Connections

Parent Prologue

In school we were reading about plants in a book. The book had very poor pictures and the words were hardly inspiring. It was like a jumbled deck of cards, except instead of suits and numbers and royal personages, it was words, words, and more words. I could easily memorize the facts, but there was no connection with the subject. And this was astonishing to me. Exploring the plant kingdom with Lola had been anything, but boring!

Lola breathed life into the story of plants, because she knew about the work of the most influential scientist you many never have heard of, Alexander von Humboldt.

Alexander von Humboldt's desire was to observe and learn about everything in nature. Throughout his life he explored the interconnections between biology, geology, geography, and weather (and many more things, but the list would be too long). Humboldt's studies demonstrated a new concept at the time – that as we peer deeper into nature we will observe intricate underlying connections and associations. He called his model "Kosmos". Humboldt instilled in generations of scientists an appetite for exploration and adventure. He believed that to appreciate the natural world, the scientist must make the world itself a laboratory using every sense and tool available. Through his mentoring over 200 years ago, he created the Citizen Scientist movement. Correspondence with scientists all over the world, provided him with samples, data, and maps through which he was able to expand on this idea of cosmos.

This little story is called Lola and the Flower.

Lola and the Flower

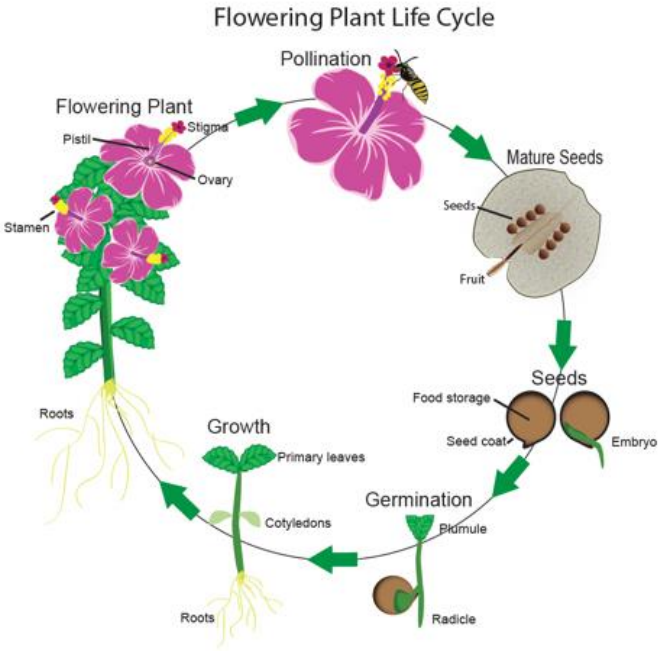
Walking home from school, I stopped by Lola's garden to admire the cactus flowers on display. I found myself wondering about the varieties of sizes, textures, fragrances and colors. Noticing my interest, Lola invited me into her "world".

I asked Lola, "These flowers are wonderful! Would you help me to learn more about them, please?" She said "why don't you pick out one plant each day. I will teach the mysteries and science of each cactus and its flowers". I was enchanted. Lola provided context for the desert flora – botanical survivors living in an environment where temperatures change from bitter cold to oven hot in the space of twelve hours.

One of the many science stories that caught my imagination was when she explained that the flowers on the cactus would become fruit. This was quite a revelation for me! I had never thought about where fruits came from before.

"Lola, where do fruits come from?" I asked.

"That is such a thoughtful question. We live in a world where we eat so many fruits, but most of us do not stop to think about where they come from. Well, fruits begin with flowers. A fruit is a seed-bearing structure in flowering plants. Plants make flowers in order to reproduce. And fruits are the way plants move their seeds from place to place", she explained.

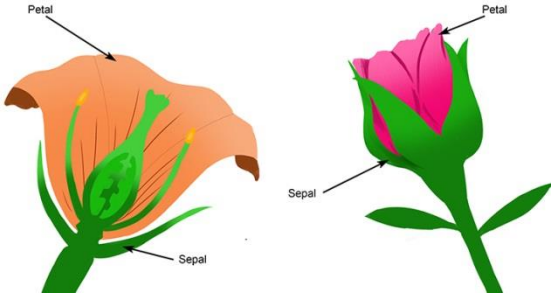


"Flowering plants have a specific life-cycle, which are the stages a living thing goes through during its lifespan", she continued. "Flowering plants begin their lives as seeds. Inside the seeds are baby plants called embryos. They have a hard seed coat that protects the seed embryo inside."

