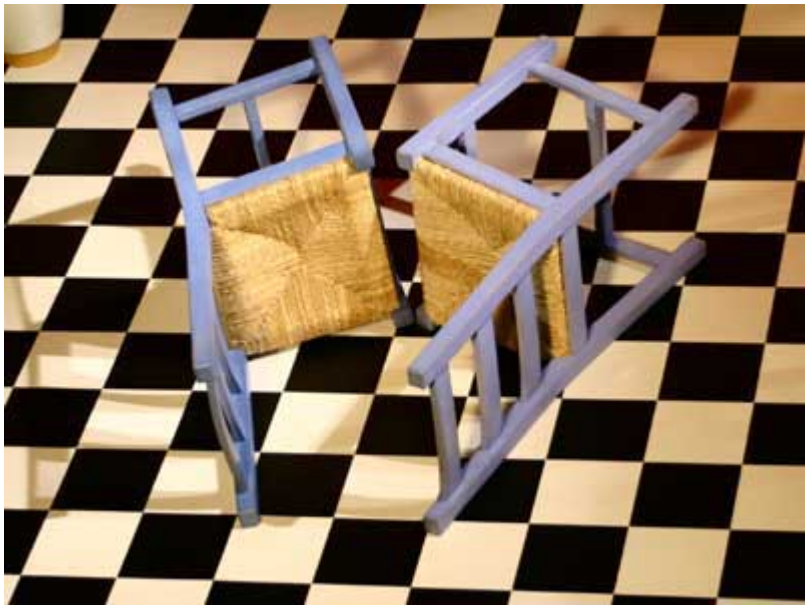

Figure 8. (BBC, 2004)

2. The owner should have the dog sit outside the V-barrier next to the gap.

3. Stand outside the barrier, with the dog, and drop the treat onto the floor the other side of the barrier so that the dog can see it through the gap. The owner should release the dog from sitting.

Figure 9. (BBC, 2004)

4. How does the dog react?

Figure 10. (BBC, 2004)

5. Interpreting the results:
    A. Dog walks immediately around the barrier to retrieve treat.
    B. After some time, dog walks around the barrier to retrieve treat.

C. Dog ignores the test or simply tries to get at the treat through the gap.
   - If option A - The dog cracked this puzzle remarkably quickly. This may be because it has come across a similar situation before, or it may be very good at looking at physical problems and coming up with solutions. This takes a fair deal of brain power.
   - If option B - The dog took a little time to crack this puzzle. It may be that it spent a few moments trying to get at the treat before deciding on a less direct action, or it could have simply stumbled upon the solution by mistake as it walked away. If you repeated the test, it may do it more quickly now it knows what to do.
   - If option C - The dog wasn't able to crack this puzzle. It may seem obvious to you, but to do this successfully, the dog must have a good understanding of its physical world, and be prepared to walk away from a treat in order to get at it. This is no mean feat.

Test 4: Spoken Commands

This is both a learning test and a memory test. The dog learns your words, phrases, body language, and vocalisations so that it can understand us and can guess what we're going to do next. The number of commands that an animal can understand is to do with both its ability to learn and the size of its memory.

Procedure for Test 4

1. Have the owner go through all the commands the dog responds to, including verbal commands, vocalizations such as whistles and hand signals. Count each of the commands to which the dog responds properly, demonstrating that it understood the command.
2. How many commands does the dog know?
3. Interpreting the results:
   A. More than 25 commands,
   B. 11–25 commands,
   C. 1–10 commands.
   - If option A - The dog is obviously skilled at learning and remembering commands. When it learns a new command, the dog is associating the sound or body signals that you create with one of its own actions. The dog's learning and memory has probably got a lot to do with your own training habits as an owner. It looks like you've given the dog plenty of opportunity to learn.
   - If option B - The dog has learned and remembered a broad selection of the commands that it finds most useful to pay attention to. When it learns a

new command, the dog is associating the sound or body movement that you create with one of its own actions. The dog's learning and memory has probably got a lot to do with your own training habits as an owner. They may be able to learn more commands with the right encouragement.

- If option C - The dog has learned and remembered a small number of commands. When it learns a new command, the dog is associating the sound or body movement that you create with one of its own actions. Some dogs are better at doing this than others, but the dog's capacity to learn and memory has also got a lot to do with your own training habits as an owner.

Test 5: Pull the String

This is a speed-of-learning test. The dog is presented with a task that it hasn't encountered before. It has to learn how to solve it by trial and error, but can it learn in just three attempts?

Procedure for Test 5

1. Tie the treat to one end of the string.

Figure 11. (BBC, 2004)

2. While the dog is watching, have the owner hide the treat under a sofa or any other suitable object so that it is out of reach, but the dog can still see it. Leave at least half of the string trailing out from under the object.

Figure 12. (BBC, 2004)

3. Have the owner encourage the dog to pull the shoelace to get at the treat, but don't let it eat it. If the dog does nothing, have the owner show it how to pull the string.

Figure 13. (BBC, 2004)

4. Repeat steps 1–3 again, so that the dog gets used to the idea.

Figure 14. (BBC, 2004)

5. Repeat steps 1–3 a third time, but this time, leave the dog to work it out on its own. What does the dog do?

Figure 15. (BBC, 2004)

6. Interpreting the results:
    A. Dog pulls or paws the string/shoelace and gets the treat immediately.
    B. Dog takes some time before it pulls or paws the string/shoelace to get the treat.
    C. Dog doesn't manage to get the treat.

- If option A - The dog has very quickly associated the action of pulling the string with the delivery of a reward. It could be that the dog has experience of performing this action already, and that it therefore took to this task quickly, or maybe the dog is simply very good at learning new physical tasks.
- If option B - The dog has worked out that if it carries out the physical action of pulling the string, it will be rewarded. This is pretty impressive because pulling a string may be an entirely novel thing for the dog to do.
- If option C - The dog has not learned that pulling the string will lead to the reward. This could be because carrying out the action of pulling the string is either a difficult or very strange thing for the dog to do, or it could be that the dog is not that good at associating a physical task with the arrival of a reward.

Variations

- Probably more so than any other domesticated animal, dogs are highly attuned to their humans. This is one of the reasons we suggest having the owner of the dog give the commands for the tests in this project. Another interesting idea would be to compare test results when commands are given by a stranger vs. by the owner. You'd need to do two separate test sessions. Half of the dogs should be tested first by the owner, and later by a stranger. Reverse the order for the other half. Is there a signficant difference in the dogs' scores when tested by a stranger?
- If you can get enough test subjects, you could use these tests to compare intelligence between two (or more) different dog breeds. Are some dogs smarter than others?

Dog Toys: What Makes One a Favorite or a Flop to Fido?

