COLLEGE OF SOCIAL & BEHAVIORAL SCIENCES
Women in Science & Engineering

Bio/Diversity Project
Lesson Title: Introduction to Sonoran Desert Pollinators

Teacher: Jennifer Luna and Dianna Sandoval
Grade Level: *9th*
Time: *45 minutes*

Adapted from: Sonoran Desert Pollinators - UA Intern-Developed Lesson Plan and Pollinators Journey

AZ State Science Standard:	HS.L4U1.27 • Obtain, evaluate, and communicate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity
Content Objective: Math, Reading, Science, Writing, Other:	• Students will be able to identify pollinator species in the Sonoran Desert. • Students will be able to explain how pollination occurs. • Students will be able to explain the symbiotic relationship between pollinators and plants.
Language Objective: (Optional)	"N/A"
Scientist of the Week:	• *Wangari Maathai (1940 -2011)* • *First African American Nobel Peace Prize Winner* • *Founder of the "Green Belt Movement"* • *Ph.D,*

Vocabulary	**Materials**
• Pollination • Pollinator Syndromes • Biodiversity	• Plain construction paper (30) • Colored pencils (enough for 30 students to have at least one) • Cheeto puffs (red and orange) • Bowls to contain Cheetos • Sonoran Desert Flower specimens • PowerPoint presentation • Index cards (30) • Popsicle sticks (35)

Seasonality:

Monsoons July-Sept.	*Autumn* Oct.-Nov.	*Winter* Dec.- Feb.	*Spring* Mar.-Apr.	*Dry Summer* May-June

Guiding Questions:
- What are the different reproduction methods used by flowering and non-flowering plants?
- What biological tool is used by plants to make seeds and aid in reproduction?
- What are pollinator syndromes?

Engagement/Introductory Activity:

Introduction:

- Introducing ourselves (Name/Major)
- Have students take 1 minutes to write down every pollinator they can think of.
- Ask for volunteers to share pollinators from their list
    - As students give you different answers propose the question "would you see this pollinator in the Sonoran Desert?"
- Kahoot game (~ 10 min)
    - https://create.kahoot.it/share/intro-to-pollinators/94c367a8-f183-4c35-92d2-d1d32604b3b9
- Review pollination with students
    - Pollination is the act of transferring pollen grains from the male anther of a flower to the female stigma. The goal of every living organism, including plants, is to create offspring for the next generation. One of the ways that plants can produce offspring is by making seeds. Seeds contain the genetic information to produce a new plant.
    - Seeds can only be produced when pollen is transferred between flowers of the same species. A species is defined a population of individuals capable of interbreeding freely with one another but because of geographic, reproductive, or other barriers, they do not interbreed with members of other species.
    - Flowers are the tools that plants use to make their seeds.
- Explain that flowering plants are much more common than non-flowering plants. Many people believe that the success of flowering plants is due in large part to the flower's close relationship with animals in pollination.
    - Many flowering plants depend on animals to reproduce. In the process, animals pollinate the flowers, bringing their reproductive cells from one plant to another of the same species.

Exploratory Activity:

- Briefly explain to students how pollen sticks to the bodies of pollinators and is then transferred to plants.
    - When an insect lands on a flower to feed, pollen grains stick to its body. As the insect moves to another flower of the same species, these pollen grains are transferred to the flower's stigma and pollination occurs
        - For example, while a worker bee visits a flower gathering nectar, pollen from the anther often sticks to her hairy body. Because the bee generally visits a number of the same type of flower in a patch, she will rub some of the pollen off onto the stigma of another flower and complete pollination. Some flowers such as orchids have elaborate mechanisms to make sure bees are dusted with pollen when they visit.
- Students will partake in a demonstration that outlines how pollinators are vital to an ecosystem: this will be done through the Cheeto Game
- Cheeto Game Instructions
    - Cheetos will be used to help students understand the pollination process
    - Have each student draw a flower on construction paper and lay it on his or her desk.
    - Next, have them eat Cheetos without licking their fingers.
        - They want to collect as much Cheetos dust on their fingers as possible!
        - Tell the students that this represents collecting pollen from their flowers.
    - Next, have them" fly" to another flower in the room and rub their fingers on their peer's flower.
        - Then, have them fly back to their seats.
    - Ask the students to examine their flowers at their desk

Explain:

- Ask the students the following questions:
  - "If your flower was only red raise your hand"/ 'If your flower was only orange raise your hand"/ "If your flower had both colors"
  - Did all the flowers get pollinated? Is that how it would work in nature?
  - What will happen to the flowers that did not?
  - Were you selective with which flowers you chose to pollinate, or was this decision made at random?
  - What could be potential issues of a flower that has two different kinds of pollen? (reproduction)
- Explain to students that some flowers rely on wind to carry pollen grains, while others use water.
  - Animal pollinators, however, give plants an advantage as may deliver pollen directly to the flower. While collecting nectar from the base of a flower, pollinators like bees brush against pollen from the flower's anther.
  - Some of that pollen reaches the female reproductive parts while the bee feeds. For other animals, the exact way they collect and deliver the pollen is different (hummingbirds sometimes collect pollen on their heads!), but the function is the same.

Extension Activity/Questions:

- Interns will hold up wild Sonoran Desert flower specimens of all different kinds for the class to see
  - Have flower specimens of different colors, shapes and sizes
- Think, Pair, Share
  - Students will take 3 minutes to write down which flower is their favorite and why.
  - Students will then take another 3 minutes to share with a partner what they have written down
  - Student pairs will then be asked to share how their answer differed from their partner and why this might be.
- Interns will then explain that Plants and pollinators have co-evolved physical characteristics that make them more likely to interact successfully.
  - The plants benefit from attracting a particular type of pollinator to its flower, ensuring that its pollen will be carried to another flower of the same species and hopefully resulting in successful reproduction.
  - The pollinator benefits from its adaptation to a particular flower type by ensuring that it will be able to find and access important food resources - nectar and pollen. Such relationships are considered mutualistic.
- Interns will then explain the attributes of certain flowers that make them attractive to various pollinator species.
  - Display the following chart on the board: https://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/syndromes.shtml
- Students will then be asked which pollinator species would be attracted to each of the flower specimens they have been given and why.
  - For example, because a butterfly has a long, slender mouth part (proboscis), they prefer flowers that are long and tube-like.
  - Some flies, on the other hand, have short, round mouth parts much like a sponge.
- The concept of pollinators preferring some plants over others is known as Pollinator Syndromes. Just like we have symptoms or characteristics which are specific to a syndrome or illness, pollinators have characteristics that are specific to their preferred plants.

Evaluation Activity:

- Based on what they have just learned ask students to identify what a pollinator is and if the ones they originally wrote down matched those in the Kahoot and if they would see them in the Sonoran Desert.

- Ask students to write their answer on an index card with their name and hand it to you as an exit ticket.

COLLEGE OF SOCIAL & BEHAVIORAL SCIENCES
Women in Science & Engineering

Bio/Diversity Project
Lesson Title: Basic Plant Anatomy/ Morphology and Classification

Teacher: Jennifer Luna and Dianna Sandoval
Grade Level: *9th*
Time: *45 minutes*
Adapted from: National Agricultural Literacy Curriculum Matrix (2013)

AZ State Science Standard:	*Essential HS.L1U1.20* *Ask questions and/or make predictions based on observations and evidence to demonstrate how cellular organization, structure, and function allow organisms to maintain homeostasis.*
Content Objective: Math, Reading, Science, Writing, Other:	For example: ● *Students will be able to identify basic parts of the morphology of flowering plants* ● *Students will be able to describe the function of the basic anatomy within and on the outer parts of the flower*
Language Objective: (Optional)	N/A
Scientist of the Week:	● *Valerie Madera-Garcia* ● *PhD in Epidemiology* ● *Originally from Puerto Rico, now works/ lives in Tucson, Arizona* ○ *MEZCOPH at the University of Arizona* ● *She is writing her dissertation based on environmental factors that influence the transmission of vector-borne diseases in Puerto Rico.*

Vocabulary	Materials
● Anther ● Characteristic ● Dichotomous Key ● Pedal ● Pollination ● Plant Morphology	● Microscopes (3-4) (at least 3) ● Microscope slides (20) ● Clear nail polish (1OR 2) ● Clear tape ● Printout of Chart (20 copies) ○ AnatomyChart ● Printout of worksheets (41 copies) ○ Plants_Parts and Functions ○ Plants_Parts and Functions Lab ● Two different flower species ○ Students will use the leaves of the two different flower species (it is key they're different leafs), but will also use the flowers to dissect ○ Flowers should have basic morphology and anatomy visible.

Seasonality:

Monsoons July-Sept.	*Autumn* Oct.-Nov.	*Winter* Dec.- Feb.	*Spring* Mar.-Apr.	*Dry Summer* May-June

Guiding Questions:
- Why do some plants have different morphologies?
- What have some pollinators developed anatomically to have an advantage in the collection of nectar?

