

Curriculum Units by Fellows of the Yale-New Haven Teachers Institute 2013 Volume IV: Asking Questions in Biology: Discovery versus Knowledge

Inquiring about Organisms

Curriculum Unit 13.04.06 by Laura J. Namnoum

Introduction

I am a first grade teacher at Nathan Hale School in New Haven, Connecticut. My classroom includes twenty-six students with a wide variety of academic abilities, interests, and prior knowledge. I have a handful of students with special education needs and accommodations. Nathan Hale is a school with students that come from a variety of backgrounds and have a diverse set of needs and skills. Inquiry based learning has been a focus at my school, but at times it is a struggle to initiate and create units and plans that promote questioning. Questioning is a skill that needs to be fostered in order for students to be comfortable with sharing or have beliefs that their questions have value. In my classroom I set my expectations high for students to independently ask and find answers to their own questions. I focus time on having students internalize their learning through exploration and questioning. Students are given many opportunities to investigate information independently, with partners, or in groups.

This unit is designed to build primary students' confidence and ability to ask questions while focusing on living organism's life cycles. The unit will teach students about organisms using an inquiry based method to foster their natural sense of wonder. The lessons will provide time for the teacher to model questioning and for the students to practice questioning. Students will learn that living things go through stages as part of their life cycle. First, students will focus only on plant life cycles. They will learn that during plants' life cycle they have needs for survival. The teacher will model questioning by asking questions and prompting inquiry discussions. Students will ask questions and make hypotheses as well. They will conclude the unit by using their knowledge about plant life cycles to study life cycles of another organism. This will allow them to compare and contrast life cycles and will generate questions and hypotheses about other organisms, based on what they already observe with plants. As a result of this unit, students will gain better skills to ask questions in all areas of life and to seek answers independently.

Science lessons should be a time for students to discover new learning about the world around them. They should have plenty of opportunities to wonder about how and why things work the way they do. Students should ask questions and aspire to learn the answers. I have noticed many times that when I ask students to tell me what they know about a topic the majority of the class is able to explain some basic understanding. However, when I ask students what they want to know about the same topic I typically only have a few students that are able to provide a question. Many times the questions that students are able to formulate are

very broad because they don't have enough experience asking specific questions. Questioning is a natural part of thinking and the students I have encountered struggle with this. I believe this could be a potential problem for our youth if they are not fostered in an environment that promotes questioning. John Dewey, a philosopher of education, elaborately describes his theory of questioning and how we think in his book *Logic: The Theory of Inquiry*. He equates questioning with inquiry when he states, "We inquire when we question; and we inquire when we seek for whatever will provide an answer to a question asked." He later goes on to explain the importance of inquiry when he writes, "Inquiry is the lifeblood of every science and is constantly engaged in every art, craft, and profession," ¹ Without wonder what kind of future does out next generation have? Where will we find our future professionals when the heart of all these fields is inquiry? More time needs to be spent in the classroom on fostering and encouraging children's natural instinct to wonder. This unit will provide plenty of opportunities for students to gain the skills necessary to ask questions and become answer seekers.

Overview

This unit will give students an analytical look at the life cycles of living organisms, opportunities to ask questions, and help them find the answers through experimentation and research. Scientific exploration will be the focus subject area for this unit. The unit will begin by observing and experimenting with plants to understand their life cycle. At the end of each lesson students will be given opportunities to share questions. At the end of each week students will be able to reflect on their questions and write down any answers that they may have learned. They will then write down any new questions that they might now have. The unit will conclude by asking at least one question about another organism's life cycle, formulating a hypothesis, and researching to find their answer. This unit will be taught over a four week period. Each week will consist of four lessons for approximately forty minutes each. As a result of this unit, students will gain the skills and confidence needed to ask and answer questions independently throughout their life.

Week 1

The unit will be introduced by hooking the students' thirst for knowledge. The unit's hook will allow students to work in teams to observe three different house plants. They will be prompted to make observations and share with the class. After each group has completed their observations, students will begin to ask questions.