(from http://sciencebuddies.com/science-fair-projects/project_ideas/MamBio_p016.shtml?fave=no&isb=c2lkOjEsaWE6TWFtQmlvLHA6MSxyaWQ6MzI5MzU5MQ&from=TSW)

Objective

The goal of this project is to test various dog toys to find out which type is most appealing to your dog.

Introduction

Animals, like people, are meant to be active. A sedentary life style is not good for anyone including our household pets or animals living in posh, but restrictive, zoo enclosures. That's why more and more pet owners and zookeepers now give the animals under their care various objects or structures that encourage movement, exploration, play, and thinking. The goal is to create stimulating environments to encourage animals to behave much like they would in the wild. This process of using objects to promote species-specific activities in animals is called *environmental enrichment*.

Environmental enrichment ensures animals are challenged in ways that are appropriate and healthy for their species. That's why most zoos now design more natural looking enclosures where animals can interact with each other in roomier, more familiar surroundings. Enrichment also includes perching or hiding structures, large and small play things, objects to investigate or pick apart, food dispensers that challenge an animal to search for treats, and even smelly fabrics or noise-making toys. Basically, any thing that can be safely chewed, picked apart, or smelled, or are novel, challenging, or fun can be part of an animal's enrichment program.

The project video shows how two animal lovers, Chelsea and Camille, helped to develop enrichment toys for a couple of animal groups at their local zoo. The girls first put good thought into what types of objects would be appropriate for each of the animals in their studies. They then worked with the zookeepers to make their specialized animal toys. Once the toys were completed and placed into the animals' areas, Chelsea and Camille made careful observations of the animals' behaviors to see first hand how much the oys were noticed and enjoyed.

In this project, you'll study your faithful and friendly dog to find out what type of toys suit him/her best. While not quite as exotic as a tiger or river otter, your favorite canine can serve as just as interesting a subject to study. And since you already probably know a lot about your dog's personality and preferences, you'll have a big advantage when trying to predict which type of dog toy will be the most favorite. Still, until you run your experiments and make your observations you won't know for sure, so you might be in for some surprises.

The goal of this project is to present different types of toys to your dog and make close observations to see which toys are hits and which ones are flops. In selecting the toy options for your study, consider several factors. Different breeds of dogs have distinct behavioral traits and general personalities. Hunting dogs innately love to explore their surrounding primarily by sniffing. Shepards and border collies can't help but look for any object to herd, and breeds like retrievers enjoy nothing more than running after sticks or balls that they can chase or catch on the fly. Most of these natural tendencies reflect the way a particular breed of dog would locate food, or *forage*, in the wild. An enrichment toy that most closely matches a dog's basic instinctive behaviors in foraging or exploring their natural environment would be the ideal choice for that dog.

You should also keep in mind your dog's basic personality and age. Some dogs may be shy or cautious. They will need you to lead them to the toys or will want you to help them interact with a new object. Other dogs who like to search may prefer that the toys be hidden underneath a basket, so they can have the challenge of finding and uncovering the new play things. And don't forget the age of your dog. Older dogs may approach the experiments more calmly and slowly and may need a little more time to fully explore the toy options compared to younger, more frisky dogs.

Before you get started, do a little research on animal behavior and environmental enrichment. Look up the background on the breed or breeds that most closely represent your dog. Check out the theories about environmental enrichment. Find out what types of enrichment are best for dogs in general and for your breed of dog specifically. You'll see a list of search terms, basic questions, and a helpful bibliography in the the following sections to get your research going. Finally, use your improved understanding of dog behavior to see if you can accurately predict the types of enrichment toys your dog will most enjoy before you run your tests. The results of your experiments will reveal whether your instincts are correct, or whether your dog is much more unpredictable and fickle than you ever realized.

Good luck, and have fun with Fido!

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- Environmental enrichment
- Dog behavior
- Canine behavior
- Dog breeds and their specific traits

Questions

- What are classic behaviors for canines and the major breeds of dogs?
- What is environmental enrichment?
- How is environmental enrichment important to animals?
- What are some examples of environmental enrichment for zoo animals? For dogs? For other pets?
- How are animal behaviors measured and interpreted?

Bibliography

Here are some websites you might want to check out as you start your research:

- Explanation and examples of dog enrichment ideas:
  Haug, L., no date. "Environmental Enrichment for Dogs," Texas A&M University [accessed on August 14, 2007]
  http://www.bcrescuetexas.org/Training/ATM_Enrichment.pdf.
- Why dogs need environmental enrichment and how to do it:
  Staff, no date. "Environmental Enrichment in Kennels," Crosskeys Animal Care Centre web site [accessed August 14, 2007]
  http://www.crosskeysbooks.com/product_info.php?products_id=436.
- Short chapter on how to properly house dogs that includes an impressive list of references on dogs and dog rearing:
  Hubrecht, R., 1995. "Dogs and Dog Housing," chapter from Environmental Enrichment Information Resources for Laboratory Animals: 1965 to 1995: Birds, Cats, Dogs, Farm Animals, Ferrets, Rabbits, and Rodents, U.S. Department of Agriculture [accessed on August 14, 2007]
  http://www.nal.usda.gov/awic/pubs/enrich/dogs.htm.
- Photos and videos of various zoo enrichment examples:
  Carlstead, K., 2007. "The Honolulu Zoo's Animal Environmental Enrichment Program," Honolulu Zoo website [accessed August 18, 207]
  http://www.honoluluzoo.org/enrichment_activities.htm.

- An example of a procedure for an enrichment experiment at a zoo: FONZ, no date. "Invertebrate Enrichment," from Smithsonian Friends of the National Zoo Park [accessed on August 18, 2007] http://nationalzoo.si.edu/Animals/Invertebrates/Enrichment/default.cfm.
- The basic idea for this project came from this DragonflyTV podcast: TPT, 2006. "Tigers and Otters by Chelsea and Camille," Twin Cities Public Television [accessed on August 14, 2007] http://pbskids.org/dragonflytv/show/tigersandotters.html.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- Your adult dog (see guidelines below for using dogs in experiments)
- An assistant to help you time your experiments and record observations
- Large room with open space, or an outdoor area with no distractions
- Plastic laundry basket or bin
- 12 dog toys: Select four toys for each experiment listed below. Choose three toys you predict your dog will like and one toy you think will be unappealing to him/her in each experiment.
    - Experiment 1. Interactive (balls that bounce, squeaky toys, rattles, toys that light up or make music)
    - Experiment 2. Different Shapes (sticks, balls, frisbee, cubes, plastic bottles or jugs)
    - Experiment 3. Different Textures (soft plush, hard rubber, leather, canvas toys of similar sizes/shapes)
    - Experiment 4. Favorite Four (use four favorite toys from experiments 1–3)
- Watch or stop watch
- Notebook or paper
- Pen or pencil
- *Guidelines for using dogs in experiments*:
    - Be sure an adult is present when you are testing a dog.
    - Don't use a puppy for this project. They don't have the maturity or training to follow instructions.
    - Never force a dog to participate in any of the experiments. If the dog is unwilling to take part, try again later.
    - If a dog begins to appear tired or bored, stop the testing, and try that experiment again later or on another day.
    - If you use any food items in your testing, do not use chocolate, raisins, grapes, garlic, or onions. These are toxic foods for dogs.