Engagement/Introductory Activity:
- Bellwork:
  - Write on a flash card
    - "What is the name for a butterfly's tongue"
    - "What do they use their tongue for?"
    - "How does their tongue help with pollination?"
- Scientist of the week
- Kahoot game (~ 10 min)- includes a review of last week (5 questions) and introduces the new topic (5 new questions)
  - Link: https://create.kahoot.it/details/review-basic-plant-anatomy/2d20115e-aea5-4c57-9dfb-b510c1ea115a
- Review plant anatomy with students
  - Plants have co-evolved physical characteristics that make them more likely to interact successfully. These characteristics are developed to attract specific pollinators.
    - For example, butterflies have a long tongue called **proboscis** which allows them to get nectar from plants that have developed long tubed shapes. Bees on the other hand would not be able to get the nectar in these types of flowers. This can be attributed to a sense of **competition** within the flowers and pollinators. Nectar is limited in each flower so if a bee has eaten all the nectar then the other pollinators won't go to the flower and some might be left with nothing to eat. So, butterflies have an advantage to be able to go to flowers that have long tubes and get the nectar bees won't be able to get.
    - This kind of development of physical characteristics flowers have developed are called **Pollinator syndromes**.
  - Watch 16 second video of how butterflies use their **proboscis**
    - Link:https://gofflebrookfarms.com/how-do-butterflies-pollinate-plants/

Exploratory Activity:
- Review plant anatomy with students
  - Last class we discussed a little about plant anatomy and morphology
    - "What's the difference between anatomy and morphology"
- Plant Anatomy: The study of the internal strructure of plants especially at the microscopic level.
- Plant Morphology: The study of the physical form and the external structure of the plant.
  - Each student will get a flower and 2 leafs (one leaf from one kind of flower and the other from another kind of flower).
    - "What kind of pollinator syndromes does your flower have?"
    - "What pollinator would be attracted to this flower?"
  - With the flower students will dissect it and put each part of the flower into the corresponding boxes (AnatomyChart document)
  - With the two leafs students will prepare slides to look under the microscopes (**Looking for Stomata Part one of the lab handout)**

- There will already be a premade slide just in case there's don't work
- Step 1: while students are working on putting the flower parts on the chart we will walk around with clear nail polish and paint the underside of the two different leaves.
- Step 2: let them dry
- Step 3: have the students place a clear piece of tape on the leaf and them slowly remove it
- After they remove it place on a microscope slide
- Look at it under the microscope
- There will likely be 4 microscopes
- there will be 2 pre made slides of each leaf so if they have trouble they can still look at it
- In groups they will practice placing theirs under the microscope and looking at it
- In the lab document they will draw the two different kinds of leaves and describe some differences
- **Part two of lab handout**
  - Students will see the chloroplasts on the screen and draw and note any similarities and/ or differences.

Explain:

- Ask the students the following questions: (pass out sheet of paper/ ask them to pull one out)
  - What is the purpose of the anther?
  - Why is the style important and essential to the reproduction of seeds?
  - Why is it important to know the anatomy of the plant to understand its functions?
  - What did you learn from the microscope activity that will be useful for the rest of the semester?
- Explain to the students
  - Questions on the lab:
    - let them know that some biology terms they will encounter if they decide to further their education in science
    - Short definition of chloroplast and photosynthesis:
- Chloroplast: organelles that conduct photosynthesis
- Photosynthesis: process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water.
    - Explain why these processes are important and how everything ties together.

Extension Activity/Questions:

- * Interns will then explain the attributes of certain flowers that make them attractive to various pollinator species.
  - Display the following chart (pass out copies of chart): https://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/syndromes.shtml
- Students will then be asked which pollinator species would be attracted to each of the flower specimens they have been given and why.

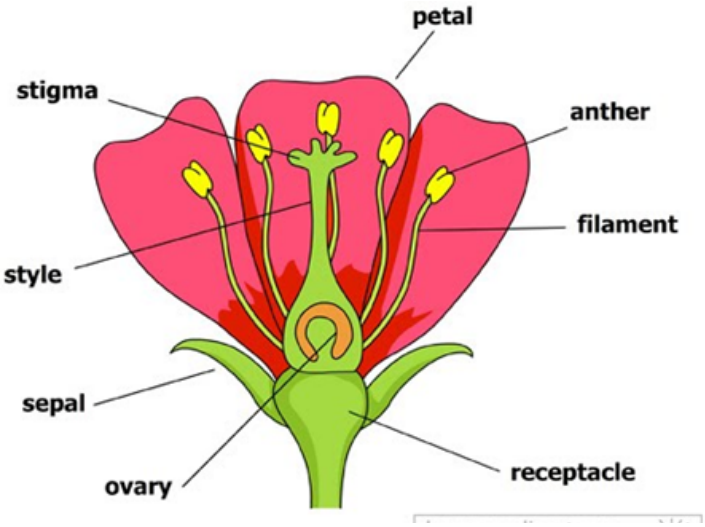
  - For example, because a butterfly has a long, slender mouth part (proboscis), they prefer flowers that are long and tube-like.

  - Some flies, on the other hand, have short, round mouthparts much like a sponge.

adapt this from last weeks since we didn't get to it and it is still relevant to this weeks

Evaluation Activity:

- Based on what they have just learned, ask students to identify 2 parts of a plant's anatomy and describe what that part does for the flower. Display the following picture:
- KEY:

- 

  - Answers: Can vary
- Ask students to write their answer on an index card with their name and hand it to you as an exit ticket.

COLLEGE OF SOCIAL & BEHAVIORAL SCIENCES
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Bio/Diversity Project
Lesson Title: Specific Pollinators: Butterflies, Moths and Bees

Teacher: Jennifer Luna and Dianna Sandoval
Grade Level: *9th*
Time: *45 minutes*

Mario J. Molina

AZ State Science Standard:	*HS.L2U1.19* • **Develop and use models** that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.
Content Objective: Math, Reading, Science, Writing, Other:	• Students will be able to identify key structures that distinguish butterflies and moths. • Students will be able to identify how this affects both butterflies and moths methods of pollination. • Students will be able to identify different qualities of desert bee species and how alike and different some of them are.
Language Objective: (Optional)	N/A

Scientist of the Week:	*Mario J. Molina*
	• His current work is related to air quality and global change issues.
	• *He is currently living in both San Diego and Mexico City, where he has created a new center for strategic studies in energy and environment.*
	• *Facts:*
	  ○ *Him and his team have succeeded in improving air quality significantly; however, he did mention that there's still much work to get done.*
	  ○ *He is in a research group in San Diego and is investigating the chemical properties of atmospheric particles*
	  ▪ *He claims that his goal is to better understand the effect of these particles on the clouds and the climate.*

Vocabulary	Materials

• Migration
• Habitat
• Ecosystem
• Pollination
• Genetic Diversity
	• index cards
	• tweezers
	• magnifying glass
	• Plates to put dead bees in
	• Worksheets
	  ○ 6 print outs of ***MvB picture***
	  ○ 6 print outs of ***MvB_comoparison picture***
	  ○ 6 print outs of
	  ■ ***bees profile***
	  ■ ***moth profile***

	■ ***butterflies profile*** ○ 40 copies of ■ ***"the ABeeeCs"*** ■ ***"moth_v_butterfly"*** ■ ***"Butterfly-guide"***

Seasonality:

Monsoons July-Sept.	*Autumn* Oct.-Nov.	*Winter* Dec.- Feb.	*Spring* Mar.-Apr.	*Dry Summer* May-June

Guiding Questions:

- What are the key structural features that distinguish butterflies and moths, and how does this affect their methods of pollination?
- What are the varying hypotheses surrounding how the Monarch butterfly finds the same overwintering site from generation to generation?
- What are potential issues affecting our pollinators right now?

Engagement/Introductory Activity:

- Bellwork:
  - Watch:
  - https://www.nytimes.com/video/science/earth/100000002143340/a-disastrous-year-for-bees.html
  - On the bellwork sheet Mr. Domsky gives them, answer the following:
    - What is the stinger of the bee called? (Aculeur)
    - Do both males and females have a stinger? (no only females)
    - Do all bees die after stinging something (no only the honey bee dies)
      - Prompt a discussion to explain these answers
- Scientist of the week
  - *Mario J. Molina*
- Review:
- (Mostly cool facts the worksheets and us walking around during the lab will go through information of bees, butterflies and moths)
  - How many species of bees are there? (over 1000)
  - Tucson actually hosts more kinds of bees than anywhere in the world (with an exception of some deserts in Israel)
  - Did you know that butterflies and moths are the second largest order of insects!

https://seeds.ca/sw8/web/pollination/pollinator-profiles/butterflies-and-moths

Exploratory Activity:

- Students will participate in a lab containing different species butterflies, moths, and bees.
  - At each station in the lab students will have :
    - A bee specimen in alcohol
    - Tweezers
    - Magnifying glass
    - Bee profile
    - Photo of butterflies Vs moths (4 pictures)
    - A lab packet (including bees, moth and butterfly sections [3 different files stapled together])
  - Students will first work with the bee anatomy lab packet and work through to identify specific parts of the bee and answer the questions in the packet.

- Once finished or half way through the class students will move on to work with the butterfly and moth activity where they will distinguish the characteristics of a moth and a butterfly and be able to see which kinds of flowers they choose to pollinate.

