

Lola and the Moth

Parent Prologue

It is often said that "it takes a community to raise a child." How do we measure ourselves as a society? Perhaps like you, I believe we are measured by how we treat the most vulnerable and voiceless when we are in crisis.

Mr. Rogers once said "Look for the helpers", and truly, we have seen so many people in our community step up to help one another, and not without great cost to themselves. Doctors, nurses, delivery persons, grocery store clerks, teachers, truck drivers, nonprofit volunteers, etc. have sacrificed to be helpers during this perfect storm. Together, we can do this!

This little story is about how a "helper" reached out to me during one of the most difficult and lonely times in my life. This is the story of Lola and the moth.

Noticing Moths

One day when I was walking home from school, I stopped to admire a beautiful cactus garden. Tending the garden was what seemed to me to be a very old lady (who actually was probably as old as I am now) named Lola. I found myself admiring the gardens' amazing flora: plants with leaves shaped like beaver tails; plants with their "stems" uplifted as if praying to heaven; and plants that looked like barrels.

Lola noticed my interest and asked if I would like learn more about her garden.

"Oh, yes, please!" I exclaimed.

When I think about that moment, even today – 50 years later - my heart races. She was giving me the gift of herself – her time, and her talent.

Lola introduced me to the skill of "noticing" things. She said that to understand nature, one had to learn to be peaceful. I wouldn't have to run around chasing nature, because the qualities of patience, external silence and internal quietness would attract nature to me. To learn from nature, it was critical to just "be" there and not "do" anything.

She invited me sit on one of her lawn chairs. As we quietly watched the sunset, with its golden-orange hues kissing our cheeks, I "noticed" a hummingbird hovering around the cacti. I wondered out loud, "Why would a hummingbird be interested in a cactus garden?"

Lola responded: "What is it buzzing near?"

This question, opened my eyes! I was surprised to see the flowers on the cacti. I hadn't "seen" these when I first entered the garden.

Lola helped me understand that nature is slowly revealed to us. As we adjust our perspective, our eyes start to appreciate different things.

Lola then asked me: "Are you sure it's a hummingbird?"

I was astounded! Of course it was a hummingbird! It had the movements, coloring and a beak that was the classic identification of "hummingbird" except, as I looked at this bundle of energetic movement, I saw that there were four wings to this bird. It wasn't a hummingbird...it was a moth!

"This is a Hummingbird Sphinx Moth. It looks like a hummingbird because it is trying to protect itself from predators. Beauty can trick us. As beautiful as hummingbirds look, they are quite fierce. When threatened they will do a "pendulum" dive straight at you, and believe me, it is enough to make anything think twice about eating it!" Lola said.

Lola was describing “mimicry”, a type of camouflage used by organisms to mimic the look or actions of another organism or object that is dangerous, threatening or poisonous.

Lola encouraged me to carefully watch the moth’s patterns. Which cactus blossoms were most interesting to the moth?

I pointed to a plant that had large circular shaped white flowers. The plant looked a lot like a waterlily. Lola informed me that this was an extraordinary orchid cactus, called Queen-of-the-night cactus. The Queen-of-the-Night cactus blooms between dusk and dawn. In other words, it is a nocturnal flowering species! Lola said the Queen seems to follow the phases of the Moon, opening up its buds completely only during the full moon. The flowers are white so that they reflect the moonlight to attract hummingbird sphinx moths and bats.

I was enchanted! And sure enough, there was the full moon.

Connections, she said, is what I would see when I was quiet. “Quiet is where we hear our soul, and where our soul hears the heartbeat of the Earth.”

Now I was completely hooked. I wanted to learn more about moths, ALL moths. Lola proposed we do an experiment together.

“The Queen-of-the-night Orchid cactus attracts the moth by using the light reflected from the moon. What other sources of light would attract a moth?” she asked.

“I’ve seen lots of bugs around porch lights”, I said.

“Porch lights do attract insects, but the light bulb can get hot and fixture is too high for us to reach”, she said, “But what if we mimicked the moon in a different way?” she asked.