Experimental Procedure

1. Select and obtain the toys for your experiments based on objects you think your dog will like and dislike.
2. Make a list of the toys you collected for each experiment, and assign a number to each toy. Indicate which toys you predict will be definite favorites, which ones could be somewhat appealing, and which ones will be of little interest to your dog.
3. Prepare a data table similar to the example below for each of the four experiments.
4. The experiments are run on four separate days, testing one type of toy per day.
5. Each experiment involves three, timed trials with the same four toys. You will rate your dog's interest in each toy from "0" to "4" in each trial based on your dog's behavior. (0 = no interest; 1 = very little interest; 2 = some interest; 3 = medium interest; and 4 = high interest).
6. Place the four toys of Experiment 1 (Interactive toys) in the basket at the far end of the room.
7. Bring your dog into the room and, on your command, let him/her loose to find and explore the basket of toys.
8. Start timing as soon as the dog approaches the basket. Let the dog explore and interact with the toys for two minutes. *Note*: If your dog needs more than two minutes to investigate the toys, you can increase the time, but be sure to use the same time limit for all trials in every experiment.
9. Based on your observations of your dog's behavior with the toys, rate each toy from "0" to "4" for interest level. Record the scores in the data table prepared for this experiment.
10. Take the dog out of the room, and repeat the procedure for two more trials using the same four toys.
11. The next day, repeat the experiment using four toys of Experiment 2 (Different Shapes). Record the scores in the data table prepared for this experiment.
12. On day three, repeat the experiment using four toys of Experiment 3 (Textures). Record the scores in the data table prepared for this experiment.
13. Based on each toy's total score from an experiment, select four toys that your dog seems to like the most to use in the final experiment.
14. Do an experiment with the four favorite toys to determine the "ultimate" favorite toy for your dog. Record your rating numbers for each toy on the data table prepared for this experiment.
15. *Hints to encourage your dog to investigate the toys*:
    a. Depending on how active and naturally curious your dog is, you may have to call the dog over the to basket or prompt him/her to look inside at the toys.

b. You could also briefly show or present each toy to your dog, but don't encourage interaction with any one toy more than another.
c. You could lay the toys out on the floor or toss them instead of placing them in a basket if it makes it easier for your dog to find and to examine them. Be sure to switch the placement order of the toys between the three trials in an experiment. That way you'll know the dog is really interested in one particular toy and not just going for the same spot each time.

Data Table Example

Dog's Name: Date:

Experiment 1 (Interactive Toys)				
	Toy 1	Toy 2	Toy 3	Toy 4
Trial 1				
Trial 2				
Trial 3				
TOTAL SCORE				

Analyzing Your Data

1. Tally the total score recorded for each toy. Rank the toys from highest to lowest within each experiment.
2. Which toys did your dog show a clear preference for in Experiment 1, 2, and 3? Which toys were the least favorite in each experiment? Were you surprised about any of the results?
3. Did your dog prefer more toys of one type than the others?
4. How accurate were your predictions about which toys your dog would like and dislike?
5. Did your dog have a single "ultimate" favorite toy, or did your dog seem to like several toys equally?
6. Explain the results based on the natural behaviors typical for your type of dog or for canines in general.
7. For help with data analysis and setting up tables, see Data Analysis & Graphs.
8. For a guide on how to summarize your results and write conclusions based on your data, see Conclusions.

Variations

- **Repeated Testing**. Does your dog learn to like certain toys over time? Repeat your experiments on multiple days over two or three weeks to see if your dog's choices are consistent or if your dog eventually starts to enjoy additional toys.
- **Try other dogs**. Does your neighbor's dog have similar tastes in toys to your dog? Try the same experiments with one or two other dogs to compare their responses to your dog's. Be sure to make predictions about what the new dogs might like or dislike based on their breed and personality before you run your tests.
- **Other Toy Choices**. What other types of toys can you come up with to test on your dog? Could you try toys that look alike but vary only in color, scent, or size, for example? What would happen if you added toys that have food within them? How about toys make from natural materials versus synthetic products? Repeat your experiments using these additional categories of toys and compare the results to your first experiments. *Important Note*: If you use any food items, do not include chocolate, grapes, or raisins as these are toxic to dogs.
- **Designer Toy**. Based on your results, design a new toy for your dog that incorporates all of his/her favorite toy features. Try to find a toy that meets all or most of the criteria or make it yourself, if possible. Test your "designer" toy against the other toy favorites of your dog in a new experiment.
- **Canine Camera**. Do you think your dog would have the same reaction to the toys if you were not in the room? Set up a video camera on a tripod and film your dog's behavior when he/she is alone in the room with each separate set of toys. Compare these results to your initial experiments when you were present.
- **The Battle of the Breeds**. If you have access to dog clubs that focus on specific breeds, recruit at least ten dogs of one breed and ten dogs of a different breed for an expanded project on dog toy preferences. For guidelines on how many animals you ideally would want to use in this type of project see: Sample Size: How Many Survey Participants Do I Need?.
- For other Science Buddies projects related to dog behavior see:
    - Dog Smarts: What's Going On Behind Those Puppy-Dog Eyes?
    - Paw Preference in Pets
    - Tail Wagging and Brain Lateralization

How Food Supplements Affect Weight Gain of Juvenile Mice

(from http://sciencebuddies.com/science-fair-projects/project_ideas/MamBio_p007.shtml?fave=no&isb=c2lkOjEsaWE6TWFtQmlvLHA6MSxyaWQ6MzI5MzU5MQ&from=TSW)

Objective

The goal of this project is to determine whether feeding juvenile mice supplements of different food types would lead to increased weight gain.

Introduction

When speaking about proper nutrition, we often use the word 'balance.' You often hear, for example, how important it is to eat a balanced diet. Health-conscious people also strive to maintain a balance between calories consumed and calories expended, by getting regular exercise and eating regular, healthy meals.

What happens when the diet is imbalanced? Can consumption of too many simple carbohydrates lead to weight gain? How about other types of food? These kinds of questions can be difficult to answer with studies on humans, since it would be unethical to knowingly subject experimental subjects to unhealthy diets. As an alternative, scientists can conduct epidemiological studies, looking at health outcomes for groups of people with different dietary habits. Another method is to use animal models for more carefully controlled experimental studies.

Mice are often used as experimental animals for many reasons. One of the biggest reasons is the degree of control that scientists have over the genetic backgrounds of the mice they study. Specific genes of interest can be turned off or on, or regulated more subtly. Also, since mice grow quickly, it is easy to generate sufficient numbers of mice with similar genetic backgrounds.