Explain:

- Throughout the lab we will be discussing with them discussing with them such as:
  - Bees:
    - Bees pollinate 30% of our agriculture and of 640 flowering species 80% of these species use bees as pollinators. Bees also allow for plants to provide food for numerous other animals such as lizards, mammals, birds and insects.
    - In some desert species bees the female will burro in sandy soils and create a lining of protective wax with glands in her abdomen, this wax prevents fungus from growing, is waterproof and maintains humidity. This is where she lays her eggs (mass provisioning- producing a lot of eggs) and leaves them will all the pollen and nectar she has collect so they can eat.
    - Most bees are solitary so they mother wont come back to her young ever again
    - Other desert bees will instead nest in tunnels of wood, dead tree limbs or standing trees
    - Only a small number of bees are actually social (honey and black/yellow bumble bees)

Butterflies/Moths:

- Butterfly v Moth
  - Though butterflies and moths appear similar in many respects, there are some ways to distinguish between them. Generally when a butterfly lands and rests on a plant it holds its wings vertically, while moths tend to rest with their wings folded back almost horizontally. Moths have heavy, furred bodies, whereas the butterflies have more delicate, slender bodies with little hair. Butterfly antennae are thin and end with a knob at the tip. Moth antennae are often feathery and without a knob.
  - Color is not a reliable indicator, as some of the moths, especially the Saturnids, are beautifully colored and some butterflies, such as satyrs and mourning cloaks, have muted coloration. Also, not all moths are night fliers. Some species, such as the buck moths and the Calleta silk moth, fly by day. (You may notice the Calleta moth as it feeds on ocotillo leaves during the summer rainy season. Look for ocotillos stripped of leaves from the top down.)
  - Both butterflies and moths lay eggs which hatch into caterpillars. These caterpillars molt into a pupa, or resting stage. After a period of time a few days to a season the winged adult emerges from the pupal case. Moths tend to construct cocoons, protective silk coverings around themselves, before molting into pupas. Butterflies do not encase themselves in cocoons.

Extension Activity/Questions:

We are not going to have time for this but instead will incorporate the information above in questions forms like ‘where do bees usually live”, “do all bees live in that area”, “what are some different areas” ect…

Evaluation Activity:

- Exit Ticket: **(Make the last 5 minutes of class designed for this activity)**
- Pass out index card
  - What are two differences between desert bee species and 2 similarities between them?
  - Can you rely on coloration to distinguish moths from butterflies?
  - What are 3 key differences between moths and butterflies?

Make sure to have students turn in the index cards before they leave.

Bats Vs. Birds

Bellwork:

(Watch the two videos in class and answer the following questions)

1. What are some reasons why people today should care about bats and birds and How do they contribute to biodiversity?

   _____
   _____
   _____
   _____

2. Why are bats and birds important to agriculture/ desert growth? Provide evidence for your conclusion.

   _____
   _____
   _____
   _____

3. How do bats hunt flying insects at night? How do birds hunt insects during the day?
   _____
   _____
   _____
   _____

4. What role could you play in helping bats and or birds? What if you worked with others?
   _____
   _____
   _____
   _____
   _____

5. Write a question about the video for your teacher or another student to answer.
   _____

Anatomy Worksheet

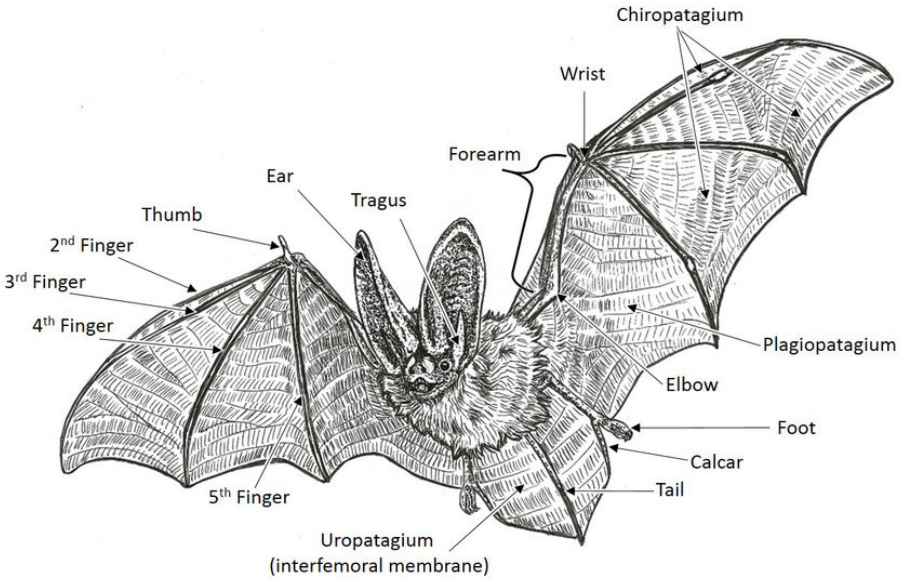
Instructions:

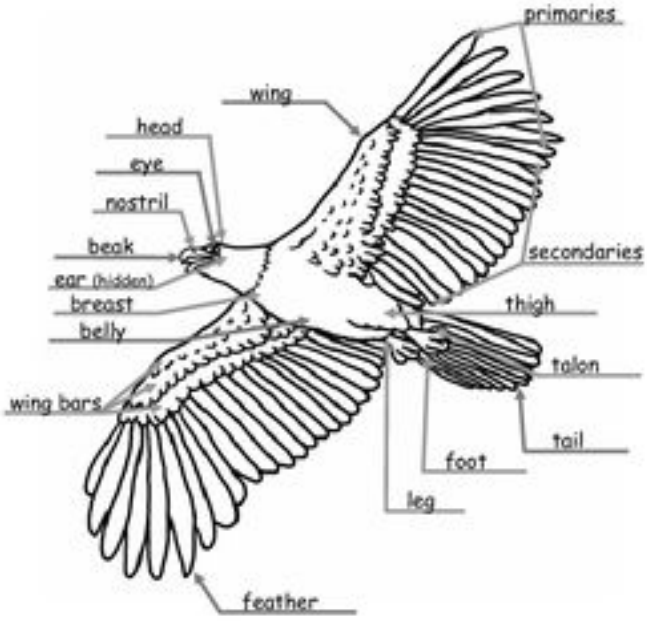
Read the document, look at the given diagrams to be able to fill out the anatomy chart of both a bird and a bat. Answer the questions at the end.

Birds and bats both use wing mechanics to stay in the air. But it's the different ways that they approach them that makes it so fascinating. Anybody who's ever swum the butterfly stroke will be familiar with the motion: more or less throwing your arms forward to drag the water (or air) behind yourself. Take a moment to think about doing that, and then appreciate the sheer force that bird and bat muscles have to be able to generate.

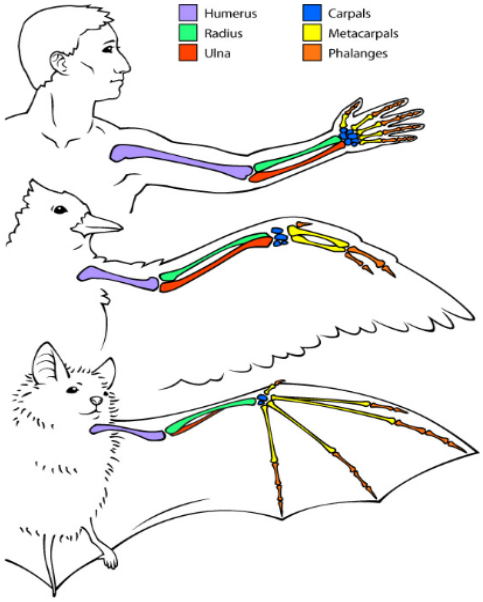
However, while this is more or less how birds fly, it turns out that bats fly with a much more complex range of motions. They're just a lot harder to see. Consider the anatomical differences between bat and bird wings. The first is obvious: birds have feathers, while bats' wings consist largely of skin membranes. The second is also pretty obvious: bird wings consist of elongated arms and a single finger, while bats use three fingers with the membrane stretched between them. Because the end shape of both is kind of similar, it's easy to miss how large this difference actually is.

The bat actually bends its fingers, which dramatically changes the shape of its wings. Birds do not have joints in their feathers, so they cannot do this. The huge amount of flexibility in bat finger joints is essential for their flight capabilities.





Flexible joints are not all the bat has in its arsenal. Its actual *bones* are flexible, due to a lack of calcium in its diet. This means that they deform and reform their shape during flight.
Birds minimize air resistance by rotating their primaries during their upstroke, allowing air to slip between the feathers. Bats, with solid membranes, can't do this- so they have an even finer means of control. There are lines of muscle present within the bat's wing membrane that can actually change the stiffness and malleability of its skin.



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Bat wings are also covered by millions of tiny, hyper-sensitive hairs that allow the bat to sense air currents and adjust accordingly.

So what does all this control do for the bat?

Well, for one thing, it means they're not limited by symmetry. Bird wings will almost always mirror each other in shape, while bats may form two different wings shapes at the same time, allowing them to perform some crazy aerial acrobatics. Some insect-eating bats will actually grab an insect by wrapping one wing around it midflight (don't believe me? You can see it in the beginning of this video!) and then get the insect in their mouth all in a split second, while still flying

Now, in terms of speed, birds can generally outpace bats. But in terms of maneuverability, bats can fly circles around birds.

