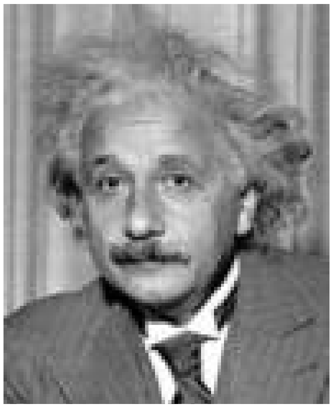
Sir Isaac Newton

Louis Pasteur



Albert Einstein

A SCIENCE Winter Inquiry Land

Life Science
(Biology, Environmental and Marine Science)

Winter 2011-2012

Miami-Dade County Public Schools
Curriculum & Instruction

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WELCOME TO *A SCIENCE WINTER INQUIRY LAND*

Preparing for Science

Science is not something mysterious. Being "scientific" involves being curious, observing, asking how things happen, and learning how to find the answers. Curiosity is natural to children, but they need help understanding how to make sense of what they see.

Bruno V. Manno
Acting Assistant Secretary
Office of Educational Research and Improvement

Many people are frightened by science and see it as something that can only be understood by the mind of a genius. Increasing the number of people going into the fields of science and mathematics is the national goal. However, even if a student is not planning to pursue a career in one of those fields, they have to be prepared to live and work in a world that is becoming increasingly complex and technical.

What Is Science?

Science is not just a collection of facts. Facts are a part of science. However, science is much more. It includes:

- Observing what is happening,
- Predicting what might happen,
- Testing predictions under controlled conditions to see if they are correct,
- Trying to make sense of our observations, and
- Involving trial and error--trying, failing, and trying again.

Science does not provide all the answers. The world around us is always changing and we learn something new every day, so we have to be willing to make changes and adjustments to our knowledge when we discover something new.

The Winter Break Packet

The activities and reading passages in this packet were selected to allow students to experience the relevancy of science in a fun and engaging way. As they navigate through these activities, students should realize that science is not limited to the classroom but that it is all around in everyday lives and that it explains most of the phenomena encountered in life.

Included as part of this packet, is a link to the Miami-Dade County Public Schools Student Portal *Links to Learning* technology activities. Individualized student learning paths have been designed based on FCAT scores and are aligned to the District's Pacing Guides. These online activities are supplemental and, as such, are not to be assigned or graded. All online activities are provided as a resource to both parents and students to engage learning using technology. Please log on just as you do at your school.

Links to Learning

Resources:
Technology-based resources can be accessed through the Student Portal on the district website, http://www.dadeschools.net, under the *Links to Learning* initiative. Here you will find additional activities designed for each student's individual needs, like virtual laboratory investigations with Explorelearning Gizmos.

The Appendix provides information designed to give the student a framework for the expectation of the scientific writing process.

Who Were They?

Sir Isaac Newton was a physicist, mathematician, astronomer, alchemist, and natural philosopher. He is best known for his explanation of Universal Gravitation and the three laws of motion. He was also able to prove that the reason of both the motion of objects on Earth and of celestial bodies is controlled by the same Neutral laws. These findings would make a revolutionary change in the development of science. His invention of the reflecting telescope was his great contribution in optics.

Louis Pasteur was a French chemist and microbiologists and one of the most famous and influential contributors in medical science. He is remembered for his remarkable breakthroughs in the causes and preventions of diseases supported by his experiments on the <u>germ theory of disease</u>. He also created the first vaccine for rabies and anthrax. Pasteur also invented the method of “pasteurization”, where harmful microbes are stopped from causing sickness in food.

Albert Einstein is the greatest scientist of the twentieth century and the most notable physicist of all time. He was born in Germany but eventually migrated to America to take a teaching position at Princeton University. It is told that he had a learning disability in his childhood. He could not talk till he was three and could not read till he was eight. Despite such problems, in 1921 he became the noble prize winner for his contributions to Physics. His *Theory of Relativity* is considered a revolutionary development of Physics.

ACTIVITY 1: GERMINATING SEEDS – LET'S OBSERVE!

(Adapted from http://biology.arizona.edu/sciconn/lessons2/Roxane/teach_sec.htm)

Benchmarks:
SC.912.L.14.7: Relate the structure of each of the major plant organs and tissues to physiological processes.

SC.912.N.4: Explain how scientific knowledge and reasoning provide an empirically-based perspective to inform society's decision making.

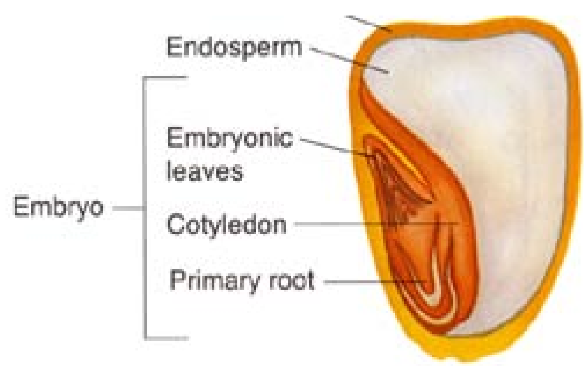
Objectives:
This lesson is designed to teach you a few germination techniques that you will use in a future experiment. These germinating seeds will provide a springboard for questions in the next few lessons. This is a simple lab intended to give you an opportunity to observe seed germination day to day, while making observations.

At the end of this study, you should be able to:

- Germinate bean seeds on your own
- Observe daily change in seed germination and plant growth
- Write and draw detailed observations of changes and differences in types of seeds

Background Information:
Inside a Seed (from: http://www.teachersdomain.org/resources/tdc02/sci/life/stru/insideseed/index.html)

Each part of a seed serves an important function. This image illustrates and identifies the five most important parts of a seed: the seed coat, the endosperm, and the embryo's primary root, cotyledon, and embryonic leaves. A seed is to a plant what an embryo is to an animal: an organism in its earliest stages of development. As lifeless as seeds may look before germination, the potential they hold is clear. Simply pick up an acorn and gaze at the oak tree from which it has fallen, and you can see the potential for yourself.



A seed consists of three main parts: the seed coat, the endosperm, and the embryo. Of these parts, the embryo is clearly the most important. Its cells will differentiate and develop into all the different tissues that will ultimately make up the mature plant. The other parts of the seed play merely supporting roles. These roles, nonetheless, are critical to the embryo's success. The seed coat protects the internal parts of the seed during a period called dormancy, prior to germination. Dormancy is a protected state during which a seed "waits" for favorable growing conditions. Indeed, the seed coats of some seeds allow them to wait a very long time. The oldest known viable seeds were from an East Indian lotus. They were 466 years old when they germinated. Germination usually begins when the embryo is exposed to water. The water swells the embryo inside, bursting the seed coat and setting growth into motion. During the earliest phase of growth, when the embryo has no leaves and therefore no means of photosynthesis, the endosperm serves as a food source. It serves the same function as the yolk in a bird egg, providing high-energy food to the developing embryo.

The embryo of a seed has three main parts: the primary root, the cotyledon(s) (there are two in many kinds of plants), and the embryonic leaves. The primary root, or radicle, is the first structure to emerge from the seed during germination. It penetrates the soil very rapidly, forming a slender, usually unbranched taproot, which, in some plants, may penetrate several feet into the soil during the first few weeks of growth. During this period, the cotyledon serves a function similar to that of the endosperm, supplying food to other parts of the developing embryo. Not surprisingly, the embryonic leaves, also known as seed leaves, develop into the plant's first leaves above ground. These leaves open within a few days after the plant emerges from the soil and begin photosynthesizing almost immediately to provide the growing seedling with its new - and renewable - food source.

Materials:

- kidney seeds (from the grocery store)
- lima bean seeds (from the grocery store)
- any other seed you like
- large empty pickle jar
- pie pan
- paper towels
- wad of newspaper
- water.

Procedures:

Formulate a Hypothesis: (Ask yourself: What will happen to dry, hard beans when they are put on a moist paper towel? How do you know?)