“Let’s make a really big white “flower” that reflects the light from a different “moon””, she proposed, “Let’s cover a flashlight with a white sheet and see if our “flower” will entice our mothy friends”.

We agreed to meet the next day at dusk. After setting up our equipment, we patiently waited. Lola reminded me – “In silence nature comes to us”.

As we went from dusk to evening, we began to observe more and more insects coming to our “flower”...moths, June bugs, Japanese beetles, crickets, grasshoppers, flies and more!

By watching nature, we were able to design an experiment that helped us to see the hidden. Before we did our experiment, these insects were invisible to me. Most of nature is too fast or too slow; too big or too small; too stealthy or too shy to be seen directly. We had to design an experiment that would visualize the invisible. After all, these insects were designed precisely to be hidden from predators!

This kind hearted woman transformed my life. During one of the loneliest times I can remember, Lola taught me peace. In solitude, she showed me a path to joy. But I needed to stop, rest and wait for nature to come to me.

Let’s Mimic the Moon

Materials:

- Flashlight
- White Sheet
- Notebook
- Pen
- Comfy chairs

- Cell phone
- Hot chocolate to drink while waiting for the moths 😊

Procedures:

1. **Explain:** Let's do Lola's experiment and see the kinds and numbers of moths that come to our yard at night!
2. Turn the flashlight on and place a sheet over it.
3. Sit on the chairs together quietly. Remember, nature comes to you when you're quiet and peaceful. Drinking hot chocolate helps to keep one silent and patient.
4. **Tell:** While drinking the hot chocolate, I would like you to imagine you're a moth.
5. **Ask:** Have you ever noticed that butterflies and moths are opening and closing their wings even when they are standing still?
6. **Explain:** Well, the wings of these creatures act like our heart! They are pumping the moth's blood throughout their body, moving oxygen and carbon dioxide just like your heart does!
7. **Engage:** While you're waiting for the moths, let's put our hands together to look like moth wings. Next, open and close them as you quietly breathe in and breathe out.. Let's do this for a couple of minutes.
8. Once you start noticing the moths and other insects, record a description of the visitor and the date and time when they show up.
9. If you can get close enough, you might be able to take pictures of the moths and insects.
10. While looking at the pictures, ask:
 - When you imagine a moth, what do you picture?
 - Why do moths have thick furry bodies and butterflies don't?
 - Why do some moths have long tails?
11. **Quietly explain:** When you look at a moth, you are seeing the results of an arms race that's been escalating in our skies for about 65 million years! The dinosaurs died off 65 million years ago. With that competition gone, mammals experienced a rapid evolution to fill the niches left behind. That's when bats evolved and they started using their sophisticated echolocation system, a sonar system, to locate their food, moths. It was a rough time for insects. And so begins the evolutionary "arms race". Insect evolution countered these predators with numerous elaborate strategies, including aerial acrobatics, sonar jamming and sonic decoys.

Moths have thick fur that works as a kind of acoustic camouflage by absorbing nearby sounds. The fur guards against bats which are a primary predator of moths and which use echolocation to hunt.

Another tool in this arms race is the moth's scales. Moths absorb the sounds of sonar using the exquisite architecture of tiny, leaf-shaped scales that decorate their wings. For example, the thick fur on the cabbage tree emperor moth's body makes for a perfect sound absorber, but to achieve the same thing on the wing, it would need 3 millimeters of fur, which would be too heavy for flight. The moths, however, have developed the perfect solution to this problem by evolving elaborate scales on their wings that act as a "resonant sound absorber." These scales are much less bulky than a traditional sound absorber. The scales have moveable surfaces, so when a bat's ultrasonic waves hit them, the surfaces will resonate, absorbing the sound energy and converting it into kinetic energy. Scientists discovered three resonant frequencies in the moth's wings that matched the entire frequency range that bats use for echolocation.