The fact that bats' bones, unlike those of birds, aren't hollow, and that their skin is heavier than feathers might seem like a disadvantage- but it isn't. Birds have much more mass in the center of their body than they do in their wings; by contrast, bats have more mass distributed through each wing (12-20% per wing). This means that bats can actually push off their own mass do do things like flip, spin, roll, etc. No bird can stop midflight and flip over to land upside-down, but bats can.

Because they have such fine control over their airfoil shape, bats can also generate lift using less energy than birds. Remember when I talked about minimizing surface area during the upstroke and maximizing it during the downstroke? Bats can bend their fingers and 'crumple' their wings as they raise them, conserving energy. Think of it like opening and closing an umbrella. While birds can pull their feathers together more tightly, they can't exactly clench them like fists.

Decreasing energy costs is good in any situation, but particularly for fliers. It takes a lot of energy to fly. In this case, bats can outcompete both birds and insects for energy efficiency- one study found that nectar-feeding bats, though the largest in size, expended the least energy hovering when compared to both moths and hummingbirds.

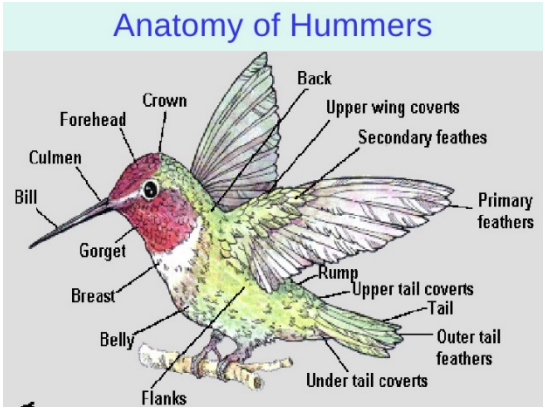
So: bats can do all these cool things while flying. Is there a downside? Mmm… yeah. Besides sheer speed, birds do have one major ability that bats don't: they can walk.

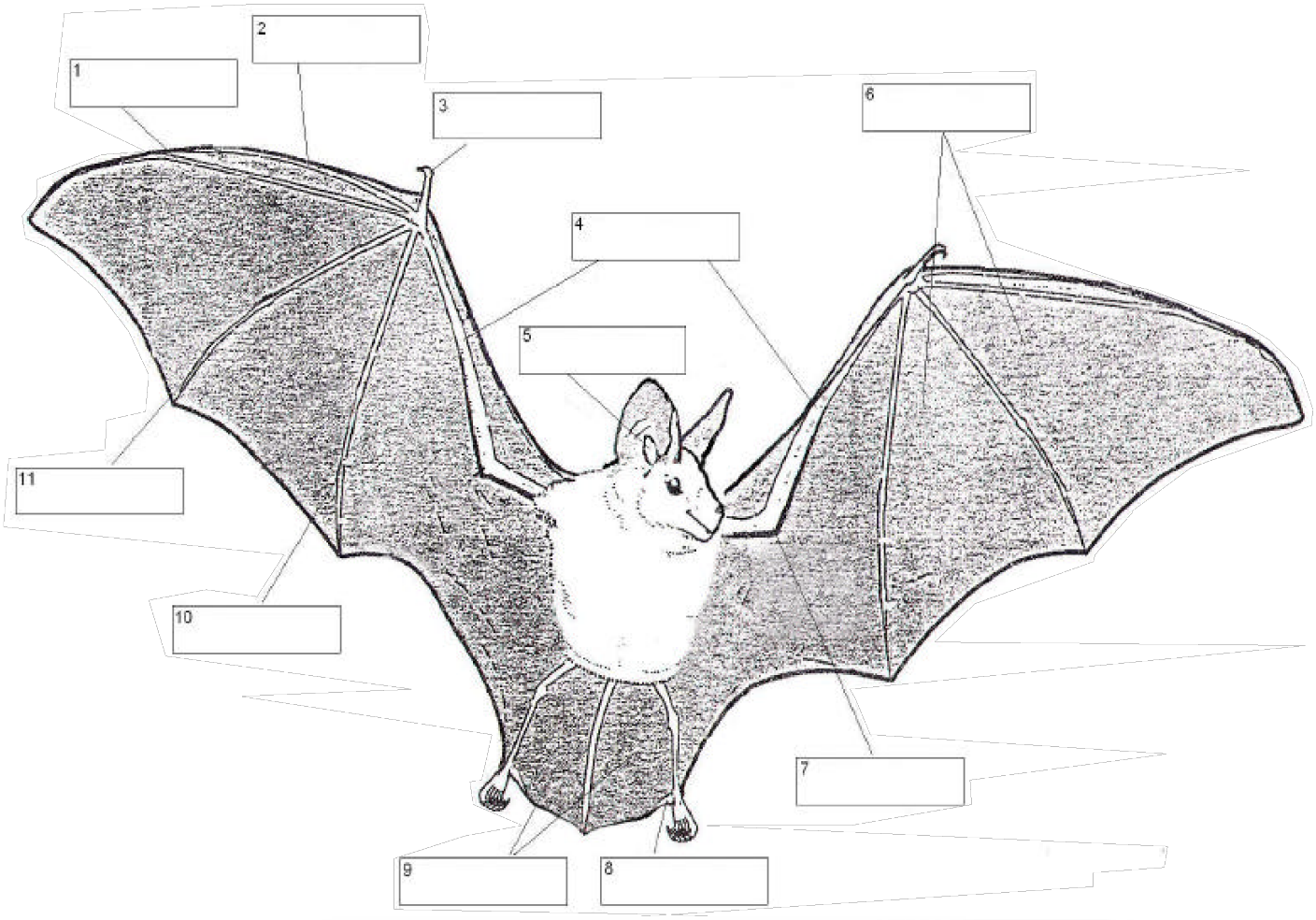
Ok, some bats can walk (four species) and some birds can't (hummingbirds), but for the most part birds are fairly okay at waddling around on the ground. Most bats… not so much.

We can draw parallels between hummingbirds and bats in this respect, as hummingbirds are among the most maneuverable of all bird species. Selection for increased acrobatics in the air seems to come at the cost of land maneuverability. It makes sense.

And unlike birds, most bats can't take off directly from the ground. It's that pesky quadrupedal stance they have. Birds, being bipedal, can push off with their hind legs. Bats can't do this, aside from a few exceptionally powerful species like the vampire bats and the eastern red bat. Generally if they land on the ground they have to climb up to a vantage point, like a tree trunk, before pushing off.

Interestingly, the other vertebrate fliers- pterosaurs- were also quadrupedal, but could push off from the ground. They used their forearms!

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Birds Vs. Bats as Pollinators

The birds and the bees may rule the daytime, but as soon as the sun sets, it is the bats that get to work pollinating. Worldwide, over 500 species of flowers in at least 67 plant families rely on bats as their major or exclusive pollinators.

1. **Not all bats eat insects.**

Eating insects is by far the most common diet found among the 1,300 species of bats worldwide, which certainly benefits our farmers in keeping many insect species in check. However, the pollinating role many of our nectar-feeding bats play is just as important. Bats like "Blossum", a Common Blossom Bat Syconycteris australis from Australia, pollinate the flowers of plants that have evolved to produce nectar to attract them. Scientists believe that many groups of plants have evolved to attract bats, as they are able to carry much larger amounts of pollen in their fur compared to other pollinators. The ability of bats to fly long distances is also another benefit to plants, especially those that occur in low densities or in habitats far apart from each other.

2. **Flowers produce a musty, rotten odor to attract bats**

While some of the flowers that attract bats can be quite beautiful, you probably wouldn't want to receive a bouquet of them. To attract these flying mammals flowering plants have evolved a musty or rotten perfume. The smell is created by sulphur-containing compounds, which are uncommon in most floral aromas but have been found in the flowers of many plant species that specialize in bat pollination.

Lesser long-nosed bat, cardon cactus, MERLIN TUTTLE (1)As well as their keen sense of smell, bats also use sight to find nectar-producing flowers. Bat flowers are often white or light-colored in an attempt to stand out against foliage or the night sky, but they also can range from brown and green to pink, fuchsia and yellow. Even though they only open at night, bat flowers are often dull in color, which scientists believe may function more as a camouflage from other visitors than as a visual cue to bats.

3. **Some bats use echolocation to find flowers**

You may have heard of bats using echolocation to hunt insects, but did you know some bats also use it to find nectar-producing plants? Indeed some plant species have evolved acoustic features in their flowers that make the echo of the bat's ultrasonic call more conspicuous to their bat pollinators. These flowers often have a bell-shaped concave form, which effectively reflect the sounds the bats emit enabling them bats to easily find flowers in the dense growth of tropical rainforests.

While this helps some species, not all bats use echolocation to find nectar. Within Chiroptera, the mammal order that encompasses all bats, two distinct groups are found. The first are the small, mostly insect eating bats called Microchiroptera (micro-bats), which predominately use echolocation. While species of this group are found worldwide, nectar-feeding bats from this group only inhabit tropical and subtropical regions of the Americas.

The second group is Megachiroptera (mega-bats), a group that includes all the large bats, including flying-foxes, which predominately eat fruit and nectar. Found in the Old World tropics of Africa, Europe, and Asia these bats lack the ability to echolocate, instead relying on their sight and sense of smell to find food. While they depend entirely on vision to negotiate their environment, they appear to do so quite well even in inclement weather and on moonless nights. So the old saying "blind as a bat" really isn't true!