"So, are seeds alive?" I asked.

"Oh yes! Very much alive. If a seed has the proper amount of sunlight, water and nutrients, it will grow (a process called germination). The first growth will usually be the embryonic root called the radicle, and then, the embryonic stem called the hypocotyl. The seedling will continue to grow into a mature plant with leaves, roots, and eventually will make flowers. Through pollination, the flowers will produce seeds inside fruits. And when the seeds end up on the right type of soil, the cycle will begin again", she explained.

Lola carefully removed a prickly pear cactus flower and handed it to me to examine. "From the outside, a flower is very beautiful, and often has wonderful scents. Yet, if you look closely, you will notice that flowers are made of many different and mysterious parts, each of which has a specific purpose. The parts that we think of as a flower are known as the perianth, which consists of the petals and sepals. The sepal is a type of leaf and is the outermost layer of the bud. The sepal leaves protect the developing petals inside the flower bud", she continued.



"The most showy elements are the petals. They can vary in shape, size and color. Petals are really just modified leaves. Their purpose is to attract pollinators such as insects, birds, reptiles and mammals. They also protect the flower's reproductive organs."

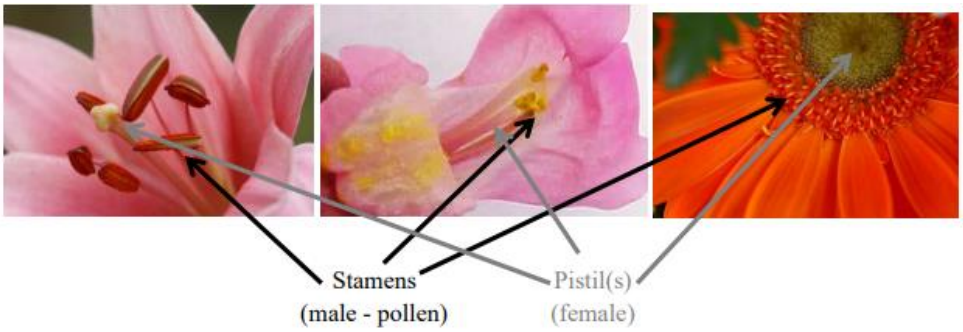
Lola encouraged me to pull the sepals and petals off, which revealed the internal structure of the flower.

"Flowers have male parts called stamens. The stamens are made of two parts, the anther and filament. The filament supports the anther and holds it up so the pollen can be spread more easily. The anthers contain plant pollen, which is the yellowish powder that pollinators carry from plant to plant. In most flowers, the anthers and its filaments are around the outside of the inner flower and surround the female parts that are in the middle", she explained.

As I carefully removed the stamens, I noticed another long stalk at the flower's center. Lola said that was the flower's female part called the pistil. The pistil is made up of the ovary at the bottom, which contains the potential seeds, or ovules; a style, arising from the ovary; and the stigma which receives the pollen.

Lola then described for me the process of pollination, which is the placement or transfer of pollen from the anther to the stigma of a different flower (cross pollination) or the same flower (self-pollination). For cross pollination to happen the pollen needs to get carried from the anther of one flower to the stigma of a different flower. Self-pollination occurs when the pollen from the anther is deposited on the stigma of the same flower.

Lola demonstrated this process by taking the pollen from the anther of one of her flowers and touched it to the pistil of another flower.



Lola told me that just like the stamen (male), the female pistil consists of various elements each with a specific function. The elements were the stigma, style and ovary.

“At the bottom of the pistil is an organ called the ovary. When the pollinator deposits the pollen into the top of a pistil (called the stigma) of a flower, the eggs or ovules, inside the ovaries are fertilized. These ovules then grow into plant seeds and the ovary becomes the fruit. Fruits smell and taste the best when they are ripe, which attracts animals. When the animal consumes the fruit, they excrete the seeds along with a little ‘manure’ so that the seed has what it needs to grow. And the process starts all over again. As you can see, a flower is much more than something beautiful to admire! Flowers have many qualities we can learn from – blooming in all kinds of environments and conditions. So always count your garden by the flowers, never by the leaves that fall”, she exclaimed.