One more development in the arm's race was the evolution of ears. Moths can hear the sonar signals and evade the bats. The next step was a group of moths called the Tiger moths. These animals evolved devices called timbal organs, and they're sound producing. The timbal organ has a little blister of cuticle and muscles associated with it. When they flex the muscles, it buckles inward producing a series of clicks, and when they relax the muscle the muscle, it produces a second series of clicks. This is the sound that they beam back at the bat. But wait...there's more! And it's much more exciting! With this clicking ability, moths can actually jam the sonar of a bat!

Explain. Bats beam out a high frequency sound and then listen very carefully for the echo. From the timing of the echo the bat can determine the distance to the moth. Now imagine a moth inserts a series of clicks. Those clicks arrive at inopportune moments and the bat can't determine which sound is in fact the echo. Bats have a great deal of difficulty locating the moths and catching them!

Elaborate: In addition to these strategies, the moths have other tricks they use. The long elaborate tails on the hindwings (lower parts of the wings) of some silk moths can help them defend against bats. When these tails spin, they can deflect bat sonar signals, creating sensory illusions that divert bats away from the moths' bodies. So when bats swoop in for the kill, they often strike the expendable tails instead. Scientists have found that as hindwing size and tail length grew, moths were increasingly better at escaping bats.

12. **Ask:** Have you ever wondered why moth's make cocoons? Cocoons appearance and texture is very different from a butterfly's chrysalis, isn't it?
13. **Engage:** Let's try to put this together with what we know about moth adaptations to bats. We learned that bats use sonar to find moths, correct? Do you think bats might use the same sonar for finding juicy cocoons?
14. **Explain:** In fact, they do! The silk on the cocoon is sound absorbent. What does that mean? Sound absorption is different from sound blocking. A moth's furry surface isn't blocking sounds rather it is absorbing the sound. Here is an analogy that will help you to see the difference. Imagine you are building an aquarium. You want to keep the water in, right? I know I do at least. 😊
15. **Ask:** What do you think will be the more effective, glass panels and seals or pillows and sponges?
16. **Elaborate:** Sound acts very similar to water when you are trying to control it. If you used sponges as the walls, they would fill with water and let all of it through to the other side. Now if, instead, you used thick glass and good seals, that would keep the water in place. Acoustical materials made from soft, squishy things like sponges are going to absorb. Dense, heavy, air-tight glass will block. That is the basics right there. Materials that are designed and intended to absorb an echo are soft, light, and fluffy. Materials that are designed to block sound are dense and heavy. An example of a sound blocking is freeway walls (which keep the sound from getting through to neighborhoods) while the trees on the freeway absorb the sound. In our case, moths are trying to keep the sound from bouncing back to the bat, so they are designed for sound absorption.
17. **Tell:** Let's revisit the idea of sound camouflage! Here is a special video to watch.
18. **Play Video of Moth Jamming Bat:** https://www.youtube.com/watch?v=GZxK_00SoFk
19. **Ask:** Do you see how the moth can use sound to disturb the bat clicks?

Open Ended Investigation

20. You might also want to restrict the amount of time for the counting.
21. Do your field work over several nights and see if the number and types of moths (and other critters!) changes.

Moth Sound Adaptations

Materials:

- Pony beads (optional)
- Moth cutout (last page of this lesson, after vocabulary section)
- Construction paper of assorted colors
- Markers, crayons or colored pencils
- Elmer's glue
- Scissors
- Paper plate, small, 1
- Q-tip, 1
- Glue stick, 1
- Toilet paper tube

- Cotton balls
- Corrugated card board
- Cloth
- Shiny paper

Procedures:

1. **Explain:** Today you will observe firsthand what it is like to be the prey and what a moth must do to blend in and make himself or herself less noticeable.
2. **Engage:** You will be selecting a habitat and designing moth with appropriate colors and texture to blend into that habitat. Remember you need to think like a moth! Be sure to use the materials that will absorb sound.
3. **Encourage:** You can also camouflage your moth by using colors and patterns. The habitat of your moth could be your bed quilt. The moth would be designed to “hide” in those colors and patterns. You can also make a moth that mimics a scary predator! A wonderful example is the Atlas Moth. Show your child the Atlas Moth Photo below.