4. One species of nectar-feeding bat has the longest mammal tongue in the world

Could you imagine having a tongue that is 9 feet long? That is what it is like for the rare Anoura fistulata, a nectar-feeding bat from South America, which has the longest tongue (proportionally) of all mammals. A. fistulata is only the size of a mouse, but its tongue is around 8.5 centimeters long, making it up to 150% of its body length! With such a long tongue it couldn't possibly keep all of it in its mouth. Instead, A. fistulata keeps the tongue in its chest, in a cavity between the heart and sternum.

5. Bats service many plants that we use for medicinal, cultural and economic purposes

Did you know that bats almost exclusively pollinate wild bananas, which originate from Southeast Asia? Bats pollinate many ecologically and economically important plants from around the world. The products that we value from these plants are more than just fruits, including fibers and timbers that we use everyday. Flying foxes, nectar and fruit eating mega bats from Australia, pollinate the dry eucalyptus forests, which provide us with timber and oils that are shipped around the world.

Mexican agave plants, a source of fiber and tequila, are solely reliant on the pollination services of several nectar-feeding bats. Many tropical and sub-tropical rainforest ecosystems also rely on bat pollinators to regenerate. Without nectar feeding bats not only would our environment suffer, but our way of living as well!

Questions:

1. What are some differences within bat species (Do all of them use echolocation, Do they all eat insects ect…)

   _____
   _____
   _____
   _____
   _____

2. What are some differences with bird vs bat anatomy? How does this effect they way they are able to fly and or pollinate?

   _____
   _____
   _____
   _____

3. What do flowers do to attract bats? What do they do to attacked birds?

   _____
   _____
   _____
   _____

4. How are bats beneficial to us?

   _____
   _____
   _____
   _____
   _____

5. What are some differences with in birds and hummingbirds anatomy? How does this contribute to their ability to pollinate and or collect nectar?

   _____
   _____
   _____
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Women in Science & Engineering

Bio/Diversity Project
Lesson Title: Birds and Bats

Teacher: Jennifer Luna and Dianna Sandoval
Grade Level: *9th*
Time: *50 minutes*

Bats V.S. Birds Flight

AZ State Science Standard:	*HS.L2U1.19* • **Develop and use models** that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.
Content Objective: Math, Reading, Science, Writing, Other:	• *Students will be able to note similarities and differences in bat and bird species that directly contribute to how they function as a pollinator* • *Students will be able to identify which kinds of Sonoran Desert species are pollinated by these pollinators*
Language Objective: (Optional)	*N/A*

Scientist of the Week:	**Michelle McMahon**
	• Associate Professor - School of Plant Sciences, Ecology and Evolutionary Biology, Bio5
	• From: Tucson, Az
	• Research in her lab focuses on the analysis of biological diversity, particularly through phylogenetic systematics of plants.
	• Research areas:
	  ○ Biodiversity and Evolutionary Biology
	  ○ Genomics, Bioinformatics, and Systems Biology

Vocabulary	**Materials**

Provide a bulleted, alphabetized list of words that students will hear, speak, write, and/or read about in the lesson. These words are integral to developing content understanding:
• Adaptation
• Biodiversity
• Invasive
• Species
• Etc...
	Provide a bulleted list of relevant materials for the lesson.
	• Worksheet
	  ○ Bats Vs Birds (35 copies)
	• Pollinator profile of birds and bats
	  ○ 6 copies of birds and hummingbirds
	  ○ 6 copies of bats
	• Index Cards

Seasonality:	

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Bio/Diversity Project
Lesson Title: Pollinators in Urban Areas

Teacher: Jennifer Luna and Dianna Sandoval
Grade Level: *9th*
Time: *50 minutes*
https://learning.blogs.nytimes.com/2013/05/08/trouble-in-the-hive-researching-the-decimation-of-honeybee-colonies/

AZ State Science Standard:	**HS.L2U3.18** ● **Obtain, evaluate, and communicate** about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.
Content Objective: Math, Reading, Science, Writing, Other:	● *Students will be able to define colony collapse disorder and will be able to understand why it is a growing concern to farmers and beekeepers.* ● *Students will be able to discuss possible causes and solutions of the ongoing decimation of honeybee colonies across the country.*
Language Objective: (Optional)	*N/A*
Scientist of the Week:	● Karl von Frisch ○ Austrian Ethologist (20 November 1886 – 12 June 1982) ○ His work centered on the sensory perception of the honeybees and was one of the first to translate the meaning to the waggle dance. ○ He was one of the first to discover ■ bees can distinguish various blossoming plants by their scent, and that each bee is "flower constant" ■ first to demonstrate (in 1914) that honey bees had color vision ● using classic condition ■ bees can recognize the desired compass direction in three different ways: by the sun, by the polarization pattern of the blue sky, and by the earth's magnetic field, whereby the sun is used as the main compass, with the alternatives reserved for the conditions arising under cloudy skies or within a dark beehive https://en.wikipedia.org/wiki/Karl_von_Frisch

Vocabulary	Materials
● Conservation ● Abundance ● Habitat Loss ● Ecosystem Diversity ● Fragmentation	● Variety of fruits that depend on pollination by honeybees: ○ apples, peaches, raspberries, almonds ● Problem-solution organizer (35 copies) ● Research Studies condensed (10 copies) ○ *will be sending this later https://static01.nyt.com/images/blogs/learning/pdf/activities/ProbSolution_NYTLN.pdf

Seasonality:				
Monsoons July-Sept.	*Autumn* Oct.-Nov.	*Winter* Dec.- Feb.	*Spring* Mar.-Apr.	*Dry Summer* May-June
Guiding Questions: ● How has urbanization impacted pollinators? ● How can urban areas act as a place of refuge for pollinators?				

Engagement/Introductory Activity:

- This week we will begin with scientist of the week.
- Get to the classroom early to set up for bellwork:
  - We will be displaying a variety of fruits (mentioned in materials) on the powerpoint:
  - On an index card students will answer the following:
    - Where do the items come from, and what ecological factors do they all have in common?
  - Elaborate by explaining to students that:
    - Fruit is a ripened ovary of a flowering plant. A fruit contains seeds, which contains embryonic plants that will eventually grow into new plants when planted in the ground.
    - Many flowering plants, including fruit crops, depend on bees to pollinate their flowers to be able to produce fruits. Therefore, bee pollination is one ecological factor.
- Ask students if they have heard about the collapse of honeybees across the country.
  - Show video (Link):
    - https://www.nytimes.com/video/science/earth/100000002143340/a-disastrous-year-for-bees.html
- Class discussion:
  - How has urbanization impacted pollinators?
    - Pollinators, firstly, are affected by urbanization for the lack of resources. and suitable habitats at the landscape scales.. Consequently, pollinator populations need to adjust their foraging and nesting behavior to maintain a sufficient net energetic gain in cities. Some previous studies have targeted on the decline of pollinator caused by the alteration and loss of habitat, especially by the increase of urbanization.
https://www.nature.com/articles/s41598-018-36773-7
- How can urban areas act as a place of refuge for pollinators?
  - However recent research globally has demonstrated that towns and cities can support large, diverse communities of bees and other insects that play an important role in pollinating urban food crops, particularly in gardens and allotments. It's important that we raise the profile of these insects to influence planning policies, ensuring that building and infrastructure development, as well as conservation strategies, takes this into account.
https://www.sciencedaily.com/releases/2016/10/161003104133.htm

Exploratory Activity & Explain: (Combining these two activities):

‘Save the bees’ Proposal and Conference

- Before doing activity ask the class and have them raise their hands:
  - Q: What is a hive?
    - A: Used to describe the nest of any bee colony.
  - Q: How many bees live within a hive, what are their roles?
    - A: A honey bee colony typically consists of three kinds of adult bees: workers, drones, and a queen. Several thousand worker bees cooperate in nest building, food collection, and brood rearing. Each member has a definite task to perform, related to its adult age. But surviving and reproducing take the combined efforts of the entire colony. Individual bees (workers, drones, and queens) cannot survive without the support of the colony.
    - https://agdev.anr.udel.edu/maarec/honey-bee-biology/the-colony-and-its-organization/
  - Q: How do honeybees communicate about the location of food resources?
    - A: They communicate through movement and can let them know of food resources that are more than 150 meters from the hive. Called the waggle dance:
- Video: https://www.youtube.com/watch?v=PMOUaoQ_9aI
  - from .27 seconds

- Dianna and I will combine the 3 research studies provided in this lesson plan to something less lengthy due to time constraints.
  - We will be passing out the "Problem-Solution" graphic organizer to gather evidence & to be able to gather their ideas. They will also be placed in groups of 3:
- Students will create a poster tackling the problem of colony collapse disorder.
  - Questions they should consider answering:
    - How would honey bees navigate the tangled interplay of pesticides, habitat loss, invasive species and parasite infections?
    - Are there initiatives they think would be feasible to lead locally, at your school or in your city or town?
  - We will suggest:
    - They focus on two likely causes of colony collapse disorder and two of the most promising solutions.