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Method 1:

1. Wet 2 paper towels then line the inside walls of a large pickle jar with the towels. They should stick to the glass.
2. Fill the core of the pickle jar with a crumpled sheet of newspaper. The newspaper will hold the wet towels in place.
3. Pour water into the bottom of the glass until it is about 2-3 cm deep.
4. Now "plant" the seeds between the glass wall of the pickle jar and the wet paper towels. Place several different kinds of seeds, in different directions (sideways, upside-down, etc.).
5. Use a glass-marking pen to number your seeds.
6. Draw your set-up in your journal and record what you have done by describing the seeds used and where and how they were placed in the tray or beaker.
7. Measure and record any changes observed. (go to step 8)

Method 2:

1. Cover the bottoms of a pie pan with 2 or 3 layers of paper towels or a combination of towels and newspapers.

2. Dampen the paper towels but do not soak!
3. Place seeds in separate regions of the pan, on top of the paper in different orientations.
4. Cover the pie pan with plastic wrap.
5. Apply stick-on labels to the plastic so you will be able to identify the seeds.
6. Draw your set-up in your journal and record what you have done by describing the seeds used and where and how they were placed in the tray or beaker.
7. Measure and record any changes observed. (go to step 8)
   (NOTE: Maintain the moisture in the germinating containers to maintain your seeds as long as possible.)
8. After at least seven days of germination, split open the seed and look for the parts of the embryonic seed as pictured at:
   http://www.teachersdomain.org/resources/tdc02/sci/life/stru/insideseed/index.html
9. Draw a picture of your own seed embryos and label the parts.

Seed Germination and Variables:
Can you think what the variables in this experiment are? Write them down in your journal. Let's add another variable to our study. This time, prepare two containers, and germinate new seeds as you did above, but place one container near a window, and another container inside a pantry or closet (without light). Record your observations as above over a seven-day period.

Questions:
1. Can a seed germinate in soil if it is placed upside down? ___________________________

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2. Is water essential for germination? How much is too much or too little? _______________

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3. Can bean seeds (embryos) grow without their cotyledons? _________________________

4. Can another food source take the place of the cotyledons? _________________________

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5. What percentage of the same type of seeds will germinate given the same conditions?

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If you have time, germinate additional seeds, but change a variable to answer one of the following questions:

1. Does the depth at which seeds are planted have any effect on their germination? Is soil necessary for seed germination? ____

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2. If you put seeds in the dark, with water, will they germinate? Is light or darkness essential for seeds to germinate? ____

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3. Do seeds need air to germinate? ____

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4. Is the seed coat necessary for germination? __________________________________

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5. If you place seeds in a refrigerator will they germinate? In the freezer? ______________

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6. How does temperature affect germination? If we used hot water, would the seeds germinate? ____

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7. Does the type of soil in which the seed is planted affect seed germination? ___________

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ACTIVITY 2: ENERGY FLOW IN ECOSYSTEMS

(Adapted from http://www.usoe.org/curr/science/sciber00/8th/energy/sciber/ecosys.htm)

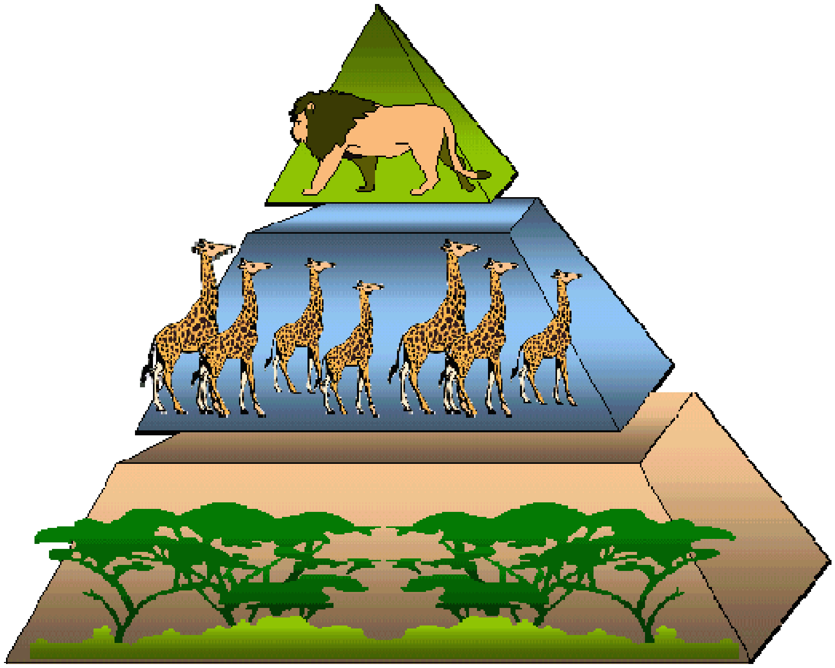
Benchmarks:
SC.912.L.15.6: Discuss distinguishing characteristics of the domains and kingdoms of living organisms.

SC.912.L.17.9: Analyze the movement of matter and energy through the different biogeochemical cycles, including water and carbon.

Background Information:
A food chain shows how each living thing gets its food. Some animals eat plants and some animals eat other animals. For example, a simple food chain links the trees & shrubs, the giraffes (that eat trees & shrubs), and the lions (that eat the giraffes). Each link in this chain is food for the next link. A food chain always starts with plant life and ends with an animal:

1. Plants are called producers because they are able to use light energy from the Sun to produce food (sugar) from carbon dioxide and water.
2. Animals cannot make their own food so they must eat plants and/or other animals. They are called consumers. There are three groups of consumers.
    a. Animals that eat ONLY PLANTS are called herbivores (or primary consumers).
    b. Animals that eat OTHER ANIMALS are called carnivores.
        i. Carnivores that eat herbivores are called secondary consumers
        ii. Carnivores that eat other carnivores are called tertiary consumers (e.g., killer whales in an ocean food web ... phytoplankton → small fishes → seals → killer whales)
3. Animals and people who eat BOTH animals and plants are called omnivores.
4. Then there are decomposers (bacteria and fungi) that feed on decaying matter. These decomposers speed up the decaying process that releases mineral salts back into the food chain for absorption by plants as nutrients.

Do you know why there are more herbivores than carnivores? In a food chain, energy is passed from one link to another. When a herbivore eats, only a fraction of the energy (that it gets from the plant food) becomes new body mass; the rest of the energy is lost as waste or used up by the herbivore to carry out its life processes (e.g., movement, digestion, reproduction). Therefore, when the herbivore is eaten by a carnivore, it passes only a small amount of total energy (that it has received) to the carnivore. Of the energy transferred from the herbivore to the carnivore, some energy will be "wasted" or "used up" by the carnivore. The carnivore then has to eat many herbivores to get enough energy to grow. Because of the large amount of energy that is lost at each link, the amount of energy that is transferred gets lesser and lesser. The further along the food chain you go, the less food (and hence energy) remains available.

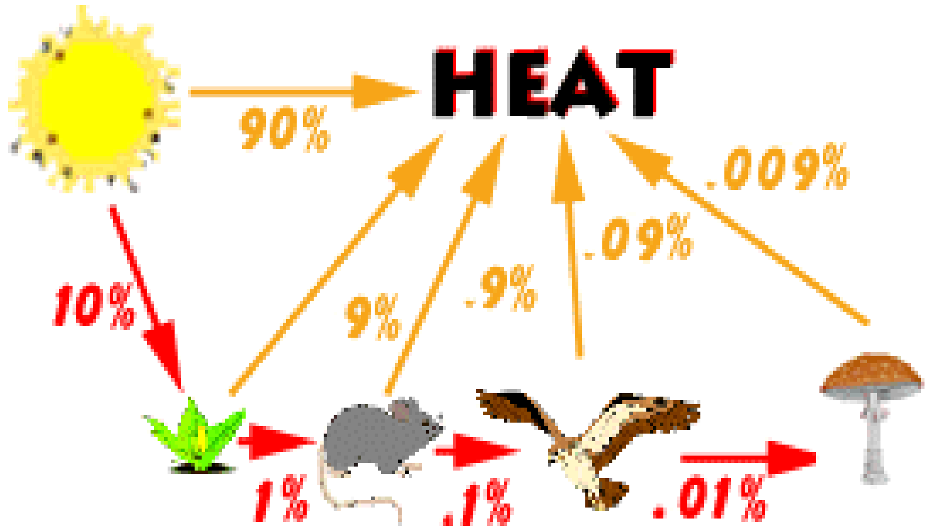


The above energy pyramid shows many trees & shrubs providing food and energy to giraffes. Note that as we go up, there are fewer giraffes than trees & shrubs and even fewer lions than giraffes (as we go further along a food chain, there are fewer and fewer consumers). In other words, a large mass of living things at the base is required to support a few at the top (many herbivores are needed to support a few carnivores).

