Lesson 1: Magic Termites: Exploring the Scientific Process

Created for SPICE by Kris Callis and Melissa Henkel

May 2009

KEY QUESTIONS: How do scientists come up with experiments? What steps are necessary to conduct an experiment? Does our experiment test our question?

SCIENCE SUBJECT: General Science

GRADE LEVEL: 6-8th Grade

SCIENCE CONCEPTS: Making observations, Identifying the problem, creating a hypothesis, designing an experiment to test the hypothesis, and analyzing the data to draw conclusions.

OVERALL TIME ESTIMATE: 1-2 50 min class periods

LEARNING STYLES: kinesthetic.

VOCABULARY:

Observation: the act of recognizing facts using one or more of the five senses. This can be done with the help of scientific equipment, such as a balance or ruler.

Inference: Using observations to draw conclusions.

Independent Variable: The parameter in the experiment that the scientist manipulates.

Dependent Variable: The parameter in the experiment that is measured to show a change due to the changing independent variable.

Compound eyes: an arthropod eye subdivided into many individual, light-receptive elements, each including a lens, a transmitting apparatus, and retinal cells.

Galleries: underground tunnels created b insects, such as termites or ants. Can also be found in wood.

Pheromones: any chemical substance released by an animal that serves to influence the physiology or behavior of other members of the same species.

LESSON SUMMARY: This is a lab that provides an opportunity for students to figure out how to conduct a scientific experiment, thus exploring the steps of the scientific method. The worksheets provided walk the students through the steps and in doing so, students discover why each step is necessary.

STUDENT LEARNING OBJECTIVES:

The student will be able to...

1. Record observations
2. Formulate a hypothesis
3. Design an experiment to test the hypothesis

4. Record data in a data table
5. Analyze the data in a graph
6. Draw conclusions based on their data
7. Explain why each step of the scientific process is needed

MATERIALS:

ESSENTIAL: Magic Termites Worksheet
Termites (4-6 per group)
Blue Bic or Papermate brand ballpoint pens (1 per group)
Filter paper (4 per group)
Petri Dish (1 per group)

SUPPLEMENTAL:
Other colors and types of pens and paper for students to use as independent variables

BACKGROUND INFORMATION: Termites are small, soft bodied, usually pale-colored insects. They live in colonies in the ground or in wood. Their food consists primarily of wood or other vegetable material, but they burrow deep into the ground to find water. Each colony has one queen, but it has many workers and soldiers. The workers are sterile and lack **compound eyes**. The workers do the main work of the colony-collecting food, feeding the queen, soldiers, and young as well as constructing **galleries** through the wood. Termites frequently groom each other with their mouthparts, a result of the attraction of secretions that are usually available on the body.

Termites follow blue Bic or Papermate pens because the drying agent in the ink contains a chemical very similar to the trail **pheromone** used by termites to help other termites locate food. Since worker termites do not have compound eyes, because they live in dark places, such as inside wood and soil, they need pheromones to communicate the location of food and water. After a demonstration of the phenomenon, students use the scientific method to figure out why termites follow the drawn line.

ADVANCE PREPARATION: Termites can be found outside in rotting trees, or can be obtained with sufficient notice from Carolina Biological Company. Termites can live in a Petri dish with moist paper towel for several days. Do not provide termites to the group until the instructor has verified the procedure the group has developed and the group is ready to conduct the experiment; the termites can crawl out of the Petri dishes if unsupervised.

PROCEDURE:

Start the demonstration of the termites by placing the termites on blank filter paper in the large side of a Petri dish and letting the students watch the termites for a few moments. Then draw a figure with the blue Bic pen; make sure to draw a closed figure, since the termites get confused and walk off course if they come to the end of a line. Figure 8s or circles work well.

The students can now complete the section of the worksheet labeled "identify the problem," which will walk them through making observations and inferences.

The students can then read the "Gather Information" section, which contains potentially new vocabulary words that are underlined. Each member of the group should read one of the numbered sentences aloud to the group. This will help emphasize the importance of reading in science. The students are now ready to identify their independent variable, dependent variable and formulate a hypothesis.