Ask them to get creative and to draw to explain their answers

Working on getting the two studies together, will be finalized by revision #5 or by our wednesday meeting!

https://science.sciencemag.org/content/336/6079/348.full
https://science.sciencemag.org/content/336/6079/351.full

Extension Activity/Questions & Evaluation Activity:

- Class Conference time:
  - Goals:
    - Students will form a consensus on the primary causes leading to colony collapse disorder and a recommended course of action for beekeepers, scientists and the government.
- When they are presenting we will inform them that they must backup their opinions with evidence from the research.
  - Dianna and I will choose two random groups to present their findings. The groups will get a maximum of 5 minutes to present due to time.
- Save 5 minutes at the end of class to decide on an action plan project that the students will be interested in doing:
  - Idea: Cultivating a bee-friendly pollinator garden

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Bio/Diversity Project
Lesson Title: Protecting Pollinators

Teacher: Jennifer Luna and Dianna Sandoval
Grade Level: *9th*
Time: *50 minutes*

https://en.wikipedia.org/wiki/Henry_Blair_(inventor)
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5073108.pdf

AZ State Science Standard:	**Essential HS.L2U3.18** • **Obtain, evaluate, and communicate** about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.
Content Objective: Math, Reading, Science, Writing, Other:	• *Students will be able to identify methods that they can implement in their everyday lives to prevent pollinator decline.* • *Students will be able to develop a sensitivity for understanding of the land ethic, determine the diversity and complexity of natural environments, and discover the impact humans create when they settle in a natural environment.*
Language Objective: (Optional)	*N/A*

Scientist of the Week:	• Henry Blair
	  ○ (1807-1860) was the second African American inventor to receive a US patent.
	  ○ His first invention was the Seed-Planter, this allowed farmers to plant more corn using less labor and in a shorter time.
	  ○ In 1836, he received his second patent for the invention of a cotton planter.
	  ○ He had been a successful farmer for years and developed the inventions in means of increasing efficiency in farming.

Vocabulary	**Materials**
• Conservation • Population • Abiotic • Biotic • Restoration • Abundance	○ Mirror ○ Butcher paper (eight to ten foot piece of paper) ○ crayons, colored pencils ○ construction paper ○ scissors ○ glue (or tape)

Seasonality:				
Monsoons July-Sept.	*Autumn* Oct.-Nov.	*Winter* Dec.- Feb.	*Spring* Mar.-Apr.	*Dry Summer* May-June
Guiding Questions: ● What is the importance of protecting pollinators? ● How can conservation and restoration be used to help protect pollinators? ● What abiotic and biotic stressors have led to pollinator decline.				

Engagement/Introductory Activity:

- Scientist of the week: Henry Blair
- On the bellwork sheet that Simon hands out, answer the following after watching video:
    - **What's a Picnic without Pollinators?**
        - What can we do to prevent the decline of pollinators?
            - Avoid the use of pesticides
            - Pollinator garden
        - What is the importance of protecting pollinators?
            - They play an important role in maintaining the health of the ecosystem and supporting agriculture by planting pollen grains, which in fruit and seeds?
- Review: Local and National Organizations actively working to protect pollinators:
    - The majority of pollinator deaths result from: habitat loss, degradation, and fragmentation; pesticide use; pest and pathogens
        - Tucsons Sonoran Desert Museum and the Community Food bank helps plant gardens in agriculture fields to attract more pollinators, while the food bank hosts events to teach the community about pollinators. The food bank also teaches groups how to garden plants and flowers to be able to host pollinators and or grow their own produce.
        - Tucsons Bee Collaborative who is partnered with the University of Arizona are currently doing a study on wild bee populations at Las Milpitas (a large acred field)

Exploratory Activity & Explain: (the activity for this lesson is the second link that is provided at the top)

- This activity we will give an overview:
    - When you look in a mirror, what do you see?
        - Let students answer & answer with the following: What else is in the mirror? in the background you will see other images (if we were conducting this outside), such as the sun, trees, or grass. We also want to take into consideration parts of the reflection that we cannot see. Think of air, water, and energy. Explain to them that this is what scientists call an ecosystem.
            - Ecosystem: connecting the physical environment with living organisms in a specific area.
        - Start conversation about energy and discuss how all living organisms require energy to live, energy is one important link that ties the various components in an ecosystem together. Take plants, they transform the sun's energy into food for other organisms, storing extra energy in structures like leaves, seeds, stems, roots, and flowers. (Draw the energy pyramid on the board) Explain that humans are part of this pyramid and that all species are all interconnected with each other.
- We will discuss as a class show the changes that have occured overtime in the U.S. Determine as a class the components that were present in one or two of the biotic communities in the area before human settlements.
    - In arizona the sonoran desert saguaro cactus has heavily decreased since 1998 and because they take so long to grow, and the smaller ones were crushed by cattle that was lent out to new farmers who migrated to arizona.
        - The saguaro national park is making efforts to protect saguaro cactus and completing the saguaro census to keep track of the saguaros.

        - Climate change is reducing precipitation, especially in the spring and early summer months, and these declines are projected to continue.
        - Reduced precipitation, increasing heat and evapotranspiration from soils and plants are making serious droughts a more frequent occurrence.

    Ask:
    - What kind of pollinators, trees, and animals were present?
- We will be dividing the class into two equal groups:
    - Group 1: Ask them to draw and color a mural of the natural environment (butcher paper) encourage them to draw as many wildlife and plant species as possible.
        - Draw things they see here in their environment, what pollinators what plants, is there water sources?
        - After they finish the mural ask:
            - What are some of the connections between the wildlife and plant species you drew?
            - Describe a food web from the drawing you are creating:
                - Describe how the chain flows in one of the food chains
    - Group 2: Ask the other group to draw/ cut human "stuff:" buildings, roads, cars, parking lots.
        - Leave them with the questions:
            - What are some of the raw materials needed to produce the products we use?
            - Where do these raw materials come from?
                - Wood is from the pacific northwest
                - Steal comes from Canada and Mexico
                - Cement comes from China, Canada, Spain
    - We will then come together as one group, taping the mural to the wall and then adding the human 'stuff' on the mural. Let them describe the human settlement. Ask:
        - What are the impacts that were made?
        - How is human impact different than the impacts of other natural phenomena, like fire or drought, in a natural environment?
    - Discuss why conservation is so important to pollinators, animals, and the environment.

Tie it all together: we need of each other for survival

Extension Activity/Questions & Evaluation :

Ask the students to write a short paragraph answering the following questions on an index card :

1. What are two ways YOU can contribute in protecting your environment/ pollinators in your community?
2. In what ways do humans destroy/ interrupt the delicate ecosystem?
3. Name 3 raw materials we discussed and where they come from

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Bio/Diversity Project
Lesson Title: Specific Pollinators: Butterflies, Moths and Bees

Teacher: Jennifer Luna and Dianna Sandoval
Grade Level: *9th*
Time: *45 minutes*
Mario J. Molina

AZ State Science Standard:	*HS.L2U1.19* ● **Develop and use models** that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.
Content Objective: Math, Reading, Science, Writing, Other:	● Students will be able to identify key structures that distinguish butterflies and moths. ● Students will be able to identify how this affects both butterflies and moths methods of pollination. ● Students will be able to identify different qualities of desert bee species and how alike and different some of them are.
Language Objective: (Optional)	N/A
Scientist of the Week:	*Mario J. Molina* ● His current work is related to air quality and global change issues. ● *He is currently living in both San Diego and Mexico City, where he has created a new center for strategic studies in energy and environment.* ● *Facts:* ○ *Him and his team have succeeded in improving air quality significantly; however, he did mention that there's still much work to get done.* ○ *He is in a research group in San Diego and is investigating the chemical properties of atmospheric particles* ▪ *He claims that his goal is to better understand the effect of these particles on the clouds and the climate.*

Vocabulary	Materials
● Migration ● Habitat ● Ecosystem ● Pollination ● Genetic Diversity	● index cards ● tweezers ● magnifying glass ● Plates to put dead bees in ● Worksheets ○ 6 print outs of ***MvB picture*** ○ 6 print outs of ***MvB_comoparison picture*** ○ 6 print outs of ■ ***bees profile*** ■ ***moth profile*** ■ ***butterflies profile*** ○ 40 copies of ■ ***"the ABeeeCs"***

	■ ***"moth_v_butterfly"*** ■ ***"Butterfly-guide"***

Seasonality:

Monsoons July-Sept.	*Autumn* Oct.-Nov.	*Winter* Dec.- Feb.	*Spring* Mar.-Apr.	*Dry Summer* May-June

Guiding Questions:

- What are the key structural features that distinguish butterflies and moths, and how does this affect their methods of pollination?
- What are the varying hypotheses surrounding how the Monarch butterfly finds the same overwintering site from generation to generation?
- What are potential issues affecting our pollinators right now?