Most food chains have no more than four or five links. There cannot be too many links in a single food chain because the animals at the end of the chain would not get enough food (and hence energy) to stay alive. Most animals are part of more than one food chain and eat more than one kind of food in order to meet their food and energy requirements. These interconnected food chains form a food web.

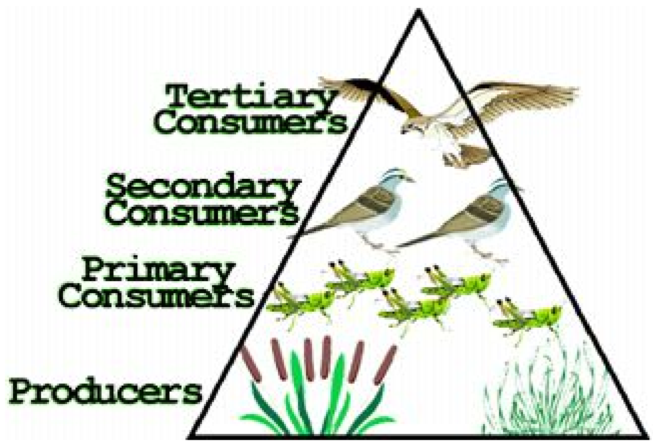
A change in the size of one population in a food chain will affect other populations. This interdependence of the populations within a food chain helps to maintain the balance of plant and animal populations within a community. For example, when there are too many giraffes; there will be insufficient trees and shrubs for all of them to eat. Many giraffes will starve and die. Fewer giraffes means more time for the trees and shrubs to grow to maturity and multiply. Fewer giraffes also mean less food is available for the lions to eat and some lions will starve to death. When there are fewer lions, the giraffe population will increase.

The energy flow in a food chain begins with the energy from the Sun that is captured by plants and used to make food, through the process of photosynthesis. Most of this captured energy is used to carry on the plant's life activities. The rest of the energy is passed on as food to the next level of the food chain. The figure below shows the energy flow in a simple food chain. At each level of the food chain, about 90% of the energy is lost in the form of heat. The total energy passed from one level to the next is only about one-tenth of the energy received from the previous organism. Therefore, as you move up the food chain, there is less energy available. Animals located at the top of the food chain need a lot more food to meet their energy needs.



NOTE!! Each organism in the food chain is only transferring one-tenth of its energy to the next organism. You can see that because energy is lost at each step of a food chain, it takes a lot of producers to support a few top consumers.

The food pyramid to the right can be compared to the previous pyramid, and can be used to relate the amount of energy transfer. If there were 1000 units of energy at the producers level, the primary consumers would receive 100 units of energy, the secondary consumers would receive 10 units of energy, and the tertiary consumer would receive 1 unit of energy.
http://abyss.uoregon.edu/~js/glossary/ecosystem.html



Additional information designed to create your own food web can be found at: http://www.vtaide.com/png/foodchains.htm

Procedures:
Place five glasses of different sizes on the kitchen counter. Each glass will represent a different organism in a food chain: a plant, an insect, a sparrow, hawk and a mushroom. You will need a liter of root beer and an eyedropper. Twenty drops of liquid from the eyedropper equals 1 milliliter. Reviewing the above diagram, we find that:

- The sun has one liter of root beer (energy) to give.
- Of that, the plant (glass) gets one-tenth or 100 milliliters.
- The mouse (glass) gets 10 milliliters from the plant.
- The hawk (gets) gets 1 milliliter from the mouse.
- When the hawk dies and is decomposed by the mushroom, the mushroom gets only one-tenth of a milliliter!

When the root beer has been distributed in the correct amount to each glass, pretend that you are the organism and consume the energy (root beer). The extra root beer that the sun does not give to the plant is the amount of energy lost to the environment (about 90%); so pour the remaining root beer down the drain!

Questions:
After doing the activity, answer the following questions:

1. Which organism was most satisfied by the amount of "energy" it received? Which organism was least satisfied? ____

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2. What happened to the 900 milliliters from the sun that the plant did not absorb? ________

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3. How much "energy" did the insect use? ____________________________________

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4. Which consumer in the food chain is going to have to eat the most food to meet their energy needs? ____

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5. Why does a food chain not have an infinite number of links? _____________________

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ADDITIONAL READING: ECOSYSTEMS

(Adapted from http://abyss.uoregon.edu/~js/glossary/ecosystem.htm)

An ecosystem is the complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space. The principles underlying the study of ecosystems are based on the view that all the elements of a life-supporting environment of any size, whether natural or man-made, are parts of an integral network in which each element interacts directly or indirectly with all others and affects the function of the whole. All ecosystems are contained within the largest of them, the ecosphere, which encompasses the entire physical Earth (geosphere) and all of its biological components (biosphere). An ecosystem can be categorized into its abiotic constituents, including minerals, climate, soil, water, sunlight, and all other nonliving elements, and its biotic constituents, consisting of all its living members. Linking these constituents together are two major forces: the flow of energy through the ecosystem, and the cycling of nutrients within the ecosystem.

The fundamental source of energy in almost all ecosystems is radiant energy from the sun. The ecosystem's autotrophic, or self-sustaining; organisms use the energy of sunlight. Consisting largely of green vegetation, these organisms are capable of photosynthesis--i.e., they can use the energy of sunlight to convert carbon dioxide and water into simple, energy-rich carbohydrates. The autotrophs use the energy stored within the simple carbohydrates to produce the more complex organic compounds, such as proteins, lipids, and starches that maintain the organisms' life processes. The autotrophic segment of the ecosystem is commonly referred to as the producer level. Organic matter generated by autotrophs directly or indirectly sustains heterotrophic organisms. Heterotrophs are the consumers of the ecosystem; they cannot make their own food. They use, rearrange, and ultimately decompose the complex organic materials built up by the autotrophs. All animals and fungi are heterotrophs, as are most bacteria and many other microorganisms. Together, the autotrophs and heterotrophs form various trophic (feeding) levels in the ecosystem: the producer level, composed of those organisms that make their own food; the primary-consumer level, composed of those organisms that feed on producers; the secondary-consumer level, composed of those organisms that feed on primary consumers; and so on. The movement of organic matter and energy from the producer level through various consumer levels makes up a food chain. For example, a typical food chain in grassland might be grass (producer) mouse (primary consumer) snake (secondary consumer) hawk (tertiary consumer). Actually, in many cases the food chains of the ecosystem overlap and interconnect, forming what ecologists call a food web. The final link in all food chains is made up of decomposers, those heterotrophs that break down dead organisms and organic wastes. A food chain in which the primary consumer feeds on living plants is called a grazing pathway; that in which the primary consumer feeds on dead plant matter is known as a detritus pathway. Both pathways are important in accounting for the energy budget of the ecosystem.