In the "Experimental design" section, the students must outline their procedures and list the materials they will need. The students seem to understand these two steps better when they write the procedure first, and then they list the materials they need to conduct the experiment. Otherwise the materials section is rewritten many times. The materials chosen should be readily available in the classroom, such as colored markers, crayons and pens. Verify that the students are using the correct constants, that their procedure is not harmful to the termites and that their proposed experiment *actually* tests the hypothesis they have made. Students may have problems identifying what should remain constant and how to test their independent variable.

Once the procedure is approved, students can set up their experiment, and the teacher can then provide the group with termites. The easiest way to move termites from one container to another is with a dry or slightly moist paintbrush. Since termites have soft bodies, they are very fragile and can easily be squished. The group can pour the termites from one side of the Petri dish to the other to test their next variable, thus reusing the same termites. Students should record their observations in the data table provided on the worksheet, and write their final conclusions on a class table on the board. The groups can then use the "Analyze data" and "Draw conclusions" sections to decide why the termites followed the line.

MAGIC TERMITES! Using the scientific process

1) Identify the Problem:

How do the termites behave when the teacher draws lines with a blue BIC pen *(Observations)?*

What are some possible explanations for this behavior *(Inferences)?*

2) Gather Information:

(1) Termites are small, soft bodied, usually pale-colored insects. (2) They live in colonies in the ground or in wood. (3) Their food consists primarily of wood or other vegetable material, but they burrow deep into the ground to find water. (4) Each colony has one queen, but it has many workers and soldiers. (5) The workers are sterile and lack compound eyes. (6) The workers do the main work of the colony-collecting food, feeding the queen, soldiers, and young as well as constructing galleries through the wood. (7) Termites frequently groom each other with their mouthparts, a result of the attraction of secretions that are usually available on the body.

3) Form a Hypothesis:

Pick one of the variables you can change (*independent variable)* to test and answer this question. You may have listed some independent when making inferences:

Does the _____cause the termites to follow the line?
(Independent variable)

I hypothesize that the termites _____,
(Why did the termites follow the line?)

because_____.
(Why do you think THAT is the reason they followed the line?)

4) Experiment Design:

List the steps you will perform to conduct your experiment *(procedure)*:

What variables will you keep the same *(constant)?*

What materials will you need to use to complete your experiment?

5) Record Data:

Independent Variable (what did you change?):	Dependent Variable: Did the termites follow the line? (Yes/No)

6) Analyze Data: Write your conclusions on the board.
Which independent variables for the whole class had positive (Yes) results?

7) Draw Conclusions:

1. Our data _____ (supported/rejected) our hypothesis.
2. If you could redo your experiment, how would you change it?

3. Since termites don't have compound eyes, how do they find each other in the wood and soil? How would they find their way back to the colony if they went deep into the soil to find water?

4. Why do you think termites follow the line of

Lesson 2: The Steps of the Scientific Method

Created for SPICE by Kris Callis and Melissa Henkel

May 2009

KEY QUESTION(S):
What is the scientific process?
What are the steps of the scientific process and why are they important?
How do we use the scientific process?

SCIENCE SUBJECT: General Science

GRADE LEVEL: 6-8th Grade

SCIENCE CONCEPTS: The steps of the Scientific process, including
Identifying a problem through observation
Gathering information from outside sources
Forming a hypothesis to focus the study
Designing an experiment that actually test the question
Recording data in a table
Analyzing data in a graph
Drawing conclusions from trends in the data

OVERALL TIME ESTIMATE: 2-50 min lesson

LEARNING STYLES: Visual, auditory, and kinesthetic.

VOCABULARY:
Empirical evidence: is evidence from research that bases its findings on direct or indirect observation of an experiment
Bias: a prejudice that could influence the observation and collection of data in an experiment, thus causing error.
Observation: an act or instance of noting or viewing a fact or phenomenon using one or more of the five senses.
Hypothesis: an educated guess as to the cause of a phenomenon.
Experiment: a test or trial, based on a protocol/procedure to with the purpose of determining the cause of something unknown.
Variables: a parameter that is able to change in an experiment.
Independent variable: the variable that changes in order to determine the cause of a phenomenon. In the termite experiment, the independent variable is the variable the scientist chooses to change, such as the color of the ink, the thickness of the line, or the brand of pen.
Dependent variable: The variable that is measured in an experiment, such as whether or not the termites follow the line drawn by a pen. This variable changes due to the independent variable. Thus the dependent variable is dependent on the independent variable.
Control: the baseline for an experiment, or the normal situation. The