Activity 1: Little Seed Skit

Materials:

- Poncho, Green, 1
- Flashlight, 1
- Back pack, 1
- Spray bottle, 1
- Trail mix bar, 1 ***(NUT and TREE NUT FREE – NOT for Eating!)***
- Labels: Seed Coat, Roots, Cotyledon, Leaf, Embryo

Procedures:

1. **Ask:** What does a well-prepared hiker wear to protect themselves from rain, wind, and cold? (A Coat).
2. **Explain:** Seeds also have coats for protection. Attach the seed coat label to the coat you are wearing. Explain that when conditions are right for growth the seed absorbs water, the seed coat cracks open, and the seed begins to sprout roots and leaves, or germinate. Have your child spray you with the water while you say, "I'm thirsty. I need water." Then have your child (or a sibling if possible) shine the flashlight on you while you say, "I'm cold. I need the warmth of the sun."
3. Tell your child that when a seed has the right amount of moisture and warmth, then it is ready to grow. Remove the coat and hang it so that the seed coat is clearly visible.
4. Ask: what else does a well-prepared hiker bring? (A backpack with supplies).
5. Let your child, acting as the hiker, discover the snack in the main compartment of the backpack. (This can be shared at the end of the workshop). Explain that seeds also need a supply of stored food. Our hiker's food is stored in a backpack. A seed stores its food in cotyledons. Attach the cotyledon label to the backpack. Cotyledons provide the plant with the initial energy to germinate and grow. Once the plant has established itself, the cotyledons fall off.
6. The hiker expends a lot of energy hiking and eventually gets thirsty. Ask: What else is important to bring on a hiking trip? (A water bottle). Have your child remove the water bottle from the backpack. Plants also need water and minerals to help them grow. How do the plants get the water and minerals? (Roots). Attach the root label to the straw of the water bottle.
7. Ask your child what other item is useful to have on a hiking trip, especially on bright and sunny days. (A hat). Have your child remove a hat from the backpack and place it on your head. Compare the hat to the first green leaves a seedling puts out to absorb sunlight. Attach the leaves label to the hat. The leaves use sunlight to make food for the plant. This process of making food from sunlight is unique to plants and is called photosynthesis. It would be like the hiker getting to the part of a trail where food grows all along the path, so there is no need to weigh the hiker down with backpack for food any longer. Soon the cotyledons will fall off and the plant is now able to get energy from the sun. Remove the backpack and place it next to the seed coat.
8. Explain that the leaves and roots grew from a tiny plant inside the seed called the embryo. Place an embryo label around your neck showing the connection between these two parts. Review the parts of the seed and their functions using the props.
9. **Ask**: Do you see any similarities between the hiker and real seeds?
10. Discuss meaning of "cycle" and have them arrange the labeled items in timeline order while reviewing the skit with your child.
11. Optional : redo the skit with your child (or sibling) as the seed/hiker. Changing roles and repetition will enhance the fun and help to solidify the concepts.

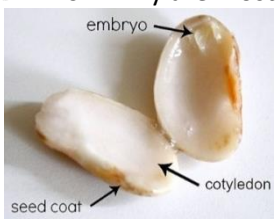
Activity 2: Lima Bean Dissection

Materials:

- Presoaked Lima Beans (24 hours soaking)
- Paper plate, 1
- Plastic knife, 1
- Magnifying glass,1
- Dry Lima beans, 1 bag
- A Seed is Sleepy, by Dianna Hutts Aston (optional)

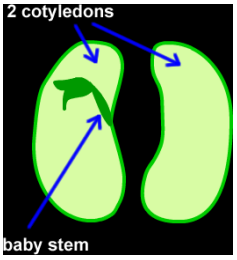
Procedures:

1. **Show the dry lima beans.**
2. **Ask:** Why are most seeds dry?



3. **Explain:** Most seeds dry out as they ripen, using a thick protective coat to keep moisture at bay. Without water, the embryo's growth slows to a near standstill, a state of arrested development that can persist for months, years, or even centuries until conditions are right for germination. In other words, seeds are living plants that have simply put development on pause, waiting until they land in just the right place, at just the right time, to send down roots and grow.
4. **Get out a pre-soaked lima bean**
5. **Engage**: You will now dissect a real seed to find and observe these different parts. Ask your child to carefully rub the seed between their fingers. What do they notice about the outside of the seed? (It has a thin moveable covering.) Carefully peel off the outer covering.
6. **Ask:** What part of the seed is this and what is its function? (It is the seed coat and it protects the seed.)
7. Inside the seed coat are large fleshy structures that form the bulk of the seed. What are these? (The cotyledons) What is their function? (They are stored food that the plant uses to get started growing.)