As energy moves through the ecosystem, much of it is lost at each trophic level. For example, only about 10 percent of the energy stored in grass is incorporated into the body of a mouse that eats the grass. The remaining 90 percent is stored in compounds that cannot be broken down by the mouse or is lost as heat during the mouse's metabolic processes. Energy losses of similar magnitude occur at every level of the food chain; consequently, few food chains extend beyond five members (from producer through decomposer), because the energy available at higher trophic levels is too small to support further consumers. The flow of energy through the ecosystem drives the movement of nutrients within the ecosystem. Nutrients are chemical elements and compounds necessary to living organisms. Unlike energy, which is continuously lost from the ecosystem, nutrients are cycled through the ecosystem, oscillating between the biotic and abiotic components in what are called biogeochemical cycles. Major biogeochemical cycles include the water cycle, carbon cycle, oxygen cycle, nitrogen cycle, phosphorus cycle, sulfur cycle, and calcium cycle. Decomposers play a key role in many of these cycles, returning nutrients to the soil, water, or air. The biotic constituents of the ecosystem can then use these nutrients again.

The orderly replacement of one ecosystem by another is a process known as ecosystem development, or ecological succession. Succession occurs when living things, first colonize a sterile area, such as barren rock or a lava flow, or when an existing ecosystem is disrupted, as when a forest is destroyed by a fire. The succession of ecosystems generally occurs in two phases. The early, or growth, phase is characterized by ecosystems that have few species and short food chains. These ecosystems are relatively unstable but highly productive, in the sense that they build up organic matter faster than they break it down. The ecosystems of the later, or mature, phase are more complex, more diversified, and more stable. The final, or climax, ecosystem is characterized by a great diversity of species, complex food webs, and high stability. The major energy flow has shifted from production to maintenance.

Human interference in the development of ecosystems is widespread. Farming, for example, is the deliberate maintenance of an immature ecosystem--one that is highly productive but relatively unstable. Sound management of ecosystems for optimal food production should seek a compromise between the characteristics of young and mature ecosystems, and should consider factors that affect the interaction of natural cycles. Short-term production can be maximized by adding energy to the ecosystem in the form of cultivation and fertilization. Such efforts, however, can hinder efficient energy use in the long run by producing an imbalance of nutrients, an increase in pollutants, or a heightened susceptibility to plant diseases as a consequence of intensive inbreeding of crops. Although an awareness of the interdependence between human society and its environment was already prominent in ancient philosophy and religion, the formulation of the basic principles of systems ecology as a scientific discipline began in the late 19th century. During the second half of the 20th century, the study of ecosystems has become increasingly sophisticated and is now instrumental in the assessment and control of the effects of agricultural development and industrialization on the environment. On farms, for instance, it has shown that optimal long-term production of pasturage requires a moderate grazing schedule in order to ensure a steady renewal of the moisture and nutrient content of the soil and has emphasized the need for multiple-use strategies in the cultivation of arable lands. Systems ecology has been concerned with the consequences of accumulated insecticides and has provided a way of monitoring the climatic effects of atmospheric dust and carbon dioxide released by the burning of fossil fuels (e.g., coal, oil, and natural gas). It has helped to determine regional population capacities and has furthered the development of recycling techniques that may become essential in humanity's future interaction with the environment.

ACTIVITY 3: SURVIVING ALIEN PLANETS

(Adapted from http://www.astrobio.net/news/article2477.html)

Benchmark:
SC.912.L.15.13: Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success.

SC.912.L.15.15: Describe how mutation and genetic recombination increase genetic variation.

Background Information:
The Voyager 1 spacecraft, after traveling about 4 billion miles into space, turned around and looked back home. From such a distance, the Earth appeared as a pale blue dot, a single point of light suspended in the vast blackness of space. If aliens from much more distant worlds were to look at our solar system, the Earth, if it could be seen at all, would seem even more tiny and faint. How could they know that dot of light represents a world teeming with life?

We face this problem when we search for life in other solar systems. Yet, we have no pictures of extrasolar planets; the evidence for their existence comes from the gravitational and spectral effects they exert on their host star. Over the next decade, however, space telescopes may begin to search for and provide images of Earth-sized planets orbiting distant stars. These telescopes include the European Space Agency's COROT and Darwin missions, and NASA's Space Interferometry Mission (SIM), Kepler, and Terrestrial Planet Finders. These missions may be able to tell us about the geology, chemistry, and atmosphere of terrestrial worlds in alien solar systems. Such information could help determine if planets are rich with life like the Earth, or dead, barren worlds where life never took hold.

In May 2007, Victoria Meadows, Principal Investigator for the Virtual Planetary Laboratory at the California Institute of Technology's Spitzer Science Center, presented a lecture at NASA's Jet Propulsion Laboratory. In part five of this six-part edited series, she explores the impact plants have on planets, and how the type of star providing sunshine may affect the color of the alien equivalent of bushes, trees, and blades of grass.

Procedures:
Answer this question as you read the following article: "Would the color of the producers affect the mechanisms of change (e.g., mutation and natural selection) that lead to the adaptations of any extraterrestrial animal species?"

READING: COLORS OF ALIEN PLANTS: A LECTURE BY VIKKI MEADOWS

“We’re studying the co-evolution of photosynthesis with the atmosphere on extrasolar worlds. Our studies determined we had a good chance of predicting the range of colors of plants on other worlds that orbit different types of stars. Studying the co-evolution of photosynthesis with its atmosphere means we were trying to determine whether plants are smart enough to work out where the best places are to get radiation for photosynthesis. If we can figure out that they are smart enough, and if we can figure out what rules they use to choose the pigments for photosynthesis, we wondered if we could apply those rules to other planets around other stars. Could we use them to predict where the photosynthetic pigments are going to be, and what color these plants are going to be? A colleague of mine, Nancy Kiang, and a bunch of her biologist friends went through all of the literature and found every pigment life uses for photosynthesis on this planet. And by pigment, I mean a particular type of molecule that’s specifically tuned to take in a particular type of light and turn that into food for the plant. She discovered, as others have done, that plants seem to be spectacularly inefficient. They throw away a large fraction of that lovely green light – we get more green light coming in from the sun than any other color that’s available to us. In fact, if you look at the energy spectrum of light that hits the surface of the planet, there’s also more green light in the energy spectrum.

So botanists and others had wondered for quite some time, why are plants green? Because, by being green, it means they’re reflecting the green light and not using it. But if there’s more green light than anything else, why would they not use it and be as efficient as they possibly could be? Why do plants absorb red and blue light but not green? She used our models to plot out the radiation that’s coming down on the surface of our planet. When we model those spectra that show you what a planet would look like through a telescope, at the same time we model what the spectrum of the star would look like to a microbe sitting on the surface. So, she used the spectrum of the star for the microbe sitting on the surface. But she plotted it in photons rather than energy, so she plotted it in particles of light. Photosynthesis is photon process – it uses particles of light. It turns out that chlorophyll A absorbs light right at the peak of the most number of particles that come down to Earth, which is near the red part of the spectrum. So, plants are using the light in the form that has the most number of particles. Now the question is, why does the peak move to the red once the light gets down to the surface of our planet? The reason is because of ozone absorption. Plants put out oxygen, which produces ozone, but in doing so they actually shift the usable region of their light more towards the red. And so plants over time have changed the composition of our atmosphere, but in the process had to evolve to keep up with what they were doing to the planet. So back in the beginning of our history when we didn’t have as much oxygen on the planet, plant pigments would have been much more towards the blue. And then over time, they would have moved towards the red as they produced ozone.

She then used that to look at planets around other stars. For example, if you’re orbiting an F star, the peak of the F radiation is towards the blue, and the ozone just makes it more towards the blue. So if you were a plant on a planet going around an F star, which is a star hotter than our sun, then your pigments are more likely to be in the blue, and so you as a plant are more likely to reflect orange or red radiation. Another thing she did was look at safe ocean depths. M stars tend to flare quite a bit, so in the very early stages of planetary development -- when you haven’t got enough photosynthesis to build up oxygen so you don’t have your ozone shield yet -- you are susceptible to large bursts of UV radiation up to 30,000 times what we’re used to in any given day. So, if you’re a life form you don’t want to be out on the surface. What can you do? Well, you can go under the surface, or you can go down in the water. So, she asked the question, if you're a microbe who likes to do photosynthesis, can you go down into the ocean to escape the flares but still have enough energy to do photosynthesis?