Small, warm-blooded animals, such as mice, generally have much higher metabolic rates (and shorter lifespans) than larger warm-blooded animals. Typical laboratory mice live about one and a half years. Mice are considered infants from birth to 21 days of age. At 21 days they are weaned—they stop nursing and switch to eating solid food. Mice are considered juvenile from 3–8 weeks. At 2 months, mice are considered adults, and are capable of producing offspring (NIDDKD, 2005b).

Even though mice have many genetic and biochemical similarities with humans, experimental outcomes with mice are certainly not guaranteed to be similar to experimental outcomes with humans. Still, experiments with animal models can provide us with many valuable insights to help fight human diseases.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- protein,
- fat,
- carbohydrate.

Questions

- What is the nutritional composition of standard laboratory mouse food (mouse chow)?
- What is the nutritional composition of the sugared cereal supplement?
- What are some of the mechanisms by which the body maintains its energy balance?

Bibliography

- For ideas for experimental design and practice with analyzing data, this site has web-based experimental simulations on the science of energy balance (see especially lesson 4, "Munching Mice", requires Flash Player):
  NIDDKD, 2005a. "The Science of Energy Balance," National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health [accessed August 11, 2006] http://science.education.nih.gov/supplements/nih4/energy/activities/activities_toc.htm.
- NIDDKD, 2005b. "Munching Mice Reference Manual," National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health [accessed August 11, 2006] http://science.education.nih.gov/supplements/nih4/energy/activities/508/mice-ref/mice_ref.htm.
- This website has descriptions and calculators for several statistical tests, including the Student's *t*-test that you can use in this project:
  Kirkman, T., date unknown. "Student's *t*-Tests," Department of Physics, College of

St. Benedict & St. John's University [accessed February 23, 2006] http://www.physics.csbsju.edu/stats/t-test.html.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- at least a dozen juvenile mice of the same age (between 3–6 weeks old),
- at least two separate cages with sufficient space for the mice;
- bedding material;
- mouse food;
- place to keep cages with normal light/dark cycle and reasonably constant temperature;
- food supplement: sugared cereal for group 1;
- latex or vinyl examination gloves (wear when handling mice);
- electronic scale for weighing mice;
- weighing chamber (see Figure 1, below).

Figure 1. To prevent mice from escaping when weighing them, use a weighing chamber. This one is made from a refigerator container with air holes punched in the top.

Experimental Procedure

Note: for experiments involving vertebrate animals, ISEF-affiliated fairs require the experimental design to be approved by a scientific review committee (SRC) prior to the commencement of experiments. Please refer to the ISEF rules for additional important requirements for studies involving vertebrate animals: http://www.sciserv.org/isef/document/.

1. Place six mice in each cage. Both groups will have free access to standard laboratory mouse food and water.
2. Feed the mice in cage 1 a supplemental food high in simple carbohydrates (e.g., sugared breakfast cereal) two or three times a day.
3. Mice in cage 2 (the control group) will receive no supplement.

4. Record the weight of each mouse daily. How do you tell them apart? Here are some tips for marking mice from the mouse experts at The Jackson Laboratory:
    a. "Several methods are particularly well suited for identifying cage mates. A felt tip marker may be used for marking an ear or tail: such marks usually disappear in 1-2 days.
    b. "Food coloring may be used to dye a patch of fur: such marks generally last for 1-2 weeks but can be used only on albino and light colored mice.
    c. "A patch of fur on the back or side of the mouse may be shaved: such marks generally last 1-4 weeks (depending on stage of the hair cycle) and can be used on any color mouse." (Jackson Laboratory, 2005)
5. For handling the mice in order to weigh them, there are three different methods you can try. Whichever method you choose, transfer the mouse to the weighing container smoothly and quickly.
    a. If you can manage the hand scoop method, it is probably the least stressful for the mice. However, you do need to be careful not to let the mouse escape.

Figure 2. The hand scoop method is usually the least stressful way of handling mice.

    b. The tail hold with hand support is the next method. Grasp the tail of the mouse close to the body (no further than half-way down the tail). Support the mouse's feet with your other hand.

Figure 3. The tail hold with hand support is an alternative method for handling mice.

    c. The tail hold alone is the final method. Remember to always grasp the tail of the mouse close to its body. Lifting near the tip of the tail will injure the mouse. Do not leave the mouse hanging, or it will climb its tail and try to bite.

Figure 3. The tail hold alone is the third method for handling mice.

6. Calculate the weight gain for each individual mouse.
7. Calculate the average and standard deviation of the weight gain for each group of mice.
8. More advanced students should use Student's *t*-test to determine whether any differences between the two averages are statistically significant. The Bibliography has a link to an online calculator you can use (Kirkman, date unknown).

Variations

- If you want to collect data on caloric intake, you can also weigh the food each day to figure out how much the mice have eaten.
- In this experiment, the food supplements primarily contained simple carbohydrates. What about other nutrients? Design an experiment to test weight gain when the food supplement contains a high proportion of fat, or protein.
- When it comes to gaining or losing weight, diet is only part of the equation. Diet determines the number of calories on the input side, but an animal's activity determines how many of those calories are used. Design an experiment to assess the difference in weight gain between "couch potatoes" and active mice.
- What role does genetics play in weight gain? Test different strains of mice for weight gain. Keep diet and exercise the same for both groups.

Paw Preference in Pets

(from http://sciencebuddies.com/science-fair-projects/project_ideas/MamBio_p011.shtml?fave=no&isb=c2lkOjEsaWE6TWFtQmlvLHA6MSxyaWQ6MzI5MzU5MQ&from=TSW)

Objective

The goal of this science fair project is to determine whether non-primate mammals (e.g., dogs or cats) have a paw preference, which might indicate lateralization of function in the brain.

Introduction

Did you know that different parts of the brain are specialized for doing different things? In mammals, for example, there are specific areas of the brain devoted to vision, hearing, touch, smell, and movement.

Most people have a distinct hand preference for actions that involve **fine motor control,** such as writing or throwing a ball. Incidentally, most people also have a dominant foot, ear, and eye.

Curiously, the two halves, called **hemispheres,** of the brain have some specialized functions (in the majority of the population). For most people, the brain areas involved in producing and understanding language (both spoken and written) are in the left hemisphere. The right hemisphere (again, in most people) is crucial for understanding spatial relationships: navigating through your house, for example, or recognizing where a piece fits in a jigsaw puzzle.

Another interesting fact about the two sides of the brain is that connections from the cortex to the body are "crossed." The left side of body is mapped to the **somatosenory cortex** in the right hemisphere of the brain, and is controlled by the right hemisphere's **motor cortex.** The reverse holds for the right side of the body. So when you move your right hand to pick something up, the "command" to initiate the action originated in your left motor cortex.