parameters under which you first observed the phenomena that you are testing in an experiment. This allows scientists to compare the experiments back to the normal situations.
Constant: variables within an experiment that do not change, so that only the independent variables are being tested. For example, if testing the brand of pen termites follow, the color of the pen should remain the same, thus the color is a constant.
Quantitative: data that is measure in numbers, such as distance, length, mass, volume, or density.
Qualitative: data that is descriptive, such as color, shape, texture, scent, sound or the presence/absence of one of these traits.
Data: the term data is always plural, with the singular being datum. Data is the individual facts or observations collected during an experiment that help determine if a hypothesis is supported.
Table: a series of boxes put together to help collect the data in one place.
Pie Chart: also called a circle chart, this graph is circular in form and is divided into sectors with the relative size of each section representing the relative contribution of that parameter to the whole.
Line Chart: a graph that uses a line to connect plotted points. Used mostly to track items over time.
Bar/Histogram graph: a graph using parallel bars of varying lengths to illustrate a comparison between quantitative or qualitative data
Conclusions: a final decision based on the results of an experiment. This states if there is a trend in the data (does it increase or decrease overall?) and also states if the data supports or refutes the hypothesis.

LESSON SUMMARY: Interactive lecture with notes to help students learn the steps of the scientific process

STUDENT LEARNING OBJECTIVES:

The student will be able to...

1.Name the 7 steps of the scientific process

2.Relate each step of the scientific process to their previous experience with the termite lab

3. Explain why each step in the scientific process is used.

4. Identify the difference between qualitative and quantitative observations

5. State the difference between observation and inference

6. Decide when to use a line, bar or pie graph.

MATERIALS:

ESSENTIAL:

Computer with projector for Microsoft PowerPoint presentation
1 copy of notes per student

BACKGROUND INFORMATION: The scientific process was formally called

the scientific method. However, since not every field of science uses each

step of the scientific method, and some fields repeat several methods, the name was changed to reflect the idea that the steps can evolve to accommodate the needs of each field. For example, while astronomy may be one of the oldest science fields, it is very hard to conduct an experiment with the stars, solar systems and galaxies. Astronomy uses the first part of the scientific process, creating hypotheses based on observations, and the last part of the process, collecting data and drawing conclusions, but rarely does an astronomer design and run an experiment. The same is true in fields of paleontology and to some extent systematics.

The scientific process is a series of steps that are used to investigate the cause and effect relationships of natural phenomena using, and sometimes correcting, previous knowledge. The process involves the collection of measurable and **empirical evidence**, controlling for factors that may **bias** and influence the outcome in order to answer a specific question or hypothesis. The steps of the scientific process are designed to be rigorous and transparent to facilitate repetition and reproduction of the experiment with a consistent outcome. This full disclosure aspect of the scientific process provides reliability in the results and subsequent conclusions.

The seven steps of the scientific process start with **observation**, which leads to questions about relationships or phenomena in the natural world. Using these observations, scientists identify a problem and formulate a question to which they would like to find the answer. Then scientists gather information from primary sources. Primary sources include books, magazines, newspapers, videos, and interviews. Scientists like to use information that is published in journals or government documents because it has been reviewed and approved by other scientists before it is published, and contains more current information than books. Using this information, scientists then create a

hypothesis that answers the question they formulated from their observations. This hypothesis is an educated guess as to the answer to their question and helps scientists narrow their search for answers. Without a hypothesis, the scientist would not know which data to collect in order to answer their question. Please note that a hypothesis is never proven. In science, the data can strongly suggest, within some parameter of confidence – usually 95%- that a hypothesis is correct, but science can never *prove* a hypothesis.