She and her team found that yes, indeed you can. And even for the worst possible M star flare we could imagine, you could go underwater 9 meters, or about 10 yards, and still be able to escape the flares but have enough energy to do photosynthesis to create your food. That meant even for early planets around M stars, there are regions where it could be possible to have life down in the oceans. Different types of stars have different temperatures and lifetimes. Cooler red M-class stars live a long time, while hotter blue A-class stars have relatively brief lives. These four pictures are actually four different views of our own star, the sun. Each false-color view highlights atomic emission in different temperature regimes of the upper solar atmosphere. Yellow is 2 million Kelvin, green is 1.5 million K, blue is 1 million K, and red is 60 to 80 thousand K. Everything I've described so far is essentially background theory to support one particular mission called the Terrestrial Planet Finders.

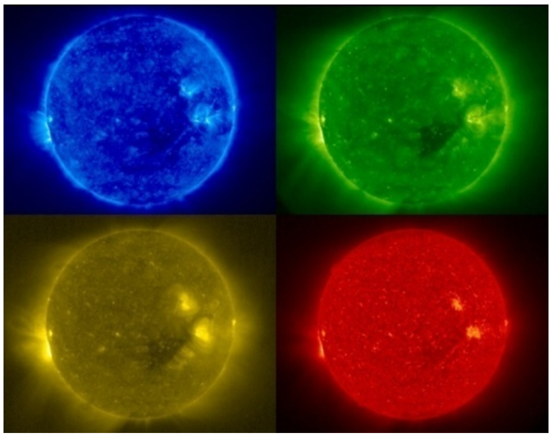

Image Credit: Stereo Project/NASA

There's also a sister mission called Darwin, which is also under concept development by the European Space Agency but is potentially a joint US and European effort. We hope that these telescopes will be launched sometime in the next 20 years or so, but for now, they've been mothballed. We hope to, at least, get the concept up and going as soon as possible, so that within many of our lifetimes we will be able to launch telescopes that will be able to take the spectra of Earth-like planets around other stars. I find that enormously exciting for a number of reasons. First of all, we can look for other habitable worlds and we can see if there are signs of life there. If we find signs of life, that will be an absolutely momentous discovery. But also, from a planetary point of view, when we look out at stars in our solar neighborhood, those stars are all very different ages. They range in age from just born to about 10 billion years old. The planetary systems around them are about the same age as the star. So if I'm looking at a 2 billion-year-old star, I'm also looking at a 2 billion-year-old planetary system. By looking at these stars in our neighborhood, we can essentially look back in time to see how terrestrial planets evolve over time. I think it would be great to be able to get the spectrum of a 2 billion-year-old planet instead of our own 4.6 billion-year-old planet, to be able to look back in time and see what was happening. So, we're looking forward to these missions being able to fly. They are enormously technologically challenging, but well worth it. I invite you to visit our VPL team web site, or the Planet Quest web site to learn about these missions that are eventually going to do this kind of science."

ACTIVITY 4: LIFE IN EXTREME ENVIRONMENTS

Benchmark:
SC.912.L.14.3: Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells.

SC.912.L.15.13: Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success.

SC.912.L.15.15: Describe how mutation and genetic recombination increase genetic variation.

EXPLORATION 4.1: CONCEPT INTRODUCTION - WHO LIVES WHERE?

Most scientists agree that the Earth is approximately 4.5 billion years old. By the time the Earth was approximately 1 billion years old, microscopic organisms had found a way to live on the volatile young Earth. However, it would take another 3 billion years before plants and animals would appear. We see that humans, plants and animals have been around for only a very short time in comparison to the time that microscopic organisms have existed. During the last three billion years, these tiny life forms have gone through a tremendous evolution to adapt to the changing conditions on Earth. They can be found living in almost any environment imaginable.

Of great interest to scientists is the unique way that these tiny organisms live in conditions in which all other forms of life fail. By better understanding how these life forms interact with their surroundings we hope to better understand how life could exist in the extreme environments found on other planets and moons in our solar system and beyond.

In this activity, you will investigate three hypothetical environments and three bacterial life forms that could exist on Earth. For each, we have provided a table with a partial list of characteristics that describe: (1) how the different environments support life and (2) the different needs of each bacterium in order to live within a particular environment. It will be your task to examine the characteristics that are provided for each environment and bacterium and then, based on this information, you will need to complete each table by deciding which bacteria could live in which environment. In the table below, we have listed the characteristics for each environment and bacteria. In the column next to each characteristic are the possible ranges of values that you will need to consider when matching each bacterium with its environment.

Characteristics	Range of Values
Temperature	0ºC – 100ºC
Salinity	Low, Medium or High <5% to 25%
pH level	1 –14
Energy Sources/Uses	Sunlight (photons) or Chemical Potential
Carbon Sources	Organic (sugars/proteins/fats) or Inorganic (CO_2 or HCO_3)
Oxygen provided by the environment or used by bacteria	Yes or No

A. Complete (fill in) each of the tables for these hypothetical environments and bacteria by determining which of the bacteria could live in which of the environments.

Environment X

Temperature	2ºC
Salinity	Low
pH level	
Energy Source	Light-Photons
Carbon Source	
Oxygen Provided	Yes

Environment Y

Temperature	90ºC
Salinity	Low
pH level	
Energy Source	
Carbon Source	Inorganic
Oxygen Provided	No

Environment Z

Temperature	25ºC
Salinity	High
pH level	
Energy Source	
Carbon Source	Organic
Oxygen Provided	No

Bacteria A

Metabolism	Fermentation
Preferred Temperature	20ºC – 30ºC
Preferred Salinity	
Preferred pH level	7
Energy Source used	Chemical Potential
Carbon Source used	
Oxygen needed	

Bacteria B

Metabolism	Respiration
Preferred Temperature	
Preferred Salinity	
Preferred pH level	7
Energy Source used	
Carbon Source used	CO_2
Oxygen needed	

Bacteria C

Metabolism	Gluconeogenesis
Preferred Temperature	
Preferred Salinity	
Preferred pH level	3
Energy Source used	Chemical Potential
Carbon Source used	CO_2
Oxygen needed	

Note: Only one bacteria will be able to live in each environment.

B. State which bacteria (A,B,C) you decided could live in which environment (X,Y,Z).

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C. How did you choose which environment bacteria A could live in? How did you rule out the other environments? What characteristics of the other environments made them too extreme for bacteria A? What were the determining/limiting characteristics for the other bacteria and their corresponding environments? Explain your reasoning.

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D. If the number of photons that arrive at environment Y were to decrease to nearly zero would the bacteria that you chose still be able to live in this environment? Explain why, or why not.

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E. Would your answer to part D change if we were instead considering environment X or Z and the corresponding bacteria? Explain your reasoning.

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F. Which of the bacteria use a source of organic carbon and which of them use inorganic carbon?

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To describe how bacteria interact with their environment it is useful to consider the different ways bacteria use energy and produce or consume food. These processes are described using the following labels:

Chemo: Uses Chemical Energy	Photo: Uses light or photon energy	Autotroph: Uses an inorganic carbon source	Heterotroph: Uses an organic carbon source

By combining the label for how the bacteria uses energy (chemo or photo) with the label that describes the type of carbon source needed by the bacteria (autotroph and heterotroph), we can generate a label that describes the interaction between the bacteria and its environment.

G. Label bacteria A, B, and C using the labels above.

Bacteria A is a ______________ - ____________
energy source carbon source

Bacteria B is a ______________ - ____________
energy source carbon source

Bacteria C is a ______________ - ____________
energy source carbon source

H. Which of these bacteria live anaerobically and which live aerobically? Explain how you know.

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I. Life forms that can live in extreme environments are often given special names. For instance, a "thermophile" can live at extremely high temperatures near the boiling temperature of water. A "psychrophile" can live at extremely cold temperatures near the freezing temperature of water, and a "halophile" is able to live in conditions that have an extremely high concentration of salts.