Engagement/Introductory Activity:

- Bellwork:
  - Watch:
    - https://www.nytimes.com/video/science/earth/100000002143340/a-disastrous-year-for-bees.html
  - On the bellwork sheet Mr. Domsky gives them, answer the following:
    - What is the stinger of the bee called? (Aculeur)
    - Do both males and females have a stinger? (no only females)
    - Do all bees die after stinging something (no only the honey bee dies)
- Prompt a discussion to explain these answers
- Scientist of the week
  - *Mario J. Molina*
- Review:
- (Mostly cool facts the worksheets and us walking around during the lab will go through information of bees, butterflies and moths)
  - How many species of bees are there? (over 1000)
  - Tucson actually hosts more kinds of bees than anywhere in the world (with an exception of some deserts in Israel)
  - Did you know that butterflies and moths are the second largest order of insects!

https://seeds.ca/sw8/web/pollination/pollinator-profiles/butterflies-and-moths

Exploratory Activity:

- Students will participate in a lab containing different species butterflies, moths, and bees.
  - At each station in the lab students will have :
    - A bee specimen in alcohol
    - Tweezers
    - Magnifying glass
    - Bee profile
    - Photo of butterflies Vs moths (4 pictures)
    - A lab packet (including bees, moth and butterfly sections [3 different files stapled together])
  - Students will first work with the bee anatomy lab packet and work through to identify specific parts of the

bee and answer the questions in the packet.
- Once finished or half way through the class students will move on to work with the butterfly and moth activity where they will distinguish the characteristics of a moth and a butterfly and be able to see which kinds of flowers they choose to pollinate.

Explain:
- Throughout the lab we will be discussing with them discussing with them such as:
  - Bees:
    - Bees pollinate 30% of our agriculture and of 640 flowering species 80% of these species use bees as pollinators. Bees also allow for plants to provide food for numerous other animals such as lizards, mammals, birds and insects.
    - In some desert species bees the female will burro in sandy soils and create a lining of protective wax with glands in her abdomen, this wax prevents fungus from growing, is waterproof and maintains humidity. This is where she lays her eggs (mass provisioning- producing a lot of eggs) and leaves them will all the pollen and nectar she has collect so they can eat.
    - Most bees are solitary so they mother wont come back to her young ever again
    - Other desert bees will instead nest in tunnels of wood, dead tree limbs or standing trees
    - Only a small number of bees are actually social (honey and black/yellow bumble bees)

Butterflies/Moths:
- Butterfly v Moth
  - Though butterflies and moths appear similar in many respects, there are some ways to distinguish between them. Generally when a butterfly lands and rests on a plant it holds its wings vertically, while moths tend to rest with their wings folded back almost horizontally. Moths have heavy, furred bodies, whereas the butterflies have more delicate, slender bodies with little hair. Butterfly antennae are thin and end with a knob at the tip. Moth antennae are often feathery and without a knob.
  - Color is not a reliable indicator, as some of the moths, especially the Saturnids, are beautifully colored and some butterflies, such as satyrs and mourning cloaks, have muted coloration. Also, not all moths are night fliers. Some species, such as the buck moths and the Calleta silk moth, fly by day. (You may notice the Calleta moth as it feeds on ocotillo leaves during the summer rainy season. Look for ocotillos stripped of leaves from the top down.)
  - Both butterflies and moths lay eggs which hatch into caterpillars. These caterpillars molt into a pupa, or resting stage. After a period of time a few days to a season the winged adult emerges from the pupal case. Moths tend to construct cocoons, protective silk coverings around themselves, before molting into pupas. Butterflies do not encase themselves in cocoons.

Extension Activity/Questions:
We are not going to have time for this but instead will incorporate the information above in questions forms like ‘where do bees usually live”, “do all bees live in that area”, “what are some different areas” ect…

Evaluation Activity:
- Exit Ticket: **(Make the last 5 minutes of class designed for this activity)**
- Pass out index card
  - What are two differences between desert bee species and 2 similarities between them?
  - Can you rely on coloration to distinguish moths from butterflies?
  - What are 3 key differences between moths and butterflies?

Make sure to have students turn in the index cards before they leave.

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Bio/Diversity Project
Lesson Title: Action Project 4/4

Teacher: Jennifer Luna and Dianna Sandoval
Grade Level: *9th*
Time: *4 week plan (4 50 minute classes)*

AZ State Science Standard:	**Essential HS.L2U1.19** ● **Develop and use models** that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.
Content Objective: Math, Reading, Science, Writing, Other:	● Students will be able to develop their own understanding of the previous lessons we have taught and use them to begin developing a presentation of pollinators and their importance for biodiversity. ● Students will use their past reading packets and science learning to write and develop a poster about pollinators. ● Students will be able to plant their own pollinator garden.
Language Objective: (Optional)	*N/A*
Scientist of the Week:	Week 1: Rachel Lousie Carson ● American Marine Biologist and Conservationist. ● *Silent Spring* and other writings are credited with advancing the global environment movement. ● After spending most of her career in exploring the oceans, she then turns her attention to conservation. More specifically problems that were caused by synthetic pesticides. Which later came the development of the book *Silent Spring*. This was one of the actions that inspired the environmental movement. ○ Led to the creation of the U.S Environmental Protection Agency. Week 2: Dianna Sandoval ● Veterinary Science Major at the University of Arizona ● Currently doing research on amphibian species specifically salamander species endangered by a deadly fungal disease. ● In the future wants to work with conservation of animal and plant species (importance of pollinators!) Jennifer Sortillon ● Pre-Med Public Health Major at the University of Arizona. ● Currently a mentor for first generation high school students on their road to achieve a college education. ● In the future wants to work in orthopedic surgeries. Week 3 All the students! ● Now it's your turn, this week's scientist of the week will be about the students. Give them around 2-4 minutes at the beginning of class to present themselves and what they'd like to be in the future. ● For 9 weeks you all learned things from anatomy, ecology, biology and biodiversity of pollinator species.

	• You all have completed worksheets and lessons that involved diving deep into the understanding of pollinators and why they are important to our society • Today you all will present your research on what you have researched about how we can help preserve our Sonoran Desert species of pollinators and why they are important. Week 4: Gillian Bowser • A researcher in the Department of Ecosystem Science and Sustainability • She will receive the Commitment to Human Diversity in Ecology Award from the Ecological Society of America. • Bowser has been a tireless advocate for increasing the ethnic and racial diversity of the study body, and really, the entire field of ecology. • Bowser has focused her career on increasing opportunities for women and minorities in science, internationally as well as in the United States. For the last eight years, she has advocated for the inclusion of gender in climate solutions as part of the Women's Major Group at the United Nations climate change talks. She helped launch the Global Women Scholars Network

Vocabulary	**Materials**
• Change • Stability • Cause and Effect • System Models	Week 1/2: ○ Previous learning packets on Bees, Butterflies, Moths, Bats and Birds (we have them) ▪ Link: https://drive.google.com/open?id=13BabdA6xZXsBoclHGFWxG11YJjWFy-mZ ▪ ○ Poster boards (Won't work on them this week but so they all can put their names on the back and keep them in the class so whenever a group is ready they can have it in class to work on) ○ Crayons (4 packs) ○ Markers (4 Packs) • Action Project Packets (1 Per student) Week 3: • Peer Evaluation Sheets Week 4: • Soil • 5 shovels • Above ground plant bed (provided by Catalina • Plants ○ Hummingbird trumpet (Plant attracts humming birds) ○ Yellow bells (Plant attracts humming birds and bees) ○ Desert Lavender (Plant attracts

	humming birds and bees) ● Edible flowers (citrus blossom, clover, daisies, dandelions, hibiscus, honeysuckle, lavender, lilac, mums, nasturtium, pansies, roses, sunflowers and violets) enough to have at least one per student ○ hibiscus, honeysuckle, lavender tea packets (one per student)

Seasonality:

Monsoons July-Sept.	*Autumn* Oct.-Nov.	*Winter* Dec.- Feb.	*Spring* Mar.-Apr.	*Dry Summer* May-June

Guiding Questions:

- What power do we have to make change and positively impact the biodiversity of pollinators at Catalina High School?
- How can you make your own pollinator garden?
- What factors are important when creating a pollinator garden?

Engagement/Introductory Activity:

- Scientist of the week
  - Week 1: Rachel Lousie Carson
  - Week 2: Dianna Sandoval and Jennifer Luna Sortillon
  - Week 3: Open for the Students
  - Week 4: Gillian Bowser

Week 1:

- Interactive class activity:
  - What power do we have to make change and positively impact the biodiversity of pollinators at Catalina High School?
    - Any action taken for change that can eventually symbolize something bigger is a step towards a better future. Don't be discouraged at how small the garden will be, this will be a great example to be able to get an idea if the students decide to do a pollinator garden in their own backyard to positively impact the biodiversity in their communities.

Week 2:

Class Discussion:

- Do you believe you have enough information to present amongst your fellow classmates about the research you have done?
- What factors should we consider when creating a pollinator garden?
  - variety of plants, plants that can be cared for easily and during the summer, Something that survives the weather here (native plants)

Week 3:

In general there are many ways to help support pollinators, as previously discussed in past lessons, what are some ways we can help outside of the classroom? Why is this important to understand?

- Keeping up to date with pollinators, volunteering with organizations that are pollinator friendly, buying local and organic foods (this is important because it encourages plant

diversity and it reduces the use of pesticides). This is important because the more people and younger gens are informed the more pollinators can thrive in their environment and we will continue to benefit from them.

- Give students 10 minutes to put finishing touches on the poster.