What about other animals? For example, do pets like dogs or cats have a **paw preference?** The Experimental Procedure, below, has some ideas you can use to test dogs for paw preference. If you would like to see some ideas for testing paw preference in cats, watch the DragonflyTV video on the right, and join Cleo, Brittany, and Molly as

they put Cleo's cats, Nudge, Cle-cle, and Brooklyn through a series of three tests to see which paws the cats use most frequently.

Some things to think about if you will be testing cats:

1. When putting a cat (or a dog) through the "food tube test" (where the animal tries to get food out of a long tube), be sure to place the tube so that when the animal first sees it, the tube is not off to the animal's right or left, but directly in front of the animal, in the middle.
2. When putting a cat through the string or toy test, again, be sure to first show the toy to the cat so that it is in the center of his or her field of view, and not off to one side, as this will influence which paw the cat uses to bat at the toy.
3. In the "smudge test," where a dab of an edible, oily substance is placed just above the cat's nose to see which paw he or she uses to wash it off with, be sure to use something that the cat is not allergic to, and is non-toxic (safe to eat). A dab of wet cat food might be a good choice. Be sure not to use too much, or do this test outside, so that if the cat shakes his or her fur, the substance doesn't fly around the room.
4. Some cats are very sound-sensitive, so be sure to do your trials in a quiet room with few people. Remember the general rules around animals: speak softly and move slowly. Fast motions can frighten many animals. If you need to get your cat's attention, try gentle kissing sounds.
5. Remember that cats, like other mammals, have a **circadian rhythm,** or daily cycle, that tells them when to sleep, eat, and play or hunt. Many cats like to sleep during the day and play or hunt in the evening or early morning when their traditional prey, like rodents or birds, become active. To get the best results, try to conduct the trials of your experiment at the same time every day, and at times when your cat is most active and interested in food.

Terms, Concepts and Questions to Start Background Research

- Fine motor control
- Brain hemispheres
- Somatosensory cortex
- Motor cortex
- Paw preference
- Circadian rhythm
- Brain lateralization

Questions

- An animal's right paw is controlled by the motor cortex in which brain hemisphere?
- If you touch your pet on it's left paw, you will activate neurons in the sensory cortex of which side of the brain?

Bibliography

- TPT. (2006). Pet Handedness by Cleo, Brittany, Molly. *Dragonfly TV, Twin Cities Public Television.* Retrieved November 13, 2008, from http://pbskids.org/dragonflytv/show/pethandedness.html
- BBC. (2004). *Test Your Pet.* Retrieved August 21, 2006, from http://www.bbc.co.uk/nature/animals/pets/testyourpet/flat_alternative.shtml
- WGBH. (1998). *Probe the Brain.* Retrieved August 21, 2006, from http://www.pbs.org/wgbh/aso/tryit/brain/#

For information on brain lateralization and handedness in humans, try these references:

- Chudler, E.H. (2006). *Hemispheres.* Retrieved August 21, 2006, from http://faculty.washington.edu/chudler/split.html
- Holder, M.K. (2005). *What does Handedness Have To Do with Brain Lateralization (and Who Cares?)* Retrieved August 21, 2006, from http://www.indiana.edu/~primate/brain.html
- Wikipedia Contributors. (2008, November 13). Lateralization of Brain Function. *Wikipedia: The Free Encyclopedia.* Retrieved August 21, 2006, from http://en.wikipedia.org/w/index.php?title=Lateralization_of_brain_function&oldid=248451127
- Gabriel, G. (2006). *"Left Brain" "Right Brain" The Mind in Two.* Retrieved August 22, 2006, from http://www.brainconnection.com/topics/?main=fa/mind-two

Materials and Equipment

- A large number (while 50–100 would be good, you should do *at least* ten, if possible) of pet dogs or cats to test for paw preference:
  - perhaps there is a nearby park where owners bring their dogs for exercise,
  - see the Science Buddies resource, How Many Participants Do I Need?, to see understand the reasons for a large number of test subjects;
- Small treats or toys for the dogs (or cats)
- Tube to hold the treat or toy in

- *Note:* Instead of using a tube, you might place the treat under a piece of furniture, where it will be within reach of a paw, but out of reach of the head.
- Lab notebook

Experimental Procedure

1. Do your background research and make sure that you understand the terms, concepts, and questions above. More-advanced students should also do research into current theories on the advantages (and disadvantages) conferred by lateralization of function in the brain.
2. For each dog you test, record the age, gender, and results for the following tests of paw preference.
3. Shake A Paw
    - Have the dog sit for you.
    - Extend a hand and give the command "shake" or "shake a paw."
    - Record which paw the dog places on your hand.
    - Take a short break, allowing the dog to get up and move around.
    - Have the dog sit for you again and repeat the test. Do at least three tests with your right hand and at least three tests with your left hand.
    - Does the dog always respond with the same paw? Does it matter which hand you offer to the dog? Record your observations in your lab notebook.
4. Get a Treat
    - Place a treat (or toy) inside a tube large enough for the dog's paw, but too small for its mouth.
    - Show the dog the treat, then place the tube down in front of the dog.
    - Observe the dog's behavior. If he tries to extract the treat from the tube, which paw does it use?
    - As an alternative to placing a treat in a tube, you can put it underneath a piece of furniture, where it can only be reached with a paw.
    - As before, take a short break and then repeat the test (at least twice more).
5. Calculate the percentage of dogs with left paw preference, right paw preference, or no clear paw preference.
6. How do these results compare to handedness in humans?

Variations

- Can you devise another test of paw preference in pets? How do the results of your test compare with results from the tests above?
- Compared to dogs with no paw preference, do dogs with a definite paw preference perform better, worse, or the same on other tests of canine intelligence? For

ideas of other tests to try, see BBC, 2004. "Test Your Pet," BBC, Science & Nature [accessed August 21, 2006] http://www.bbc.co.uk/nature/animals/pets/testyourpet/flat_alternative.shtml).

- Can you think of a way to test people for foot preference? How about a way to test which ear is dominant, or which eye? Do these always match with hand preference?

Predators and Prey: How Do Cats Respond to Bird Sound Recordings?

(from http://sciencebuddies.com/science-fair-projects/project_ideas/MamBio_p017.shtml?fave=no&isb=c2lkOjEsaWE6TWFtQmlvLHA6MSxyaWQ6MzI5MzU5MQ&from=TSW)

Objective

The goal of this project is to determine whether cats respond preferentially to familiar bird sounds.

Introduction

This experiment is based on a 2007 California State Science Fair project by Kelly McGinnis. Kelly's mom was learning to recognize birds and bird calls by watching and listening to a DVD with recordings of birds in the wild. Kelly had the impression that her pet cat became alert and turned its head more often when it heard recordings of birds that were found in their area, and less often for birds that were unfamiliar. She was curious to find out if her hunch was correct, so she set up an experiment to find out. She selected recordings from three different birds, two local, and one non-local. She used DVD recordings, with both sound and video, and played these test recordings for each of the 32 cats in her study, using a laptop computer. The order of presentation was randomized for each cat tested. She played the recordings for either three minutes or until the cat made an *orienting response* to the recording (i.e., seemed to search for the bird, by moving its head or body toward the computer).