Cobra-like design on wingtips

4. **Ask:** Did you know the Atlas moth even moves like a snake?
5. **Explain:** When threatened, the moth will drop to the floor and writhe around, slowing flapping its wings to imitate snake head and neck movements and scare away predators. Show Atlas Moth Video on your phone:

YouTube Link Showing Atlas Moth movements: <https://www.youtube.com/watch?v=9r9Laslf4hc>

6. **Ask:**
 - Since they can't hide, how might they protect themselves from predators? What are some of the advantages and disadvantages of camouflage compared to advertising or warning coloration or mimicry?
 - What materials did you choose and why?
7. **Also, let your child know that the survival adaptations they choose cannot be man-made devices! i.e. no robots, guns, etc.**
8. Once their insect is completed, they should share the story of their animal with you.

Resources

- Carter, David. 1992. **Butterflies and Moths (Eyewitness Handbooks)**. Dorling Kindersley, Inc., New York.
- Covell, C. V., Jr. 1984. **A Field Guide to the Moths of Eastern North America**. Houghton Mifflin, Boston.
- Hodges, R. W. 1971. **The Moths of America North of Mexico. Fascicle 21: Sphingioidea**. Curwen Press, London.

- **200-million-year-old Insect Color Revealed by Fossil Scales:** <https://knowridge.com/2018/04/200-million-year-old-insect-color-revealed-by-fossil-scales/>
- **How Long Wings Help Huge Moths Evade Bat Attacks:** <https://www.nationalgeographic.com/animals/2018/07/moth-tail-evolution-bat-echolocation-sensory-illusion/>
- **Luna Moth's Tails Fool Bat Sonar:** <https://www.sciencemag.org/news/2015/02/luna-moth-s-tails-fool-bat-sonar>
- **Go Mothing:** <https://www.sciencefriday.com/educational-resources/observe-moths/>
- **This Caterpillar Mimics a Snake When Frightened:** <https://www.facebook.com/9gag/videos/vb.21785951839/10156369195026840/?type=2&theater>
- **Seeking Clues to Natural Selection in Butterfly Wings:** https://www.bu.edu/research/articles/natural-selection-in-butterfly-wings/?utm_source=facebook&utm_medium=link&utm_campaign=social_burst
- **Deaf Moths Use Acoustic Camouflage to Escape Bats:** <https://www.zmescience.com/science/deaf-moths-use-acoustic-camouflage-to-escape-bats/>
- **YouTube Link Showing Atlas Moth movements:** <https://www.youtube.com/watch?v=9r9Laslf4hc>
- **Striking Macro Photos Reveal Incredible Scale-Like Patterns of Butterfly Wings:** <https://mymodernmet.com/macro-photography-butterfly-wings-chris-perani/>
- **The Surprising Story of the Color in a Butterfly's Wing:** <https://baynature.org/article/the-surprising-story-of-the-color-in-a-butterflys-wing/>
- **Sound-Absorbent Wings and Fur Help Some Moths Evade Bats:** https://www.sciencenews.org/article/sound-absorbent-wings-and-fur-help-some-moths-evade-bats?fbclid=IwAR39yROYePmG_3WDDaF6P6dXQ3SCHB_T6fY17trmIPfYq3kCI89rn6zMNFo
- **What is this Moth that's almost as big as a Hummingbird?** <https://baynature.org/article/what-is-this-moth-thats-almost-as-big-as-a-hummingbird/?fbclid=IwAR37695kkWat7LXeckX07NcwkDVLoRfJ6Q35JMgdkffN8Kqo959VFDLk-uA>
- **An Example of Rapid Adaptation – The Peppered Moths:** <https://study.com/academy/lesson/artificial-selection-and-evolution-the-peppered-moths.html>
- **Maria Sibylla Merian - Naturalist, Etymologist and Botanical Artist who was the first to record metamorphosis:** <https://www.botanicalartandartists.com/about-maria-sibyllamerian.html>
- **Luna Moth Living Care Information:** <https://www.carolina.com/teacher-resources/Interactive/living-organism-care-guide-saturniid-moths/tr10541.tr>
- **Sound Familiar – The Insect Ear That Works Like Your Own:** <http://theconversation.com/sound-familiar-the-insect-ear-that-works-like-your-own-10794>
- **Awesome Ears:** <https://www.scientificamerican.com/article/awesome-ears-the-weird-world-of-insect-hearing/#targetText=In%20mosquitoes%20and%20fruit%20flies,others%20by%20fluid%2Dfilled%20ones.&targetText=Insect%20ears%20come%20in%20many%20forms>
- **How Do Insects Hear:** <https://www.thenakedscientists.com/articles/interviews/how-do-insects-hear>
- **Insects are Helping Us to Develop the Future of Hearing Aids:** <https://theconversation.com/insects-are-helping-us-develop-the-future-of-hearing-aids-64619>
- **YouTube Link Showing Atlas Moth movements:** <https://www.youtube.com/watch?v=9r9Laslf4hc>
- **How a Moth Went Dark to the Dark Side:** <https://www.sciencenewsforstudents.org/article/how-moth-went-dark-side>
- **Moths in Cities Don't Flock to Bright Lights:** <https://www.scientificamerican.com/article/moths-in-cities-don-t-flock-to-bright-lights/>
- **Nocturnally Migrating Insects Use Earth's Magnetic Field to Navigate:** <http://www.sci-news.com/biology/migrating-bogong-moths-earths-magnetic-field-06124.html>
- **Moth Tongues, Orchids and Darwin – The Predictive Power of Evolution:** <https://www.theguardian.com/science/lost-worlds/2013/oct/02/moth-tongues-orchids-darwin-evolution>
- **Moths Can Escape Bats by Jamming Sonar:** <https://www.sciencefriday.com/videos/moths-can-escape-bats-by-jamming-sonar-2/>
- <https://www.education.com/science-fair/article/moth-light-color-preference/>
- https://www.sciencebuddies.org/science-fair-projects/project-ideas/Zoo_p059/zoology/moths-attracted-colored-light
- <https://myisngollner.weebly.com/moth-lab.html>