Which of these hypothetical bacteria (A, B, or C) is a thermophile, a psychrophile or a halophile?

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EXPLORATION 4.2: EXTREME LIFE STYLES - WHAT ARE THE LIMITS?

Read the following on-line written materials about life in extreme environments. Be sure to examine the link labeled Punishing Environments at the beginning of the article and the link labeled Images of Extremophiles at the end of the article.

"Extremophiles" from the Virtual Museum of Bacteria:
http://cw.prenhall.com/bookbind/pubbooks/brock/chapter17/deluxe.html
This article provides a great deal of background information into the names and life styles of many extremophiles found on Earth.

"Chapter #17: Microbial Diversity in Archaea" from Brock -Biology of Microorganisms by Madigan, Martiko and Parker:
http://cw.prenhall.com/bookbind/pubbooks/brock/chapter17/deluxe.html
This excerpt provides a brief synopsis of Chapter #17 on the ways different archaea exist in extreme environments.

"Inroduction to the Archaea" from UC Berkeley's Museum of Paleontology:
http://www.ucmp.berkeley.edu/archaea/archaea.html

Questions:
Answer the following questions based on your readings from these sources in full sentences.

1. What are the three primary branches of the tree of life?

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2. In which branch(es) of the tree of life do we find plants and animals?

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3. In which branch(es) do we find single celled organisms that lack a nucleus?

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4. Which is the highest temperature at which life become too extreme for eukarya?

5. What is the name of the organism thought to live at the greatest temperature? At what temperature does it live? Where does it live?

6. What is thought to happen at temperatures above 150^{o}C that prevents all life forms from existing above this temperature?

7. List the different species that scientists have found living in the extremely cold Antarctic sea-ice.

8. How do organisms live without freezing in extremely cold environments?

9. At what temperature do Polaromonas vaculota grow best? At what temperature does life begin to become too warm for Polaromonas vaculota?

10. How do halophiles adjust their structure to cope with life in extremely salty conditions?

11. What range of values in pH does an acidophile prefer? What about an alkaliphile?

12. Do acidophiles have high acidity in their cells? Explain why or why not.

13. What is unique about the cell walls of archaea?

14. What would a halophile do to adapt to a change in the salinity of the solution in which it was living?

15. Which extremophiles use inorganic carbon in anaerobic respiration to produce organic carbon and the by-product CH_4?

16. What is the electron acceptor utilized by all hyperthermophiles in metabolism?

17. Is the electron acceptor from question 16 an energy source or a carbon source? Is it oxidized or reduced?

ACTIVITY 5: MILK MAKES ME SICK: EXPLORATION OF THE BASIS OF LACTOSE INTOLERANCE

(Adapted from http://www.exploratorium.edu/snacks/milk_makes-me_sick/index.html)

Benchmark:
SC.912.L.18.1: Describe the basic molecular structures and primary functions of the four major categories of biological macromolecules.

Background Information:
Lactose is milk sugar. It is composed of two molecules of "simple" sugars chemically bonded together - glucose and galactose. The enzyme lactase breaks down lactose into glucose and galactose, which are easily digested by humans. Most human infants produce ample quantities of lactase for milk digestion. However, in the vast majority of adult humans, the gene that specifies production of lactase is turned "off" and these individuals cannot digest lactose - they are lactose intolerant. Symptoms of lactose intolerance include cramps and diarrhea. The lactose molecule, which is large, accumulates in the large intestine and affects the osmotic balance there. Since water moves across semi-permeable membranes, such as the intestine, from areas of high concentration to low concentration, the addition of large lactose molecules causes water to enter the intestine. This can result in the very unpleasant experience of watery stool or diarrhea. Since lactose is a sugar, it is an ideal food for the bacteria that normally inhabit our intestine (which are essential to digestion). However, the lactose will be fermented by these same friendly bacteria, and organic acids are gas are produced by them and we all know what discomfort intestinal gas can cause! So most folks who are lactose intolerant choose to avoid lactose-containing milk products, or modify the lactose, to avoid the cramps and diarrhea associated with the intolerance syndrome.

Materials:
- Regular milk
- Lactaid milk (Lactaid 100 is 100% lactose free; available at most grocery stores; some stores now carry their own brands - just be sure it is 100% lactose free)
- Lactase drops referred to as "mystery drops" (available in most grocery or drugstores).
- Test tubes or glasses, to contain about 20 ml fluid (NOTE: One teaspoon equals about 5 milliliters).
- Glucose test strips for urine samples (available at drug stores; you may cut in half length-wise to double the number you have).
- 2% glucose solution: make by dissolving 2 grams of glucose (or dextrose) in 100 ml water or by grinding one glucose tablet (4 grams/tablet; found in drugstores) in 200 ml of water. (NOTE: One teaspoon equals about 5 milliliters).

Procedures:
1. Test that your glucose test strips work by testing them with positive and negative controls. Follow the directions on your brand of strip, and dip strips into a) glucose solution positive control), and b) water (the negative control). Wait for length of time specified by strip directions, then record any color changes of the strip and compare to the key on the bottle to determine glucose concentration of the tested fluid. If the strips determine that the glucose solution has NO glucose in it, or registers far less than 2%, the strips are defective and should be discarded. The experiment cannot be performed until new strips are obtained.

2. Pour about one half inch of regular milk (about 3 ml) and Lactaid (lactose free) milk into separate test tubes, one of each for each group, and label "A" and "B"
3. Determine the glucose concentration of "A" by following the directions for your brand of glucose test strips. Compare the color of the strip after dipping it in the milk (as per directions on the test strip bottle) with the color-coded key on the side of the bottle to determine the concentration of glucose in the milk.
4. Determine the concentration of glucose in "B" by using a fresh test strip, following the directions on the bottle and comparing the color of the test strip after dipping it in the milk with the color-coded key on the side of the bottle.
5. Your results should be recorded in your journal. Acknowledge that small variations between trials may be due to differences in how the procedure was carried out (for example; most strips require reading at an exact time after dipping; if you do not follow the instructions exactly, small variations in results may be obtained). Do not be overly concerned about small variations, as long as the water is "negative" for glucose and the glucose solution is "positive" for glucose.
6. Add one drop of "mystery drops" to one half inch of "A" (the same "A" from step #3). Warm the milk by rolling the tube back and forth in your hands for 2 minutes. Repeat the glucose test with a fresh test strip as indicated in #3 above. Is the glucose concentration now the same or different as compared to the concentration in "A" prior to adding the "mystery drops"?
7. Add one drop of mystery fluid to "B" (the same "B" from step #4 above. Warm the milk by rolling the tube back and forth in your hands for 2 minutes. Repeat the glucose test with a fresh test strip as indicated in #4 above. Is the glucose concentration now the same or different as compared to the concentration in "B: prior to adding the "mystery drops"?
8. Tabulate your results as in #5 above.
9. Explain your results. Is there a difference in glucose concentration between fluids "A" and "B" before addition of the "mystery drops"? Postulate as to what the difference means. Do the glucose concentrations of "A" and "B" change after the addition of the "mystery drops"? What could account for the change? At this point, students may conclude that somehow the "mystery drops" converted something in the regular milk to glucose. This may be true, but at this point, one other possibility cannot be ruled out - see if the class can think of what that is. If they are unable to present an alternate hypothesis, prod them with the following: How do you know that the mystery drops are not glucose? The "mystery drops" are added to a substance which had a negative glucose reaction, and all of a sudden that same substance gives a positive reaction. Unless the mystery drops (i.e. lactase drops) themselves are tested with the glucose strips, no conclusions can be reached! You should then test the "mystery drops" with the glucose strips. Add the result of this test to the data recorded on the board. Now what sort of conclusions can be drawn from the data?