You could do the experiment with a DVD, as Kelly did, or with an audio CD of bird calls, using a portable CD player to play back the sounds. It's a good idea to have a large sample of cats, like Kelly did, and you may want to select even more bird calls to try. For example, you might want to select three different local bird calls and three different non-local bird calls to test with each cat.

Do you think that cats will pay more attention to bird calls that they have heard before? Or perhaps a novel bird call will prove to be more interesting? You can find out for yourself with this experiment.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- Predatory behavior in cats
- Stimulus
- Orienting response
- Bird calls
- Bird identification
- Ornithology

Questions

- What bird species are native to your area?
- What bird species pass through your area during migration, and when?

Bibliography

- To learn more about predatory behavior in cats, try these webpages:
  - Carter, J., 1998. "Feral Cat Behavior: Stalking a Mouse," Amby's Feral Cat Information Page [accessed June 8, 2007] http://amby.com/cat_site/carter_3.html.
  - Perfect Paws Publishing, 2007. "Predatory Behavior of Cats," Perfect Paws Publishing [accessed June 8, 2007] http://www.perfectpaws.com/help3.html.
- For identifying birds, the Peterson field guides are a valuable resource (various publication dates and titles, typical examples follow):
  - Peterson, R.T., 2002. *A Field Guide to the Birds of Eastern and Central North America* Boston, MA: Houghton Mifflin Co.
  - Peterson, R.T., 1990. *A Field Guide to Western Birds: A Completely New Guide to Field Marks of All Species Found in North America West of the 100th Meridian and North of Mexico.* Boston, MA: Houghton Mifflin Co.
- Here's an online guide to identifying birds that includes audio clips of calls for many of the birds:
  eNature.com, 2005. "FieldGuides: Birds," eNature.com [accessed October 1, 2007] http://www.enature.com/fieldguides/intermediate.asp?curGroupID=1.
- You can also study birds online:
  CLO, 2007. "All About Birds," Cornell Lab of Ornithology [accessed June 8, 2007] http://www.birds.cornell.edu/AllAboutBirds/BirdGuide/.

- This project is based on the following 2007 California State Science fair project, a winner of the Science Buddies Clever Scientist Award:
  McGinnis, K., 2007. "Domestic Cat (Felis catus) Responses to Bird Sounds ," California State Science Fair Abstract [accessed June 8, 2007] http://www.usc.edu/CSSF/History/2007/Projects/J1119.pdf.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- At least 20 domestic cats to test (more is better)
- Audio recordings of bird songs, e.g. Borror, D.J., "Common Bird Songs Book and Audio CD," ISBN: 0486996093, available from Dover Publications
- Portable CD player

Disclaimer: Science Buddies occasionally provides information (such as part numbers, supplier names, and supplier weblinks) to assist our users in locating specialty items for individual projects. The information is provided solely as a convenience to our users. We do our best to make sure that part numbers and descriptions are accurate when first listed. However, since part numbers do change as items are obsoleted or improved, please send us an email if you run across any parts that are no longer available. We also do our best to make sure that any listed supplier provides prompt, courteous service. Science Buddies receives no consideration, financial or otherwise, from suppliers for these listings. (The sole exception is any Amazon.com or Barnes&Noble.com link.) If you have any comments (positive or negative) related to purchases you've made for science fair projects from recommendations on our site, please let us know. Write to us at scibuddy@sciencebuddies.org.

Experimental Procedure

1. Do your background research so that you are familiar with the terms, concepts, and questions, above.
    a. You will need to spend some time identifying local birds that the cats in your study are likely to have encountered.
    b. You will also need to identify some non-local birds that the cats in your study are unlikely to have encountered.
2. Pick 2–3 examples of local bird songs from your audio CD.
3. Pick 2–3 examples of bird songs from birds not found in your area.
4. For each cat in the study, play each of the recordings, in randomized order, at least three times (again, more trials are even better). Naturally, you must test each cat when it is awake and alert!
    a. To randomize the presentation order, first number (or name) each recording.

    b. Write the numbers (or names) down on separate pieces of paper.
    c. Mix up the slips of paper, and blindly draw them from a bowl to determine the presentation order for each test.
5. Observe the cat closely, and note the responses to each recording in your lab notebook.
6. You should test at least 20 different cats (more is better). For more information, see the Science Buddies How-To page, Sample Size: How Many Survey Participants Do I Need?
7. It is a good idea to allow the cat some down time in between the trials, so that it does not become habituated to the recordings. Multiple, short trials will probably work best.
8. After your tests are complete, you'll need to analyze and summarize the results in your lab notebook.
    a. For each cat, count how many orienting responses were made to each different bird sound.
    b. For all of the cats, what was the average number of orienting responses to each bird sound?
    c. More advanced students should also calculate the standard deviation of the number of responses.
9. Make bar graphs showing the average number of orienting responses to each bird sound. Did the cats respond preferentially to local birds?

Variations

- You can also find DVD recordings of birds, with both sounds and images. You can play clips from selected local and non-local birds for cats using a laptop computer. Does the addition of the images increase the likelihood of an orienting response? Are the cats more likely to respond to local vs. non-local birds?
- Does it make a difference if the cat tested is an indoor-only cat vs. a cat who gets outside? You'll need two test groups for this experiment, each with at least 20 cats. One group needs to be indoor-only pets, and the other group must be cats who are allowed outside. Compare the test results between the two groups. Does outdoor experience make a difference in orienting repsonses to bird sounds?

Tick Tock, Tick Tock, Does Your Mouse Know the Time on the Clock?

(from http://sciencebuddies.com/science-fair-projects/project_ideas/MamBio_p023.shtml?fave=no&isb=c2lkOjEsaWE6TWFtQmlvLHA6MSxyaWQ6MzI5MzU5MQ&from=TSW)

Objective

The objective of this science fair project is to study how the activity level of your pet rodent varies over the course of a day-night cycle, and what factors affect this activity level.

Introduction

Cycles of biological activity that vary over the course of a 24-hour period are called **circadian** (the word comes from *circa,* which means *approximately,* and *dia,* which means *day*). The circadian rhythm is tied to the outside world, such as daytime and nighttime, but it is also dependent on an internal clock. This **internal clock** needs to be "reset" when the external signals change. For example, when you travel to a region in a different time zone, your internal clock needs to adjust to the new day-night cycles. In addition to the sleep-activity cycle, there are numerous other processes that follow a circadian rhythm. Figure 1 shows the timing of various circadian cycles in humans.