Next, students will observe, compare, and contrast three different seeds. They will also ask questions about the parts of a seed. They will then dissect a lima bean seed to answer their questions and identify the parts (see lesson plan 1 for more information.) Finally, students will put three different seeds in a clear bag with a wet paper towel in the sun to begin germination. The growth of these seeds is important because during the next few weeks of the unit students will make observations, nurture their seeds, and experiment with them. Students will also ask questions about the cycle that a plant goes through.

Week 2

During the second week, students will observe their seeds' growth. They will water the seeds and watch what happens when they meet their seeds' survival needs. They will discuss what all plants have in common for survival. Students will transfer their seeds to soil and place them in the sun to grow. Students will think about

how to create a self-sustaining environment for their plant. They will create a garden in a jar (see lesson plan 2 for more information.) Students will be able to observe and describe various stages of a flowering plant's life cycle and the necessary conditions to support growth. They will also compare and contrast the growing process for small, medium, and large seeds. Class discussions will promote wondering by talking about what would happen if there was no light, no water, or no soil. Students will write their predictions to what they think would happen if we took one of those things away.

Week 3

During the third week, the teacher would model questioning by asking a variety of questions about what would happen if we changed the plants' environment. For example, "what would happen if we took away the sunlight from the plants?" or "what would happen if we watered our plants with apple juice?" The students would choose which experiment they would like to perform on the plant and create a hypothesis for what they think would happen. Together the students and the teacher would perform a class experiment and determine results using their findings. Students would then work together in small groups and ask their own "what if" questions. Students will ask questions, make hypotheses, and work together to perform their own experiment on their plants by changing something needed for survival with something else. Students would make observations with their groups and determine what happens to their plants. The class would share their findings. During this week of experimentation, students will be sure to continue making observations on their plants and continue to think about the changes and cycle their plant is going through.

Week 4

To finalize the unit and promote independence with questioning and hypothesizing, students will use their new knowledge of plant's life cycles to formulate a question and hypothesis for life cycles of an organism of their choice. They will research their question using books and internet resources. They will then compare what they learned about the life cycles.

The unit would be wrapped up by reflecting on the questions that they answered and explaining why the plant survived in the terrarium. The teacher will also stress the importance of asking questions with science, but remind students to consult with an adult before beginning any experiment.

Standards

This unit is in accordance to the Connecticut State Standards and New Haven Standards. Under both sets of standards, students must be exposed to a variety of literature and have opportunities to respond in literal, critical, and evaluative ways. Students will listen and speak to communicate ideas clearly. Students will express, develop, and substantiate ideas through their own writing and artistic and technical presentations. This unit is designed to meet the following state standard on structure and function: 1.3 Organisms change in form and behavior as part of their life cycles. This standard is set to ask the question- How are organisms structured to ensure efficiency and survival? Students should learn that some organisms undergo metamorphosis during their life cycles; other organisms grow and change, but their basic form stays essentially the same. Students will be expected to describe the changes in organisms as they undergo metamorphosis and describe the life cycles of organisms that grow but do not metamorphose. This unit is also

supportive of the science goal for pre-K through 2 nd grade instruction to develop a wonder about the natural world and the ability to observe, describe and apply basic processing skills.

Background Knowledge

Variety of Life

Earth is home to a great variety of living things. Living things are called organisms. FreeDictionary.com defines organism as an individual form of life that is capable of growing, metabolizing nutrients, and usually reproducing. Organisms can be unicellular or multicellular. From 1969 to 1990 life was classified into five kingdoms: they included prokaryotes (simple bacteria), protists (protozoans and algae of various types), fungi, plants, and animals, and that are further subdivided based on common ancestry and homology of anatomic and molecular structures. Then, in the 1970s a group of scientists, led by Carl Woese, began to discover a new group of prokaryote species that survived in extreme conditions (like the bottom of the ocean). These organisms appeared prokaryotic but from biochemical characteristics and DNA sequence analysis it became clear that there were numerous differences between them and other bacteria. Soon after, it was found that they were more closely related to eukaryotes than bacteria. Scientists had to rename these species to archaea. They then created the highest organizational category of living organisms into domains to include achaea, bacteria, and eucaryotes. Figure 1 shows a diagram based on Woese's discovery. This structure now supports that organisms within kingdoms or between kingdoms may be related through evolutionary relationships.