Observations:
The lactase enzyme breaks down milk sugar, that is, lactose into glucose and galactose, making it digestible for people with lactose intolerance. Regular milk contains a high concentration of lactose, and no glucose, as shown by the negative reaction of the glucose test strip (no color change). The lactose-free milk has been treated with lactase, which broke down the lactose into glucose and galactose; when lactose-free milk is tested, the glucose test strips will change color to indicate a high concentration of glucose present in the milk. When lactase drops are added to the regular milk, the enzyme breaks down the lactose into glucose and galactose, as revealed by testing lactase treated milk with the glucose test strips. It's very important that someone in the class test the lactase drops - after all, they're the "mystery drops" and how do you know it isn't just a bottle of glucose? Usually we let a student figure out that the "mystery drops" should be tested, and they will give a negative reaction to the glucose test.

The vast majority of the worlds' peoples are lactose malabsorbers (lactose intolerant). All Eskimos and American Indians studied thus far, as well as most sub-Saharan African peoples, Mediterranean and Near Eastern groups as well as those of Indian, Southeastern and East Asian descent, and Pacific groups contain a vast majority of lactose malabsorber. There is a strong correlation of the incidence of adult lactose absorbers (lactose tolerant) and those whose ancestry included dairying as a means of subsistence. For example, among hunter-gatherer societies that traditionally lack dairy animals, about 2.5% of the Kung Bushmen are lactose absorbers, ranging to a maximum of 22.7% of the Twa Pygmies of Rwanda. The average percentage of adult lactose absorbers for nondairying agriculturalists (such as the Yoruba and Hausa of Africa) is 15.5%, as contrasted to milk-dependent pastoralists (such as the Arabs of Saudi Arabia and Tussi in Africa) where the average percentage of lactose absorbers is 91.3%. Dairying peoples of northern European descent average 91.5% adult lactose absorbers. Some groups of peoples do have intermediate percentages of lactose absorbers in their populations, but these groups are the vast minority and stem from societies that have ancestry in both absorber/nonabsorber populations. These mixed populations are largely the dairying peoples of North Africa and the Mediterranean, including Jews in Israel, Ashkenazic and other Jews, Arabs, Egyptians and Greeks. These peoples average 38.8% adult lactose absorbers, with a range of 0% (non-Saudi Arabs) to 52.1% (mainland Greeks) among individual ethnic groups.

In general, only Northern Europeans, who drink much milk, seem to have a high degree of lactose tolerance in the adult population. Many Americans are lactose tolerant, due to mixing of ethnicities - lactose tolerance seems to be genetically transmitted. The speculation is that at some point, a mutation occurred, which caused individuals to produce lactase throughout their lives, and for some reason this trait gave these individuals a survival advantage and was selected for during natural selection. In very early human societies, people did not consume milk beyond early childhood, so the lactase gene was "turned off". As people migrated to distant parts of the world and domesticated cattle, in some instances, dairy products provided a food source through adverse winter conditions. Hence, Northern Europeans whose lactase gene remained active could consume milk products without becoming ill, thus providing a survival advantage. This was not an issue in warmer climates where food was cultivated year round and societies were not tied to dairy cattle for sustenance. Thus, the majority of the world's populations, whose ancestors were not dependent upon dairy products for survival, retained the characteristic of adult lactose malabsorption with no adverse consequences to them.

Speculation as to why the lactose gene "turns of" is a fascinating topic. One theory suggests that lactase deficiency evolved early in mammalian history, perhaps 75 million years ago, as a means to facilitate weaning and shorten the dependence of the child on the parent for lactation. The gas and diarrhea produced by lactose malabsorption would stimulate the child to become weaned. One competing theory suggests that lactose malabsorption in adults prevents competition of adults with infants for food (who can only digest milk early in life), and another theory proposes that lactose intolerance evolved as a defense mechanism against intestinal infections.

For those of you with some chemistry background, it's interesting to note that the reaction that causes a color change in the glucose test strip is also catalyzed by enzymes. Glucose oxidase present in the test strip catalyzes the formation of gluconic acid and hydrogen peroxide from the oxidation of glucose. A second enzyme impregnated in the test strip, peroxidase, catalyzes the reaction of hydrogen peroxide with a potassium iodide chromogen (in the strip) to produce changes in the test strip colors ranging from green to brown. This information is included in the product information sheets included in the box with the glucose test strips.

Extension:
This activity can also be used as an exploration of enzyme function. Concentration of lactase enzyme, effects of temperature, acids, and bases on its activity can all be tested. Since nearly all enzymes are proteins, these macromolecules are subject to the physical properties that affect protein structure. The proper functioning of enzymes is directly related to their three-dimensional structure. Physical factors such as heat, extremes of pH and salinity can cause the denaturation, or unfolding of the enzyme's three-dimensional structure, thus preventing it from normal functioning.

Gentle heating and cooling, as well as the concentration of the enzyme in a chemical reaction, may affect how long the reaction takes to complete. These enzyme properties can all be easily tested in the context of this lactase experiment. For example, heat a bottle of lactase to boiling prior to use. Let cool. Repeat the experiment as outlined above. Are there any differences in results? The lactase should be denatured, and will not be able to convert lactose into glucose and galactose.

PARTS OF A LAB REPORT: A STEP-BY-STEP CHECKLIST

Good scientists reflect on their work by writing a lab report. A lab report is a recap of what a scientist investigated. It is made up of the following parts.

Title (underlined and on the top center of the page)

Benchmarks Covered:

- Your teacher should provide this information for you. It is a summary of the main concepts that you will learn about by carrying out the experiment.

Problem Statement:

- Identify the research question/problem and state it clearly.

Hypothesis(es):

- State the hypothesis carefully. Do not just guess; instead try to arrive at the hypothesis logically and, if appropriate, with a calculation.
- Write down your prediction as to how the independent variable will affect the dependent variable using an "if" - "then" – "because" statement.
  - ❖ If (state the independent variable) is (choose an action), then (state the dependent variable) will (choose an action), because (describe reason for event).

Materials and activity set up:

- Record precise details of all equipment used.
  - ❖ For example: a balance that measures with an accuracy of +/- 0.001 g.
- Record precise details of any chemicals used.
  - ❖ For example: (5 g of $CuSO_4 \cdot 5H_2O$ or 5 g of copper (II) sulfate pentahydrate).

Procedures:

- Do not copy the procedures from the lab manual or handout.
- Summarize the procedures that you implemented. Be sure to include critical steps.
- Give accurate and concise details about the apparatus and materials used.

Variables and Control Test:

- Identify the variables in the experiment. State those over which you have control. There are three types of variables:
  1. Independent variable (also known as the manipulated variable): The factor that can be changed by the investigator (the cause).
  2. Dependent variable (also known as the responding variable): The observable factor of an investigation that is the result or what happened when the independent variable was changed.
  3. Constant variable: The other identified independent variables in the investigation that are kept or remain the same during the investigation.

- Identify the control test. A control test is the separate experiment that serves as the standard for comparison to identify experimental effects and changes of the dependent variable resulting from changes made to the independent variable.

Data:

- Ensure that all data is recorded.
  - ❖ Pay particular attention to significant figures and make sure that all units are stated.
- Present your results clearly. Often it is better to use a table. Record all observations.
  - ❖ Include color changes, solubility changes, whether heat was evolved or taken in, etc.

Data Analysis:

- Analyze data and specify method used.
- If graphing data to look for common trend, be sure to properly format and label all aspects of the graph.

Results:

- Ensure that you have used your data correctly to produce the required result.
- Include any other errors or uncertainties that may affect the validity of your result.

Conclusion and Evaluation:

A conclusion statement answers the following seven questions in at least three paragraphs.

I. First Paragraph: Introduction

1. What was investigated?
   a) Describe the problem.
2. Was the hypothesis supported by the data?
   a) Compare your actual result to the expected result (either from the literature, textbook, or your hypothesis).
   b) Include a valid conclusion that relates to the initial problem or hypothesis.
3. What were your major findings?
   a) Did the findings support or not support the hypothesis as the solution to the restated problem?
   b) Calculate the percentage error from the expected value.