In order to test a hypothesis, the scientist needs to design an **experiment** and identify all the **variables** involved. Variables can come in two forms, **quantitative** and **qualitative**. A quantitative variable is one that is measured and uses numbers, such as length or distance (in meters), mass (in grams), volume (in liters). Qualitative variables, on the other hand, use descriptions, such as color, texture, shape, or presence or absence of a trait. An **independent variable** is the parameter that is changed during the experiment. In other words, this is the variable that the experiment is actually testing. The **dependent variable** changes due to the independent variable, and is therefore dependent on the independent variable. This variable is the change that is measurable and provides the data that is recorded. The **control** is the parameter that is set up as the normal situation and is compared to the independent variable to see if there is a difference. The **constants** are usually numerous and they are all the parameters in the experiment that should remain the same between the experimental treatment and the control.

The last three steps of the scientific method involve using the data collected in the experiment. **Data** should be recorded in an organized fashion, such as a **table**. Note that the term data is always plural, with the singular form

being datum. Therefore, one specific piece of data is datum, but all the pieces of data are data. The independent variable is usually listed down the left side of the table and the dependent variable(s) is/are listed on the right side of the table. Several tables may be needed to facilitate organization. Using the data recorded from the experiment, a graph can be created to analyze the data. While many middle school students seem to understand and prefer using a **pie chart**, this type of graph is rarely used in science. Instead, a line chart can be used when data is continuous, such as time sequence data. Another good option is a **bar or histogram graph**, which is good for categorical data. Trends can be seen using the graphs, such as ascending or descending lines. These trends can be used to draw **conclusions** about the results of the experiment and can support conclusions that answer the initial question. These results should either support or refute the initial hypothesis. Note that a hypothesis can never be proven. Science can never prove anything, as scientists cannot guarantee that future experiments will not have data that refutes the conclusions they have developed. However, experiments can give credible evidence that supports a hypothesis. If the hypothesis is refuted, then scientists use this new information to reform a new hypothesis and design a new experiment. An experiment that does not support a hypothesis can be just as valuable as an experiment that does, because in both cases the scientist learns something new. In the scientific world, the experiment should be repeated several times in order to substantiate the results.

ADVANCE PREPARATION: Teachers should review the Microsoft Powerpoint presentation and be familiar with the presentation style, along with examples and imbedded questions. The Notes section of the presentation has additional information and comments to help teachers prepare. The **bolded and underlined** words in the presentation are the

key words the students can use to fill out the guided notes. The guided notes worksheet follows along with the presentation and has places for students to answer the imbedded questions. Make sure enough copies of the guided notes are available for each student. These notes can be used as evaluation items or as future reference and study material for the students.

SUNSHINE STATE STANDARDS:

6th Grade: SC.6.N.1.2; SC.6.N.1.3; SC.6.N.1.4; SC.6.N.1.5; SC.6.N.2.1; SC.6.N.2.2

7th Grade: SC.7.N.1.2; SC.7.N.1.3; SC.7.N.1.4; SC.7.N.1.5; SC.7.N.2.1; SC.7.N.2.2

8th Grade: SC.8.N.1.2; SC.8.N.1.3; SC.8.N.1.4; SC.8.N.1.5; SC.8.N.2.1; SC.8.N.2.2

Credits:

Photos in the Microsoft Powerpoint® were found on the internet are either open-use stock images or have the photographers copyright included in the image.

Steps of the Scientific Process

The Scientific Process is a logical, _____ _____ technique

Step 1: Identify a Problem

Using _____, identify a problem you would like to solve

-This is a question you DO NOT know the answer to and can't look up.

A good type of question is:

Observation

Uses our _____ to gather information

_____ uses our 5 senses

Quantitative observations: uses _____

Inference

A logical interpretation of events based on prior _____ or _____

–Educated guess

Do we use observations or inferences when identifying a problem?_____

Step 2: Gather Information

One example of a reference is:_____

Step 3: Formulate a Hypothesis

A hypothesis is a possible answer to a question that can be tested based on _____ and knowledge

Do we use observation or inference to formulate a hypothesis? _____

Step 4: Develop an Experiment

Materials: _____

_____: Step by step instructions

-Identifies the variables used in the experiment

Independent Variable: The variable _____ change or manipulate

Dependent Variable is _____ in the experiment

-Changes because of the independent variable

Constant include all the factors in the experiments that are kept the _____

-Everything except the independent variable

_____: the normal condition that you compare the other conditions to

Step 5: Record and Organize Data

Write all observations and measurements

Use a _____ to organize your data

–List your _____ variable on the left side

–Record your dependent variables on the _____

Step 6: Analyze Data

Compare and look for trends and patterns by using graphs

-Bar Graph is used for:

-Line Graph is used for:
-Pie Chart is used for:

Step 7: Make Conclusions

You should run your experiment at least _____ times to confirm your results
Each separate experiment is called a _____.