Phylogenetic Tree of Life

Figure 1: Phylogenetic Tree Based on Woese Analysis

Accessed from http://en.wikipedia.org/wiki/Carl_Woese

Scientists have classified organisms in order to organize and study the billions of different types. Scientists classified organisms by grouping species that are closely related to each other. They compare groups with one

another. They look at every aspect such as color, shape, and genes inside its cells. They use the information to sort millions of different things into groups.

Plantae

Plantae includes all organisms living on earth that have been classified as being plants. Plants are classified in this group if they use photosynthesis to produce their own energy from the sun's rays. All plants included in this kingdom can be broken down into smaller divisions based on characteristics. Some characteristics include, if they can circulate fluids through their bodies or if they absorb them, how they reproduce, and their size.

The first grouping of plants is made from plants that are non-vascular. Non-vascular plants lack an internal structure and means to circulate water throughout them. They do not have roots, stems, and leaves with vascular tissue to transport water. These plants must absorb water directly from their cell walls and transport it from cell to cell through osmosis. They also do not produce seeds or flowers and generally only grow to a height of about one or two centimeters because they lack the woody tissue necessary to support anything taller. Non-vascular plants can produce both sexually and asexually. Sexual reproduction is more common where external water is needed for the sperm to swim to an egg. Asexual reproduction happens when plant material falls to the ground and generates a new plant. Nonvascular plants almost always live in damp, shady places. They get water similar to sponges and use their surfaces to slowly distribute water. Because of their structure, nonvascular plants have never populated much of the earth. A common example of this kind of plant is moss. There are three subdivisions of nonvascular plants. They are divided into bryophyta, hepatophyta, and anthocerophyta. These divisions were created due to distinct differing characteristics.

The second grouping of plants is the vascular category. Vascular plants have tubes running through them to carry water and nutrients through the plant. They can circulate fluids through a true root, stem, and leaf system. This group of plants contains many more plant species and it makes up the majority of plants on the earth. These plants have a woody stem that helps them grow taller than nonvascular plants. Some of these plants include trees, grasses, and ferns. Plants with flowers or cones fall into this category. These plants all reproduce from seeds. This unit will focus on vascular plants: specifically those that produce flowers.

The Parts of a Flowering Plant

Flowering plants have many parts needed to carry out their life cycle. Most plants belong in the category that produces flowers. The main parts of the flowering plants include the seeds, leaves, roots, stems, stomata, and flowers.

Seeds

Seeds can look simple from the outside, but inside they contain special elements needed to create a new plant. They contain stored energy to support development. Seeds are found inside the part of a plant called a fruit. Each seed contains a food store. A food store is the part of the seed that holds food for the plant as it begins to grow. It is made of starch, protein, and oil. Sometimes it is located in a special part of the seed called the endosperm. Not all seeds have an endosperm. If the seed does not have an endosperm then the food is stored in the embryo. The embryo is another part of the plant that contains information that is needed for the seed to grow. It is joined to the food store and may be composed of just a few cells or may be larger and actually looks like a miniature plant already. Another part of a seed is the seed coat that surrounds and protects each seed. The last part of the seed is the micropyle that is a small hole in the seed coating that

allows water to enter the seed.

Seeds can lay or travel around for long periods of time, even years, before they are given the right conditions to begin growing. Seeds will not germinate without water. Germination is when a seed begins to grow. Smaller seeds germinate faster than larger seeds. Seeds use their micropyle, a small hole in their protective coating, to allow water to get inside. As the water soaks in through the hole, the seed starts to swell. Seeds also need oxygen to germinate. The seed needs to breathe and take in oxygen. Oxygen is necessary because it breaks down the food store and releases energy needed for growth. If a seed is buried too deep in the ground and cannot get enough oxygen it will not be able to germinate. Seeds also need warmth to germinate. Many seeds cannot germinate in temperatures colder than 59? Fahrenheit. Light can also stimulate or inhibit some seeds from germinate in either condition. Germinating seeds eventually split their coating and the first root emerges. The root will always bend downward to soak up water and minerals from the soil. The seed also grows a shoot upward. Most plants that begin to germinate quickly produce one pair of leaf-like structures called cotyledons. These leaves are often a different shape from leaves that are produced from the plant in the future. The cotyledons of some plants become the food stores for these plants.