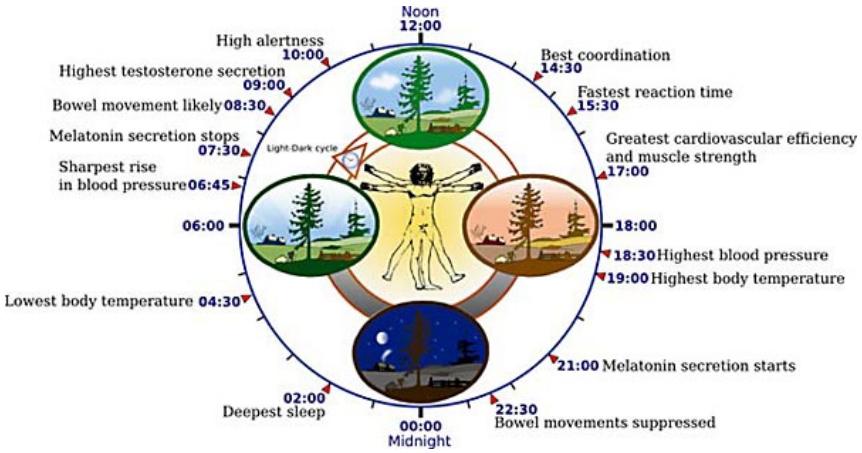

Figure 1. This diagram depicts some of the circadian patterns that occur in humans. Note that the clock is on a 24-hour cycle, so that 3:30 PM, for example, is noted as 15:30. The hormone *melatonin,* which is a key regulator of the internal circadian clock, peaks in concentration at 21:00 (9:00 PM). (Wikipedia, 2008).

Rodents are typically nocturnal, resting during the day and becoming active at night. In the wild, **nocturnal activity** helps the animal avoid predators. For rodents living in a desert environment, nocturnal activity also has the advantage of restricting activity to the cooler part of the day.

Animals actually have a number of internal clocks that are critical for normal functioning. The internal clocks are "set" by environmental cues, such as the day-night cycle, but they will continue to run even when the animal is kept in total darkness.
The objective of this science fair project is to study how the activity level of your pet rodent varies over the course of a day-night cycle. You will build a device that measures your rodent's activity by tracking the motion of your pet's exercise wheel. You can also experiment with factors that alter the normal day-night cycle of activity, such as keeping your pet awake during the day by playing with it.

Terms, Concepts and Questions to Start Background Research

- Circadian rhythm
- Internal clock
- Nocturnal activity

Questions

- At what time of day is your pet rodent most active?
- When your pet rodent is active, is it for short bursts of a few minutes, or is it extended over a longer period of time?
- How quickly does your pet rodent's daily activity schedule adjust to changes in its environment?

Bibliography

- Wikipedia Contributors. (2008, August 3). Circadian Rhythm. *Wikipedia: The Free Encyclopedia.* Retrieved August 3, 2008 from http://en.wikipedia.org/w/index.php?title=Circadian_rhythm&oldid=229637148
- For a history of the science of circadian rhythms and a glossary of terms, see this website:
  Harmer, T. (2008, June). *Introduction to Chronobiology.* Retrieved June 9, 2008 from http://www.sbms.mvm.ed.ac.uk/bmto/neuroscience/NeuroSci4/harmar/Chrono1a.pdf
- This site at the University of Utah has a good introduction to the genetics of mammalian internal clocks.

Siegel, L.J. (2008). *The Time of Our Lives.* Retrieved June 9, 2008 from http://learn.genetics.utah.edu/content/begin/dna/clockgenes/

- The Howard Hughes Medical Institute has a number of animations about the fundamental biology of circadian rhythm:
  Howard Hughes Medical Institute. (2008). *Biological Clocks: Animations.* Retrieved June 9, 2008 from http://www.hhmi.org/biointeractive/clocks/animations.html

Materials and Equipment

- You should already own a mouse, a rat, a guinea pig, or a hamster, and know how to take care of it. Or you can study a pet rodent at your school.
- A rodent exercise wheel; the "Silent Spinner," available at most pet supply stores, works well because it turns smoothly with minimal wobble. But you can probably use the exercise wheel you currently own.
- An electronic bicycle speedometer; it should have a magnet that attaches to the wheel, and a sensor that counts the magnet's revolutions; you can purchase this at most sports stores or online.
- Clear adhesive tape or modeling clay
- Lab notebook

Experimental Procedure

To study circadian rhythms in your pet rodent, you will need to devote some time every day for several weeks to observing its activity levels. Your pet's response to changes in the environment, such as varying the amount of playtime your pet experiences during the day, may take several days to observe. Plan your experiments carefully, take thorough notes, and give yourself plenty of time for observation. And, of course, be sure not to cause any stress to your pet during the experiments.

1. To start this science fair project, you should have access to a pet rodent that you are comfortable working with, either at home or at your school.
2. Observe the pet during the day and record its activity levels. Check on it every 2 hours and watch it for 10-minute periods. If you aren't able to check on it that often, see step 3.
3. To measure the activity level when you are not present, install a bicycle speedometer on the pet rodent's exercise wheel.
    a. Read the instructions so that you know how to determine the distance traveled.
    b. The speedometer has a magnet that rotates with the wheel, and a sensor that counts the revolutions each time the magnet passes by.

    c. Tape or glue the magnet to the wheel.
    d. Attach the sensor to the wheel so that it records the magnet's movement. You can use clear adhesive tape or modeling clay to hold the sensor in place.
    e. The magnet needs to pass fairly close to the sensor for the speedometer to work.
4. Check the speedometer readings in the morning and in the evening for total distance travelled. If possible, check more often (every few hours) to determine the times of peak activity. Reset the speedometer between readings.
    a. If you want to record the actual distance, you will need to account for the size of the exercise wheel vs. the bicycle wheel. For example, if the speedometer is set to work with a wheel with a diameter of 26 inches, and the exercise wheel is 6.5 inches in diameter, then dividing the distance by 4 (that is, 26 inches/6.5 inches) will yield corrected results for distance traveled.
    b. To measure the relative activity levels, you can use the numbers on the speedometer without converting.
5. The initial goal is to determine your pet's "baseline" activity level; that is, its daily activity level prior to any experimental changes in its environment. Observe your pet for several days to establish its baseline behavior and record the results in your lab notebook.
6. After several days, try increasing or decreasing the amount of time you are playing with your pet during the day. Record the time you spend playing each day. How does the amount of playtime you have with your pet during the day affect its nocturnal activity cycle?
    - *Note:* Remember to change only one variable at a time. For example, to study how the length of playtime your pet has affects its activity level, first determine its "normal" baseline level of activity over the course of 24 hours, then change *only* the amount of playtime. Try to keep everything else in the pet's environment the same so that any changes you observe are due to the variable (playtime) that you control.
7. How long does it take for your pet to change its activity cycle after you alter its playtime during the day? When you return your pet to its "normal" schedule, how long does it take for your pet to return to its "baseline" activity schedule?
8. You might plan your experiments to last about one week each. For example, you could have a 3-day period of increased daytime activity, followed by a 4-day recovery period in which you return to your normal baseline activity.
9. Repeat your experiments at least three times.