II. Middle Paragraphs: These paragraphs answer question 4 and discuss the major findings of the experiment, using data.

1. How did your findings compare with other researchers?
   a) Compare your result to other students' results in the class.
      - The body paragraphs support the introductory paragraph by elaborating on the different pieces of information that were collected as data that either supported or did not support the original hypothesis.

- Each finding needs its own sentence and relates back to supporting or not supporting the hypothesis.
- The number of body paragraphs you have will depend on how many different types of data were collected. They will always refer back to the findings in the first paragraph.

III. Last Paragraph: Conclusion

2. What possible explanations can you offer for your findings?
   a) Evaluate your method.
   b) State any assumptions that were made which may affect the result.
3. What recommendations do you have for further study and for improving the experiment?
   a) Comment on the limitations of the method chosen.
   b) Suggest how the method chosen could be improved to obtain more accurate and reliable results.
4. What are some possible applications of the experiment?
   a) How can this experiment or the findings of this experiment be used in the real world for the benefit of society?

POWER WRITING MODEL IN SCIENCE

1. Introductory Paragraph:
State the purpose of the experiment, what was set out to prove, and explain the reasoning behind the experiment. This is where the problem statement and the hypothesis are introduced. The problem statement introduces the problem you are trying to solve and the hypothesis describes the solution that you hope to obtain after the experimentation. (This section answers question 1: “What was investigated?”). Continue by providing relevant information supporting or not supporting the hypothesis (This section answers question 2: “Was the hypothesis supported or not supported by the data?”). This is how the rest of the sentences in the introductory paragraph are linked. They will describe the data that was collected and the major findings of the investigation (question 3) that supported or did not support the hypothesis as the solution to the restated problem.

2. Body Paragraphs:
The body paragraphs support the introductory paragraph by elaborating on the different pieces of information that were collected as data that either supported or did not support the original hypothesis. Using terms such as “as a matter of fact” or “for example” and “not only but also” for successive sentences is useful. Each finding needs its own sentence and relates back to supporting or not supporting the hypothesis. The body paragraphs may include Question 4, which describes how the findings compared with other researchers or groups investigating the same problem. The number of body paragraphs you have will depend on how many different types of data were collected. They will always refer back to the findings in the first paragraph. The concluding sentence can begin with a term such as “clearly” which would be followed by the statement that is true (support or non support) for the entire paragraph as it relates to the hypothesis. The commentary can include some inferences (opinions) although the major inferences should be reserved for the concluding paragraph.

3. Concluding Paragraph:
The concluding paragraph contains the major commentary about the problem statement and the hypothesis in the first paragraph of the conclusion. This is where question 5, what possible explanations can you offer for your findings? can be answered. The paragraph should also include answers to questions 6 and 7 that include what recommendations do you have for further study and for improving the experiment and some possible applications of the experiment? At the end of the paragraph the problem statement and hypothesis (introduction and thesis) is restated more specifically with an abbreviated version of the explanation of the findings to summarize the conclusion.

Questions and Examples:

Questions	Examples
1. What was investigated? (Describe the problem statement)	The relationship between the age of compost used in soil and the growth, health, and quality of the leaves of tomato plants were investigated.
2. Was the hypothesis supported by the data?	The data appears to support the hypothesis that the growth, health, and leaf quality of tomato plants would improve increasing the age of compost mixed with soil.
3. What were the major findings?	As the age of the compost increased the health, quality of the leaves, and the mean height of the tomato plants increased. The mean height of plants grown in soil with compost aged for six months was greater than the control group, with plants exhibiting similar health. More plants grown in soil with one month-old compost exhibited poor leaf quality than in the control.
4. How did your findings compare with other researchers?	No similar studies were found relating the age of compost to the growth of tomato plants.
5. What possible explanations can you offer for your findings?	As the compost decomposes, nutrients needed by the plant may be released thereby improving the growth of the plant.
6. What recommendations do you have for further study and for improving the experiment?	This experiment could be repeated with an increased number different ages of compost. Measurements of soil temperature may help to understand what is happening to the compost.
7. What are some possible applications of the experiment?	The use of compost aged for longer than six months will improve the growth of tomato plants.

II. Laboratory Report Writing Form (Template)

Title

FSSS (Strands, Standards, Benchmarks): ______________________________________

____

Science Concept (s): (Background information) _________________________________

____

____

____

Problem Statement: (Can be written as a question) ______________________________

____

____

Hypothesis (es): (explanation to the Problem statement – should be written as an IF – THEN – BECAUSE statement) ____

____

____

Procedures: (as many as needed)

1. ____
2. ____
3. ____
4. ____
5. ____

Variables: ____

____

Independent (Manipulated) Variable: (if not comparative or observational investigation)

____

____

Dependent (Responding) Variable: ____

____

Variables Held Constant: ____

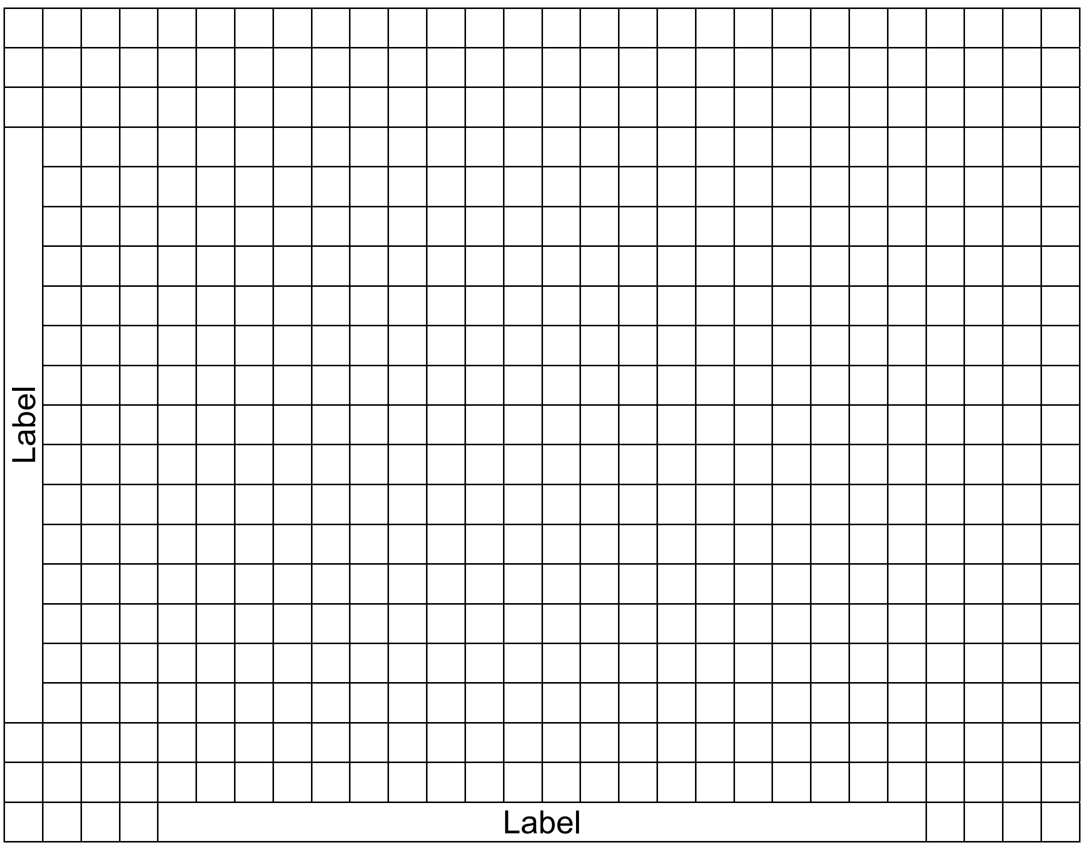
Number of Trials: ____

Control Test: ____

Data: (Tables, Charts, etc.) _____________________________________

Data Analysis and Interpretation of data: (Graph and/or written description of results)

Title



Conclusions: (Use Seven Question Conclusion Form)

References: (Bibliography, Interviews, etc.)

Use additional pages if necessary

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