Lesson 3: What Do Plants Need to Live? Using the Scientific Process

Created for SPICE by Kris Callis and Melissa Henkel
May 2009

KEY QUESTIONS: How do we use the scientific process to answer questions? What do plants need to live?

SCIENCE SUBJECT: General Science

GRADE LEVEL: 6-8th Grade

SCIENCE CONCEPTS: The steps of the scientific process.

OVERALL TIME ESTIMATE: 2 weeks total. 4 50 min class periods

LEARNING STYLES: kinesthetic.

VOCABULARY:
Photosynthesis plants use water, carbon dioxide, and light to produce sugars and oxygen. Photosynthesis occurs in the green tissues of the plant, usually the leaves, but possibly also the stem.
Food webs: the interaction between organisms in an environment on how they obtain nutrients.
Chlorophyll: a green pigment in leaves that captures light and turns it into sugar.
Xylem: The vascular tissue in plants that transports water and nutrients .
Phloem The vascular tissue in plants that transports sugars from the leaves to the other plant tissues.
Diffusion: The movement of a substance across a semi-permeable membrane.
Cellular transporters: areas in the cell membrane that use energy to actively move compounds into or out of the cell.
Germinate: the early stage of a plant, which starts when it emerges from the seed and ends when a shoot emerges from the soil and can start producing its own energy.
Dioecious: a plant with either male or female flowers, but not both.
Monecious: a plant with flowers that are both male and female.
Adaptations are special features that allow a plant or animal to live in a particular place or habitat.
Hydroponics: growing plants without soil, just in water.
Macronutrients nutrients needed in large quantities
Micronutrients- nutrients needed in small quantities

LESSON SUMMARY: This lesson provides an outline for a long-term (2 weeks) experiment based on growing pea plants. The lesson teaches the students the steps of the scientific process through an open inquiry lab.

STUDENT LEARNING OBJECTIVES:

The student will be able to...

1. Identify a scientific question involving plant growth and development
2. Create a hypothesis related to the problem
3. Create an experiment to test the hypothesis
4. Identify the variables involved in the experiment
5. Collect data to answer the question
6. Analyze the data using Excel
7. Draw conclusions based on the data to answer the original question

MATERIALS: For each group:

ESSENTIAL: 3 Pea seeds, 3 plastic cups, soil, water, sharpie marker
SUPPLEMENTAL: colored light bulbs with goose neck lamps, plant fertilizer, salt, sugar, sand, gravel, peat moss

PROCEDURE:

After reading the Background section include below:

1) Present the "What plants need" Power Point to introduce the experiment
2) Break students into groups of 3-4 students
3) Have groups complete the first part of the "Experimental design" worksheet
    a. Including their experimental question, list of variables, constants, hypothesis, methods and materials
    b. Review these for accuracy and feasibility
    c. Variable suggestions are listed in the "List of Variables" document for groups who need more guidance
4) Gather the necessary materials for the experiments
    a. Place pea seeds in water to break dormancy overnight
5) Have students follow their procedure for planting the plants and treating their independent variable
6) Have students measure height and number of leaves of the seedlings every 2-3 days for 2 weeks.
    a. Record these measurements on the "Experimental design worksheet"
    b. Water plants every 2-3 days as needed
7) Help students graph their data on the "Experimental design worksheet" or in Excel.
    a. Look for trends, did one treatment have different results than another treatment? (taller plants? More leaves?)
8) Wrap up the experiment by having students draw conclusions
    a. This can be used as a final assessment tool in the form of a lab report

ADVANCE PREPARATION: Soak the pea seeds in water overnight to break dormancy. Poke holes (about the size of the tip of a pen) in the bottom of the cups to allow for water drainage. Once the students have determined an independent variable, collect the materials needed for that experiment. Make the necessary copies of the handout, 1 per group.