Seeds must travel in order to find the right conditions for them to grow. Seeds travel in many ways. Some seeds have hooks and act like hitchhikers. They fasten themselves to moving objects, such as animals, and then drop off at a new location. Some seeds have bristles that allow the seed to move forward on an animal's coat and will eventually drop later during the animal's travels. Other seeds travel in the wind, such as using a parachute -like structure that allows them to glide through the air. Other seeds are hidden inside fruit. When an animal eats and digests the fruit, the seed stays intact and is left in a new location in the animal's waste.

Leaves

Leaves come in many shapes and sizes but they all have the same purpose. They are necessary for plant survival because they make food for the plant. During the daylight, most of a plants' food is made in its leaves. The plant uses this energy, in the form of sugars, to create food. This process is called photosynthesis. During the nighttime, the food is produced and taken from the leaves to where it is needed.

Most leaves are designed to catch as much sunlight as possible. They are flat and thin maximizing the leaf's surface area. Some leaves are simple and made of one leaf blade and a leaf stalk. Other leaves are more complex. Compound leaves are made up of several leaflets attached to a leaf stalk. Simple leaves have one large vein, called a midrib, that branches into smaller veins covering the leaf. These veins carry water and minerals to the leaf and take sugars, made from photosynthesis, away from the leaf. Underneath the leaf there are many tiny holes called stomata. The plant uses the stomata to breath in carbon dioxide and release oxygen. Water that has moved throughout the plant is released through the stomata as water vapor.

Roots

The roots of a plant are usually found below the ground deep in the soil. Roots have two important uses. Roots work like straws by absorbing water and minerals from the soil and bringing them to the farthest stems and branches. Large roots divide into smaller rootlets that are covered in tiny root hairs. The tiny root hairs hang out from the root helping the plant absorb water. The water contains minerals and nutrients necessary for a healthy plant. Roots also act as an anchor keeping the plant in the soil so that it does not fall over.

Stems

Stems are found above the ground. Stems have three important roles. They support the leaves and flowers. They transport water and minerals from the roots to the leaves and other parts of the plants. The water is transported in small channels called veins. Lastly, the stem carries glucose created during photosynthesis from the leaves to the rest of the plant. Stems are sometimes green and can be pliable. They can also be woody like the stem from shrubs.

Stomata

Plants breathe through a process called respiration, similar to animals, occurring throughout 24 hours. Both plants and animals breathe through an exchange of oxygen and carbon dioxide at a cellular level. Their process is different than in animals though, because plants breathe in a passive process. Plants respiration process occurs through their leaves where they 'inhale' carbon dioxide and 'exhale' oxygen. Carbon dioxide is taken in from the air through tiny holes called stomata, and oxygen is given off into the air through the stomata.

Flowers

Flowers are not only beautiful to look at, but serve a very important purpose as well. Flowers are the plant's reproductive system. Not all flowers are the same. Some plants have flowers with both male and female reproductive parts in each flower. Others have only male reproductive organs or female reproductive organs. Some have both male and female flowers. Others have males on one plant and females on another. Some flowers are called complete flowers because they have stamens, a pistil, petals, and sepals. But, incomplete flowers do not include one of these parts.

Flowers with both male and female reproductive organs provide a basic understanding of the parts of flowers. Flowers with this design are made up of several layers. The flower bud is covered with a protective layer of green sepals. The flower then opens to reveal colorful petals. In the center of the flower are the reproductive male and female parts needed to make seeds. Figure 2 displays the location of these parts on a mature flower with male and female organs.