   The cotyledons also have two tiny ready-made leaflets, inflatable for temporary use. They are as small and insufficient as the spare tire that is not intended to take you any farther than the nearest gas station. Once expanded with sap, these barely green cotyledons start up photosynthesis like an old car on a bitter winter morning. Crudely designed, they limp the whole plant along until it can undertake the construction of a true leaf, a real leaf. Once the plant is ready for a real leaf, the temporary cotyledons wither and are shed; they look nothing like all the other leaves that the plant will grow from this point forward.

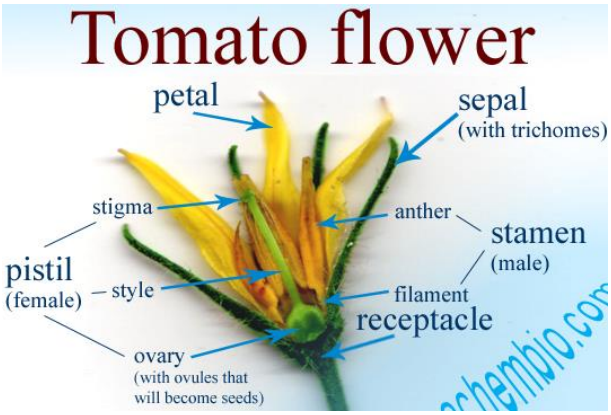


8. Carefully split these in half lengthwise. What does the student see tucked inside along the inner curve of the cotyledon? (A tiny plant or embryo, made up of the leaflets (called the hypocotyl) and root (called the radicle.)) Encourage the use of the magnifying glass if available to get a closer look.
9. **Tell:** The embryo is a collection of only a few hundred cells, but it is a working blueprint for a real plant with root and shoot already formed.
10. **Elaborate:** No risk is more terrifying than that taken by the first root. A lucky root will eventually find water, but its first job is to anchor – to anchor the embryo and forever end it traveling, however passive that traveling was. Once the first root is extended, the plant will never again enjoy the hope of relocating to a place less cold, less dry, less dangerous. Indeed, it will face frost, drought, and greedy jaws without any possibility of flight. The tiny rootlet has only one chance to guess what the future years, decades – even centuries – will bring to the patch of soil where it sits. It assesses the light and humidity of the moment, refers to its programming, and quite literally takes the plunge.
11. **Explain:** The first real leaf marks the beginning of a new orientation where attention is turned upward. As soon as a seed is anchored, its priorities shift and it directs all its energy toward stretching up. Its reserves have nearly run out and it desperately needs to capture sunlight in order to fuel the process that keeps it alive. As the tiniest plant in its habitat, it has to work harder than everything above it, all the while enduring the misery of shade.

Activity 3: Flower Dissection

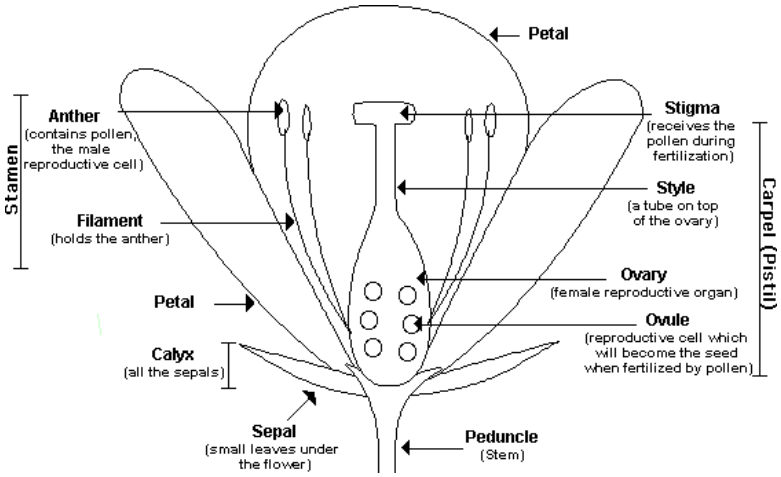
Materials:

- Day Lilies (best) or other flower such as a tomato plant flower
- Scissors
- Scotch tape
- Construction or copy paper, ½ sheet
- Pencil
- Paper towel
- Tweezers, plastic
- Magnifying glasses
- Paper plate, small
- Flower Anatomy Diagram



Procedures:

1. **Ask:** So, where does the fruit come from?
2. **Answer**: It comes from a flower!
3. **As you review the Flower Anatomy Diagram, explain:** Flowers have both male and female parts. The pistil is the female part that contains the stigma, style and ovary. The male parts are the stamens. The stamens are made of two parts, the anther and filament. The filament supports the anther and holds it up so the pollen can be spread more easily. The anther makes the pollen required for fertilization. Most flowers do not self-pollinate, but require the assistance of insects or wind to spread pollen from one flower to another. The pollen lands on the stigma and travels down the tube to join with the ovule and fertilize the plant.