BACKGROUND INFORMATION:

Plants are primary producers, which means they make their own food from sunlight – a process called **photosynthesis**. Since plants are the only organisms that are able to produce its own food, all the other metabolic energy on earth comes either directly or indirectly from the consumption of plants. Therefore, plants are the basis of all **food webs**. During photosynthesis, plants use water, carbon dioxide, and light to produce sugars and oxygen. Photosynthesis occurs in the green tissues of the plant, usually the leaves, but possibly also the stem. The main components of the plant are: leaves, stem, roots, flower and seeds.

Leaves

The leaves are the principal organs of photosynthesis in the vascular plants. The leaves contain **chlorophyll**, a pigment that makes the leaves green. Chlorophyll converts carbon dioxide, water, nutrients, and energy from sunlight into sugars and oxygen.

Stem/Trunk

The stems of vascular plants, or trunks in the case of trees, have several functions, including structural support, transport of water and nutrients into the plant by the vascular system (**xylem**), transport of sugars from the leaves to the other plant tissues (**phloem**), and generation of energy through photosynthetic cells (if the stem is green). Some stems also function in food and water storage.

Root

Roots not only help anchor the plant to the ground, but are also the principal way for taking up water and nutrients, which are essential for photosynthesis, respiration and amino acid production. Nutrients dissolved

in water enter the roots through **diffusion**. Larger nutrients, or those that cannot be dissolved in water are actively taken into the root through **cellular transporters**. Roots can also be used a energy storage organs, such as potatoes.

Flower/Seeds

Seeds will break dormancy and **germinate** under the right conditions, which include adequate water, temperature and environment (such as soil). The seed then uses oil and starch reserves to begin sprouting, until it is large enough to start photosynthesis. The germination stage ends when a shoot emerges from the soil and can start producing its own energy.

Flowers are the reproductive organ of Angiosperms – the group of plants that produces flowers, instead of cones. Flowers can be **dioecious** with either male or female flowers female or **monecious**, which is when the flower has both male and female parts. In this experiment, the plants will probably not get to the flowering stage.

Requirements for Plant Growth and Development

Plants are adapted to live in almost every environment on earth. Pushing plants to the limits of their natural environment can teach us a lot about plant **adaptations**. Adaptations are special features that allow a plant or animal to live in a particular place or habitat. These adaptations might make it very difficult for the plant to survive in a different place. Even so, all plants need certain things to survive: water, light, a nutrient source, and some sort of substrate, such as soil.

Water

Water is taken up by the roots, into the xylum and is used by the plant during the photosynthesis process. Water is essential for plants, even in

low water, or hot environments such as the desert. However, plants can also have too much water. Overwatering plants is the number one cause of death in houseplants. Therefore, when running this experiment, make sure the soil or substrate stays moist, but is not swampy.

Hydroponics is a method used to grow plants without a substrate. Plants seeds are suspended at the surface of water, so that when they germinate, the roots grow into the water. The prime example of this is germinating an avocado seed with toothpicks and a cup of water. Provided enough fertilizer in the water, most plants will happily grow in hydroponic systems. If students want to try to grow their seeds hydroponically, I suggest germinating the seeds in a moist paper towel first, then transferring the seeds to water, with the leaves suspended above the water. This could be accomplished by taping the seedling to the side of a cup.

Light

Plants need light in order to photosynthesize. This light can come either in the form of sunlight, or as artificial light, such as light bulbs. In order to photosynthesize, the chlorophyll must capture the energy released from the sun in the form of wavelengths. When sunlight passes through a prism, a rainbow of colors appears. Each color has a distinct wavelength Plants tend to use the high and low wavelengths of this visible light spectrum. In other words, plants use light in the violet to blue range, as well as the red-orange to red range. Light with a medium wavelength, such as green light is reflected, therefore giving chlorophyll the appearance of being green. Pigments play a critical role in photosynthesis because they are the molecules that absorb light. Since plants do not use green wavelengths of light, growing a plant under a green light is similar to growing a plant in the

dark – it has no useable light for photosynthesis. Growing a plant under either purple/blue light or orange/red light provides enough useable light to sustain photosynthesis, but is really only half the wavelengths the plant usually uses. Therefore plants grow best under 'white' light. Many places sell special 'plant grow' bulbs – however since plants use the high and low ends of the light spectrum, any white light bulb is sufficient for photosynthesis. Therefore, there is no such thing as a special plant light.