- <https://store.lab-aids.com/kits-and-modules/details/natural-selection-experiment>
- <https://www.sciencefriday.com/educational-resources/observe-moths/>
- **Songs of Insects:** <http://songsofinsects.com/thumbnaill-guide-to-species>
- **Butterflies that Hear with Their Wings:** <https://www.theatlantic.com/science/archive/2018/10/butterflies-hear-their-wings/573193/>
- **The Unexpected Ways Butterflies and Moths Hear:** <http://www.bbc.com/earth/story/20160217-the-unexpected-ways-butterflies-hear>
- **Hearing in Insects:** <https://www.annualreviews.org/doi/full/10.1146/annurev-ento-010715-023631>

Vocabulary

- **Acoustics:** Studying sound and controlling how sound is produced, transmitted and received
- **Adaptation:** A trait or characteristic that helps a plant or animal survive in its habitat
- **Aposematism:** A family of antipredator adaptations in which a warning signal is associated with the unprofitability of a prey item to potential predators
- **Biodiversity:** The variety and complexity of life on Earth.
- **Camouflage:** Structural adaptation that enables species to blend with their surroundings; allows a species to avoid detection by predators
- **Competition:** Living things striving for food, living space, mates, and other resources.
- **Crypsis:** The ability of an animal to avoid observation or detection by other animals
- **Echolocation:** The location of objects by reflected sound, in particular that used by animals such as dolphins and bats
- **Evolution:** The process whereby new species arise from earlier species by accumulated changes. Often referred to as “descent with modification”
- **Fitness:** The ability of a living thing to survive and reproduce in its environment
- **Mimicry:** Structural adaptation that enables one species to resemble another species; may provide protection from predators or other advantages
- **Natural Selection:** The process by which individuals in a population inherit genes that allow them to survive and be reproductively successful
- **Transposable Element:** Also known as a “jumping gene” or transposon. This is a sequence of DNA that moves — or jumps — from one part of the genome to another. Such jumps can cause mutations or alter the size of a genome
- **Variation:** Differences in individual living things from each other