Variations

- Change the pattern of light and darkness in your pet's cage. For example, what happens if you shorten the number of hours of light that the pet experiences? Remember not to stress your pet in any way, and keep your playtime and other variables constant.
- Many schools have classroom pets: a rat, rabbit, hamster, fish, or frog. If your class has a pet, study its behavior to see if you can determine any circadian rhythm patterns.

What Is Home Sweet Home to a Bug?

(from http://sciencebuddies.com/science-fair-projects/project_ideas/Zoo_p021.shtml?fave=no&isb=c2lkOjEsaWE6Wm9vLHA6MSxyaWQ6Mzl5MzU5MQ&from=TSW)

Objective

The goal of this project is to investigate what types of micorenvironments are preferred by sowbugs (or pillbugs).

Introduction

You can often find sowbugs and pillbugs in damp, dark places, like the soil under rocks or decaying wood. Do you think that they are insects? Think again! Unlike insects, they have seven pairs of legs (insects have three pairs). Sowbugs and pillbugs are both crustaceans called isopods, and look fairly similar. Pillbugs are commonly known as "roly-polies" for their defensive behavior of rolling up into an armored ball. Sowbugs don't roll themselves up, and also have a pair of tail-like structures on the last segment of the body. The pictures below (Figures 1 and 2) show examples of each type of "bug."

Unlike insects, sowbugs and pillbugs breathe with gills, so they need moisture in order to breathe. In this project, you will observe how these bugs behave in an experimental habitat that you construct in order to learn about their preferred habitat. Your habitat will be divided into compartments that provide different benefits to the bugs, e.g., moisture, or shelter, or food. Where do you think they will spend the most time?

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- crustacean,
- habitat.

Questions

- How do sowbugs and pillbugs breathe?
- Are sowbugs and pillbugs insects?
- What do sowbugs and pillbugs eat?

Bibliography

- Here are some sources to get you started on researching isopods:
    - Staff, 2005. "Animal Fact Sheets: Sowbugs & Pillbugs," Woodland Park Zoological Society, Seattle, WA [accessed August 8, 2006] http://www.zoo.org/factsheets/pillbugs/pillbugs.html.
    - Staff, 2004. "Bug Facts: European Sowbug (*Oniscus asellus*)," Royal Alberta Museum, Edmonton [accessed August 8, 2006] http://www.royalalbertamuseum.ca/natural/insects/bugsfaq/sowbug.htm.
- For photographs, see:
    - Ames, L.M., 2005. "A Lovely Sowbug," BugGuide.Net [accessed August 8, 2006] http://bugguide.net/node/view/15890/bgpage.
    - Egelsreiter, W., 2006. "Pillbug," BugGuide.Net [accessed August 8, 2006] http://bugguide.net/node/view/49888.
- This book is a teacher's guide to using pillbugs in the classroom for science investigation:
  Burnette, R., 1999. *The Pillbug Project: A Guide to Investigation.*, NSTA Press, Arlington, VA.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- sowbugs or pillbugs,
    - you can collect these yourself—look under stones or in decaying wood; you may also find them in gardens, along house foundations and basements (Staff, 2005), or
    - they can be purchased online from Carolina Biological Supply Co., part number 14-3050;
- materials for constructing experimental habitat:
    - two clean, shallow plastic containers,
    - sharp utility knife or small modeling saw to cut doorways between them,
    - materials for creating test habitats: soil, water, wood, leaf litter, etc.

Experimental Procedure

1. Build an experimental habitat for testing sowbug preferences using two shallow plastic containers, placed side-by-side. Cut access holes between the containers where they touch, so that the bugs can pass from one container to the other.
2. Create separate microenvironments in each container to test the bugs' preferences. Change only one variable at a time. For example, you could try moist soil in one container, and dry soil in the other.

3. Release a dozen or more bugs into the containers (put an equal number in each container), and allow them to explore while you observe.
4. At five- or ten-minute intervals, count the number of bugs in each container, and record the results in your lab notebook.
5. Make a graph of the fraction of bugs in the moist soil container (y-axis) vs. time (x-axis).
6. Repeat the experiment for several different pairs of conditions. Test preferences for light vs. darkness, potential food sources, different soil types. Use your observations of sowbugs in natural environments to think of additional tests.

Variations

- An alternative method would be to use time-lapse photography to estimate how much time the bugs spend in each available microenvironment when given a choice. How frequently do you need to take pictures to make this work?

The Use of Lichens as Bioindicators

(from All Science Fair Projects/ http://www.all-science-fair-projects.com/project936_108.html)

Problem

The purpose for this experiment is to investigate the effect of acidic solution on fruticose, foliose, and crustose lichens. This experiment is being done to model the effect of acid rain on lichens in the natural environment and to use this information to determine if these lichens can be used as bioindicators.

Materials

- Lichen sets that included portions of crustose, foliose, and fruticose lichens
- Glass jar for each sample
- Two Spray bottles
- Bottled water
- Vinegar
- Plastic wrap

(Can purchase lichens from: http://www.sciencekit.com; http://www.sargentwelch.com/; http://www.carolina.com)

Procedure

To study the effect of acid rain on different samples of lichens, I first ordered two lichen sets that included portions of crustose, foliose, and fruticose lichens from the Carolina Biological Supply Company. I then took both sets of lichens and placed each individual sample into its own glass jar. I then filled one spray bottle with 10 ounces of Dannon bottled water. I placed a label on the spay bottle and labeled it water. I took a slit of white tape a put it on one of the ditches in the twisting top to the spray bottle. I then turned it around four times. I then filled half of the other spray bottle with 5 ounces of vinegar and the other half with 5 ounces of Dannon bottled water. I did this because acid rain has the same effect on plants and organisms as water and vinegar mixed together; only vinegar and water works slower and is weaker (Wilkes 1991). I then placed a label on the spray bottle and labeled it acid. I took a slit of white tape and put it a ditch of the twisting top of this spray bottle. I then turned it four times so the mist settings of both bottles were the same. I then took a sample of crustose, foliose, and fruticose lichens and used them as a control, misting them daily with water. After I

misted each sample three times with water I placed Saran wrap on the opening in the jars and sealed it with a rubber band. I then took the remaining samples of crustose, foliose, and fruticose lichens and misted them daily with the acid. After I misted each sample with the acid three times I placed Saran wrap over the opening in the jars and secured it with a rubberband. Everyday I took off the Saran wrap and examined the lichen samples with a magnifying glass, took pictures, and wrote down my observations in my logbook. After doing this, I misted the plants again and replaced the Saran wrap. I did this repeatedly for ten days. I then performed the experiment again with new lichen samples keeping all the variables the same. I recorded all my observations in my logbook.