Substrate

Most plants grow in soil, which provides the nutrients the plant needs to photosynthesize and create amino acids. It also provides a surface for the plant to attach to. However, soil is not the only substrate plants grow in. Desert plants grow in sandy soils, which provide fewer nutrients and dry faster than potting soil. Mountainous plants can grow on very rocky surfaces, and even out of a crack in the face of cliff (although there is likely soil accumulated in the crack). Using various substrates, such as soil, peat moss, sand, gravel and even hydroponics, can create an interesting experiment into how each substrate effects plant growth. In order to control for the difference in nutrient levels between the substrates, fertilizer should be added to each type of substrate.

Nutrients

Plants require three **macronutrients** – nutrients needed in large quantities- and a wide array of **micronutrients**- nutrients needed in small quantities. The macronutrients for plants are potassium (K), nitrogen (N) and phosphorus (P). The potassium in fertilizer comes in the form of K_2O and is water-soluble. Phosphorus is in the form P_2O_5 in fertilizer and is also water-soluble. Most fertilizers include these three nutrients in various ratios

always in order of N:P:K. A 20-15-10 fertilizer is 20% N, 15% P and 10% K. An easy way to see the effect of one of these nutrients on plants is to use two different fertilizers, one with all three nutrients, and one that has 0% of one of the nutrients.

In addition to the main macronutrients, there are secondary macronutrients, which include, calcium (Ca), magnesium (Mg) and sulfur (S). The micronutrients include carbon (C), iron (Fe), manganese (Mn), zinc (Z), copper (Cu), boron (B), chlorine (Cl) and nickel (Ni). I do not recommend experimenting with various concentrations of micronutrients, since the effects will not be evident in the time frame of the experiment proposed.

What Do Plants Need to Live? – **Designing the Experiment**

What question are you going to answer?

What is your independent variable?_____

Hypothesis:
If_____
then_____
because_____

Procedure: What steps do you need to do to conduct your experiment?

What dependent variables will you measure?

How often will you measure them?_____
What scientific equipment will you use to measure them?_____

Materials: What materials will you need for your experiment?

Predict:
What are two possible results that come from the experiment you designed above?

Will those results support or fail to support your hypothesis?

1) The INDEPENDENT variable goes in the *left column*
2) The DEPENDENT variable goes in the *right columns*: the variable name goes in the long box, and the name for each trial/rep goes in the smaller boxes
3) Make sure to include your units when necessary

What Do Plants Need?

1) **Water**
   How much water do plants need to live? 10 ml/week? 100 ml/week?
   How often do you need to water plants? 1 time per week? Everyday?
   What kind of water can we use? Salt water? Sugar Water?

2) **Soil**
   Do plants grow the same in soil, sand and rocks?
   Do plants grow the same in hydroponics (water) and soil?

3) **Nutrients**
   Which nutrient is more important: nitrogen (N) or potassium (K)?
   Do plants need calcium (Ca)?

4) **Light**
   Will plants grow the same under blue and red light?
   What happens to plants if they are grown in the dark?

Water:
How much water do plants need to live?
- 25 ml 1x week or 25 ml 1x day?
- 25 ml 1x day or 5 ml x day for 5 days?

What kind of water can we use?
- Sugar water (note that sugar water accumulates mold) vs. Salt water
- Bottled water vs. tap water vs. rainwater
- Sparkling water vs. regular water.

Nutrients:
What kind of nutrients do plants need? How much of each? (this is easy to change depending on what type of fertilizer you use.)
- Potassium (K): used in photosynthesis
- Nitrogen (N): used to make enzymes and cells
- Phosphorus (P): Helps make DNA

Light:
How much light do they need?
In the winter the day is short - but some plants still grow!
What kind of light?
Does a light bulb work?
Will red light or blue light work? What about a black light?