Figure 2: Parts of a Flower with Male and Female Organs

Accessed from https://en.wikipedia.org/wiki/File:Mature_flower_diagram.svg

The reproductive parts are male and female. The male cells are in the form of fine grains called pollen. Insects, some other animals, or the wind carry pollen to other flowers of the same species. The male cells from one flower combine with the female cells from another flower and fertilize the egg. This process leads to the formation of seeds. The female ovary is at the base of the flower with the style and stigma above it. The male cells are in the pollen and the female egg cells are in the ovary. In order to produce a seed the male and female cells must join together.

Some seed production takes place in the middle of the flower. The stamen holds masses of brightly-colored pollen at its tip. When the flower opens, the stamen elongates and the pollen becomes light and fluffy. The stigma is surrounded by stamens. It looks similar to the stamens but it does not have pollen. The stigmas purpose is to collect pollen from other flowers on its sticky tip. The stalk supporting the stigma comes from the heart of the flower, the ovary. When a pollen grain in the stigma starts to grow, the stigma sends a thin tube down inside the style to the ovary. Male genes from the pollen grain travel down the tube to meet with the female gametes in the ovary to form seeds. This is the location where fertilization and gene mixing happen.

Flowers have a role of ensuring that the next generation of plants will grow. No matter what their makeup is, they all have the same purpose to produce seeds. They allow the genes of plants to mix. This insures that offspring are not exactly alike. The small differences allow some plants to survive when others might die if environmental conditions changed.

Life Cycle of a Sunflower

The sunflower provides a basic example to illustrate the life cycle of a flowering plant. They are also easy to use in a classroom because they grow fast. Sunflower plants grow quickly; they grow at a rate of about fourtenths of an inch (1 cm) per day (Hunter, 2003). See Figure 3 for an illustration of the life cycle of an angiosperm (this is not an illustration of a sunflower, but it would be the same process a sunflower cycles). The inner diagram would be appropriate to use with first graders while the exterior diagram would be for the expert teacher.



Figure 3: Life Cycle of an Angiosperm

Accessed from: http://en.wikipedia.org/wiki/File:Angiosperm_life_cycle_diagram.svg

Sunflowers are annual plants; which means that they grow from a seed each year. Their seeds are large triangle shaped with stripes. The seed will germinate if it has enough water and the temperature is right. When a germinated rootlet is sent down into the soil and a green shoot is sent upwards breaking through the seed covering. The seed covering is shed and discarded. The first leaves are called seed leaves. They contain a food store for the plant until the true leaves begin to use the sun's energy to create food. The tip of the shoot grows the most. The plant has a strong stem to support the tall plant.

As the plant grows the leaves begin to open out flat to catch the sun's rays. When the leaves are ready they will begin to produce energy using the process of photosynthesis. The energy produced is used for growing the flowers. First the flower buds are protected by strong sepals until it is fully grown.

The sunflower head has many bright yellow petals and is made up of many florets. These bright colors attract various insects. Insects are needed to crawl over the surface of the head and transport pollen from one floret to another. When the pollen is transported the flowers are pollinated and seed growth is started. Each

sunflower head holds hundreds of seeds. Each seed has the capability of growing a new sunflower the following year.

Examining Inquiry

Allowing time for students to wonder and ask questions is vital in their learning.

We live in a complex hard to understand world. Our species is naturally curious about how the world works. It is natural for us to take in information using our five senses and try to make sense out of it. However, one thing I have observed as a teacher in the upper grades is that the higher the age the student is, the less willing they are to ask or share questions. Is this because of a reduced curiosity, lack of interest in the material, or are they fearful of ignorance being compared to peers and in the eyes of the teacher?

Creating a unit that promotes inquiry allows for initial wonder or ignorance to be fostered. Stuart Firestein explains why ignorance and questions are important to the field of science in *Ignorance: How it Drives Science* . Firestein states, "Questions are more relevant than answers. Questions are bigger than answer." He explains that answers are often the end of the learning process, but "one good question can give rise to several layers of answers, can inspire decades-long searches for solutions, can generate whole new fields of inquiry, and can prompt changes in entrenching thinking." Questions can create a rippling effect of new learning. He explains that information is growing and readily accessible through the use of the internet and technology and many questions can be answered quickly, so scientists don't invest as much time in facts. They invest more time in unanswered questions. He explains that scientists, "don't stop at the facts; they begin there, right beyond the facts, where the facts run out." He later states that, "facts serve mainly to access the ignorance." ² Promoting questioning in the classroom would also promote the idea that ignorance is the first step to finding new answers.