4. Give your child a half sheet of construction or copy paper, scotch tape and a pencil.
5. Begin with the sepals. Then the petals. He loves me, She loves me not, She loves me, He loves me not. ☺ Line up the sepals and then all the petals on the lower level of your paper. Demonstrate how one large piece of tape can cover all sepals and hold them to the paper. Then use another piece of tape for the petals placed just above the sepals.
6. **Explain:** Flower sepals and petals are really just modified leaves.
7. The male parts are next. Gather and tape onto sheet (stamen: anther, filament) above the petals.
8. Then the female parts. (pistil: stigma, style, ovaries). Tape onto sheet above the male parts. (For younger students, you may want to have them write "boy" and "girl" next to the appropriate parts).
9. **When complete, the dissection diagram traveling from bottom to top will resemble the flower moving from outside to inside.**

Open Investigations

- If you can, harvest blossoms from outside. Demonstrate how to carefully separate and identify the different parts.

- Give your child a paper towel and one or more flowers to dissect on their own. Larger flowers with obvious pistils and stamens, such as lilies are best for younger students, and are easy to dissect by hand.
- As you dissect the flowers, spread the different parts — petals, sepals, pistil, and stamens — out on the paper towel and label them. They may need help with ID. Have students tape the parts to the paper towel to preserve them for later use.
- Use iNaturalist to help with flower identification and Google to identify hard to discern components.
- For older students, in addition to some of the traditional flowers, introduce blooms with different adaptations. For instance, begonias and squash have separate male flowers and female flowers. By dissecting both, students can see and understand the differences. You could also use hibiscus flowers, which have stamens fused onto pistils so that it looks like the two are the same structure. Try introducing something unusual, such as an oak tree flower; most students don't think about oaks and other trees as flowering plants.
- Children will need to use tweezers and a magnifying glass to get a closer look at the structures of smaller flowers.

Resources

- **'Rip Van Winkle' plants hide underground for up to 20 years:** https://www.sciencedaily.com/releases/2018/04/180419130935.htm
- **Plants 'hedge their bets' in germination: The route to better crop yields:** https://www.sciencedaily.com/releases/2018/04/180411220812.htm
- **Discovery of compounds that keep plants fresh - Controlling plant pore openings for drought tolerance and delay in leaf withering:** https://www.sciencedaily.com/releases/2018/04/180409103942.htm
- **Plant Structure:** http://www.bozemanscience.com/plant-structure/
- **The First Flower:** https://www.youtube.com/watch?v=f7ztefVrFnU
- **The Origins of Flowers:** https://www.youtube.com/watch?v=POv-TPX7REw
- **Botany – A Blooming History Confusion of Names:** https://www.youtube.com/watch?v=cVDpdmlpZKw
  What flowers Looked Like 100 Million Years Ago: http://www.geologypage.com/2017/08/flowers-looked-like-100-million-years-ago.html#ixzz5aje0LHVa

Vocabulary

- **Anther**: Pollen box in which pollen grains are formed containing the genetic material which produces sperm (pollen)
- **Filament**: Supports the anther
- **Germination**: The process by which a plant grows from a seed
- **Hypocotyl:** The embryonic stem called the hypocotyl
- **Ovary**: Enlarged part of the pistil attached to the receptacle (stem tip on which the flower rests) and contains the ovules
- **Ovules**: Small white structures within the walls of the ovary which produce the plant egg cells
- **Petals**: Colored parts inside the sepals which attract insects
- **Pistil**: Female reproductive organ which consists of three parts
- **Radicle:** The embryonic root of the plant
- **Sepals:** Structures which are usually green outside the petals which help to protect the flower bud
- **Stamen**: Forms the male reproductive organ and consists of an anther and a filament
- **Stigma**: Found at the top of the pistil, is often sticky and hairy adapting it to catch and hold pollen
- **Style**: Tube-like connection between the stigma and the ovary

Graphics Resources