Week 4:
Gillian Bowser

- A researcher in the Department of Ecosystem Science and Sustainability
- She will receive the Commitment to Human Diversity in Ecology Award from the Ecological Society of America.
- Bowser has been a tireless advocate for increasing the ethnic and racial diversity of the study body, and really, the entire field of ecology.
- Bowser has focused her career on increasing opportunities for women and minorities in science, internationally as well as in the United States. For the last eight years, she has advocated for the inclusion of gender in climate solutions as part of the Women's Major Group at the United Nations climate change talks. She helped launch the Global Women Scholars Network

Exploratory Activity:

Week 1 and 2:

- Quick brainstorm activity:
  - Get in groups of 4 and choose one pollinator out of Bees, Butterflies, Moths, Bats and Birds.
  - Pick one student from each group to research/read about one of the following
    - What kind of plants/ flowers does this specific pollinator like/ is attracted to? (physical characteristics and also names of actual flowers)
    - What specific (scientific name, not just long mouth) anatomical structures does this pollinator have that makes them different from the rest and how does this tie into what kind of flowers they like. Also this person should research how plants/ flowers grow.
    - What contributions does this pollinator have on the ecosystem/ biodiversity (pollinates food, spreads plants that feed/shelter other wildlife, ect…) (Use the readings and research to help!)
    - What are some efforts around the world, in Arizona and Tucson that are helping the protection of this specific pollinator (we have mentioned a ton in class but you can also research some). What are some locations we can find these pollinators (worldwide?, Arizona?)
  - (Teachers go around and help students fill out the document and come up with ideas/ materials they will need)

Week 3:

- Students will each present their presentations (5 minutes each group) of each pollinator and explain each section to us. After the presentations the students will be working on the Action Project packet. Before class is over, the students will vote for 2 pollinators they wish to plant specific plants for.

Week 4:

- Students will have a fun activity seeing the different types of edible flowers that can be produced by plants and the different usages for these flowers
  - Teas: hibiscus, honeysuckle, lavender
  - Essential Oils : Lavender
  - Salads: Violets
  - Beauty: roses (rose water, rose infused serums)
  - Medical : Dandelion (All parts of the dandelion are edible and have medicinal and culinary uses. It has long been used as a liver tonic and diuretic.)

- Students will have a chance to see and taste these flowers among others not in the powerpoint.

Explain:

Week 1:

- Once the students are done/ or close to the end of class we will ask where they put each plant by raising their hand (ex: where do you put the night-blooming Saguaro flowers? Who put bats, raise your hand. who put birds, raise your hand and who put both raise your hands.) We will then pick a student to ask why they decided to put this plant in this specific area. Reasonings should include anatomical answers and or answers reasoned from the videos we have shown in class (we will have them ready for students who want to watch them again), worksheet or conversations we've had with students.

Week 2:

- Check In with each student as they continue/ finish up there project, it is important they finish on this day as they will be presenting next week

Week3: Students will vote on which 2 pollinators they wish to plant plants for: bees, bats, birds, butterflies and moths.

Week 4:We will meet students at the garden and begin planting the plants for the pollinators.

Extension Activity/Questions:

Week 1:

- Ask students to each fill out an index card with their group name and write down any last minute questions they have/ things they didn't find information on so we can find some for them. They will also write any materials other than coloring supplies they might want (flowers ect…).
- Students will also write anything they might want us to print (pictures ect…)

Week 2
Extension and explanation is combined

Week3:
Extension and explanation is combined

Week 4: We will meet students at the garden and begin planting the plants for the pollinators.

Evaluation Activity:

Week 1:

- On the packet that was assigned to the students they will write their names and what each person is assigned to, what pollinator they're doing research on and what specific species they will be doing.

Week 2:

- Offer the students one last chance to print things for their poster; they will have 10 minutes next class to finish up the presentations. Ideally it should all if not mostly be done by this day.

Week3:

- Since presentations won't take all of the 50 minutes, the students will be using the rest of their class period finishing up the Action Project packet that was assigned before presentations for research.
- Before they are dismissed, remind them of the guiding question from lesson #7: What power do we have to make change and positively impact the biodiversity of pollinators at Catalina High School?
    - Highlight its importance and relevance, recap from week #7:
    - *Any action taken for change that can eventually symbolize something bigger is a step towards a better future. Don't be discouraged at how small the garden will be, this will be a great example to be able to get an idea if the students decide to do a pollinator garden in their own backyard to positively impact the biodiversity in their communities.*

Week 4: We will discuss how these flowers will help future pollinators and see if we could spot any in the new garden.

Action Project

- Get in groups of 4 and choose one pollinator out of **Bees, Butterflies, Moths, Bats or Birds.**
- One student from each group to research/read about one of the following :

  - What kind of plants/ flowers does this specific pollinator like/ is attracted to? (physical characteristics and also names of actual flowers)

  - What specific (scientific name, not just long mouth) anatomical structures does this pollinator have that makes them different from the rest and how does this tie into what kind of flowers they like. Also this person should research how plants/ flowers grow.

  - What contributions does this pollinator have on the ecosystem/ biodiversity (pollinates food, spreads plants that feed/shelter other wildlife, ect…) (Use the readings and research to help!)

  - What are some efforts around the world, in Arizona and Tucson that are helping the protection of this specific pollinator (we have mentioned a ton in class but you can also research some). What are some locations we can find these pollinators (worldwide?, Arizona?)

<u>Section 1:</u> What kind of plants/ flowers does this specific pollinator like/ is attracted to? (physical characteristics and also names of actual flowers)

- Find 3 plants your pollinator is attracted to (name the flower it doesn't have to be the scientific name) (NOT FOOD, although for bats even though the cacti produce fruit its okay to put it on here)
    - Flower 1: _____
        - What color is flower 1:
        - What are some physical characteristics? (long, shorts, lots of flowers, no flowers, tubule?, fruit?, a tree? Does it smell?)
        - What kind of care does this flower need ? (how much watering, how much sunlight? Direct sunlight? shade? , ect...)
        - Does this flower attract any other pollinators that are different from your pollinator? If so which one(s):
- Flower 2: _____

- What color is flower 1:

- What are some physical characteristics? (long, shorts, lots of flowers, no flowers, tubules?, fruit?, a tree? Does it smell?)

- What kind of care does this flower need ? (how much watering, how much sunlight? Direct sunlight? shade? , ect…)

- Does this flower attract any other pollinators that are different from your pollinator? If so which one(s):

- Flower 3: _____

- What color is flower 1:

- What are some physical characteristics? (long, shorts, lots of flowers, no flowers, tubules?, fruit?, a tree? Does it smell?)

- What kind of care does this flower need ? (how much watering, how much sunlight? Direct sunlight? shade? , ect…)

- Does this flower attract any other pollinators that are different from your pollinator? If so which one(s):

Section 2: What specific (scientific name, not just long mouth) anatomical structures does this pollinator have that makes them different from the rest and how does this tie into what kind of flowers they like.

What is your pollinator? _____

Name 4 specific anatomical structures/features/characteristics of this pollinator that are different than other pollinators:

1: _____

- What is it used for?

- Why is it beneficial?

- How is it used to be a good pollinator

- Does it differ between species

1: _____

- What is it used for?

- Why is it beneficial?

- How is it used to be a good pollinator

- Does it differ between species

1: _____

- What is it used for?

- Why is it beneficial?

- How is it used to be a good pollinator ?

- Does it differ between species?

1: _____

- What is it used for?

- Why is it beneficial?

- How is it used to be a good pollinator

- Does it differ between species

Section 3: What contributions does this pollinator have on the ecosystem/ biodiversity (pollinates food, spreads plants that feed/shelter other wildlife, ect…) (Use the readings and research to help!)

What is your pollinator?_____

- What foods does your pollinator pollinate? (name 3)
    - Food 1: _____
        - Is your pollinator the only one who pollinates this food? If not, who else does?
        - Is this something we could grow without pollinators?
    - Food 2: _____
        - Is your pollinator the only one who pollinates this food? If not, who else does?
        - Is this something we could grow without pollinators?
    - Food 3: _____
        - Is your pollinator the only one who pollinates this food? If not, who else does?

- Is this something we could grow without pollinators?

What else does your pollinator do for the ecosystem ? (spreads plants that feed/shelter other wildlife, ect…)

Section 4:What are some efforts around the world, in Arizona and Tucson that are helping the protection of this specific pollinator (we have mentioned a ton in class but you can also research some). What are some locations we can find these pollinators (worldwide?, Arizona?)

What's your pollinator? _____

Name 3 efforts either around the world or in Arizona that are helping with the conservation of your pollinator. (at least one in arizona)

Effort 1: _____

- Where is it located?(be as specific as possible, if in Arizona, which city, is it in Tucson? Where in Tucson? The University of Arizona?)

- What exactly do they do?

Effort 2: _____

- Where is it located?(be as specific as possible, if in Arizona, which city, is it in Tucson? Where in Tucson? The University of Arizona?)

- What exactly do they do?

Effort 3: _____

- Where is it located?(be as specific as possible, if in Arizona, which city, is it in Tucson? Where in Tucson? The University of Arizona?)

- What exactly do they do?

Peer Evaluation Form for Presentation

Presenters Names: _____

_____

Evaluator's Name: _____

1. Provide feedback pertaining to something you liked or thought was specifically well done while they presented. Be specific.

_____

_____

_____

2. Provide feedback pertaining to something that could be enhanced or improved. Be specific.

_____

_____

_____

3. What was the most interesting fact that you learned from this presentation?

_____

_____

_____

Rate the overall effectiveness of the presenters speaking ability:

Excellent Good Fair Poor