Lesson Plans

Lesson Plan 1: Dissect a Lima Bean

Objective: Students will be able to locate and describe the three main parts of the lima bean seed.

Essential Question: Why are the three observed parts of a flowering plant's seed necessary for the seeds growth?

Materials: 2 soaked lima beans per child (soak the seeds overnight in water)

Procedure:

1. Begin an inquiry discussion by asking students what they think makes a seed grow. Have students think about how seeds work.

2. Pass out 2 seeds to each child and ask them to make observations to the seeds. Have them draw a picture of what it looks like.

3. Encourage students to investigate their seed by using a toothpick.

4. Encourage observations by handing out hand held magnifying glasses. Encourage students to observe the size, shape, number of parts, and texture. Students should make observations appropriately by drawing what they see.

5. Once all observations have been made, ask students to hypothesize what they think each part they observed might do to help the seed grow into a plant. Ask students how they might test hypotheses

6. Instruct students to hypothesize the needs of the seed in order to germinate. Ask students how they might test their hypotheses. Would the same needs be true for all seeds?

Lesson Plan 2: Garden in a Jar: Stages of Flowering Plants

Objective: Students will be able to observe and describe various stages of a flowering plant's life cycle. They will compare and contrast the growing process for small, medium, and large seeds.

Essential Question: Why is water necessary for germination? Why do small seeds start germinating quickly but are unable to grow for a long amount of time?

Materials: Large glass jar with straight sides, blotting paper, scissors, glue, clean sand, various seeds of various sizes (be sure to include sunflowers)

Procedure Day 1.

1. Promote an inquiry discussion by holding up a variety of seeds. Ask the students if they think seeds can grow without soil. Ask them what they think would happen if they are held securely and given a water source. Ask them what they think seeds will do to begin growing. Have students hypothesize which seed they think will begin growing first. Begin making a garden in a jar.

2. Cut a strip of blotting paper to fit securely inside the walls of the jar.

3. Drip small spots of glue to attach a variety of seeds to one side of the blotting paper. Arrange the seeds in a pattern with the smallest seeds in a row at the top of the paper, medium seeds in a row in the middle of the paper, and large seeds in a row at the bottom of the paper. Allow enough room for the seeds to grow. Let the glue dry.

4. Gently place the paper into the jar with the seed covered side facing the outside glass. Make sure the paper expands in the jar so that the seeds are securely pressed against the glass.

5. Pour clean dry sand into the jar to hold the blotting paper and seeds in place.

6. Pour water into the jar so that the sand is damp and there is a little visible water at the bottom of the jar.

7. Place the jar in sunlight.

Procedure: Day 3-14

1. Wait for the first sign of growth. You should notice that the inside of the jar will start to get condensation on it. Make observations about any patterns from the condensation. You might find that there is a circle of clear

glass around each of the bigger seeds. This is because they are collecting the water and absorbing it.

2. The seeds will begin to swell until a white tip from their roots comes out. The small seeds will begin to germinate faster than the large ones, but they do not grow for very long. This is because they have a small food stores. Big seeds take longer to germinate but are able to grow for a longer amount of time because they have a larger food stores.

3. Make observations about the green shoots that come out of the top. Students should notice that the plants produce two starter leaves that look different from the leaves that continue to be produced. Compare and contrast the growth of the different sized seeds.

Procedure: Day 14

1. Ask students what stages they think happen next to a flowering plant. Create an inquiry based conversation about how plants continue to grow. Have students think about where seeds come from. Read the chapter *Life Cycle of a Sunflower* from the book *The Facts about Flowering Plants* by Rebecca Hunter to learn how the final stages of plants life cycle.

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Notes

1. (Dewey, 1938)

2. (Firestein, 2012)

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