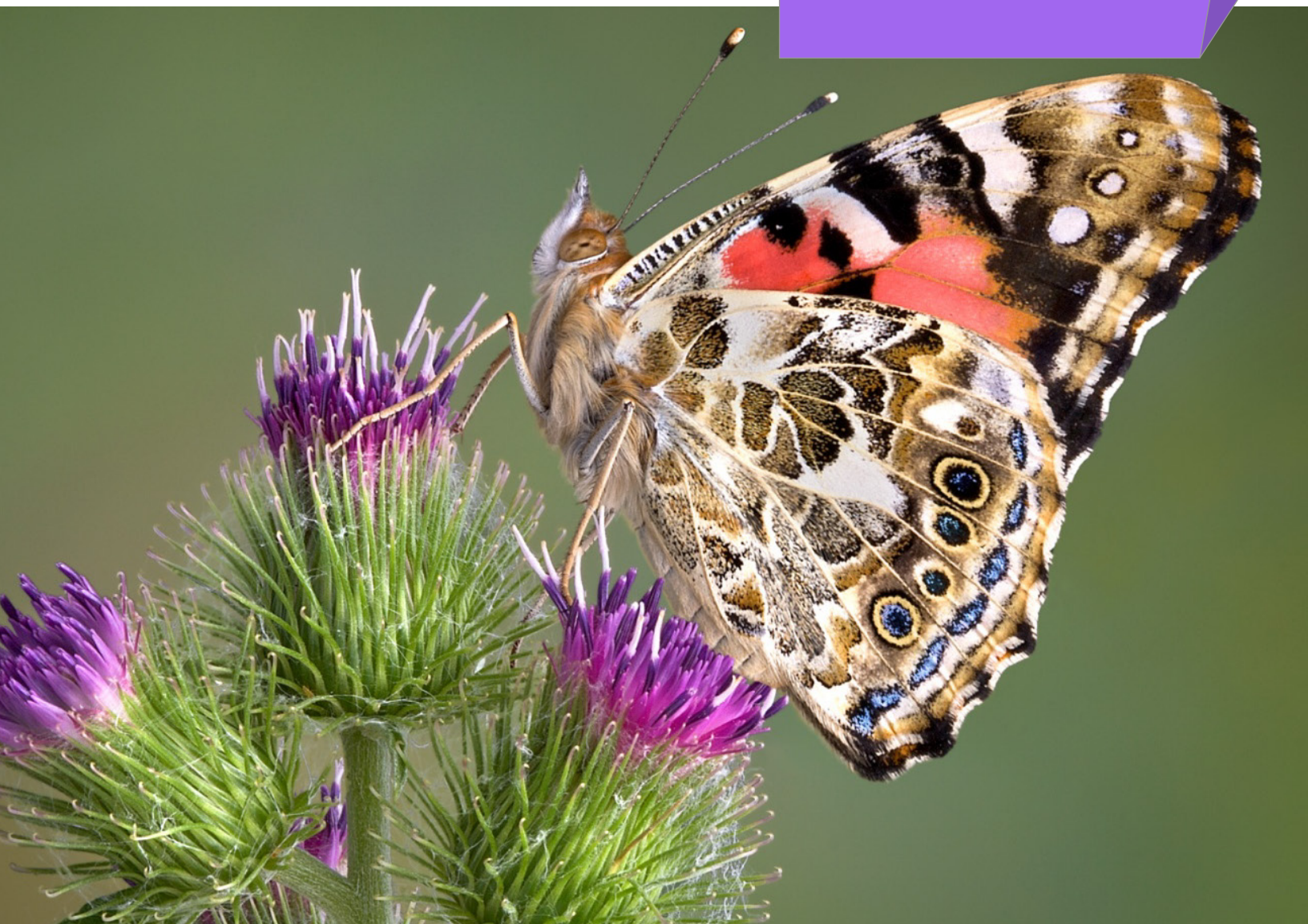
6 Plant and Animal Relationships

At-a-Glance:

In the last unit, students investigated whether plants need light and water to grow, and then explored how flowers have specific structures that help them attract pollinators to make seeds. In this unit, students focus on one kind of pollinator—the butterfly. They observe butterflies moving through their life cycle and then create a model butterfly to observe its different parts. Students apply what they know to design a hand pollinator.

Common Misconceptions:

- **Misconception**: Animals don't need plants to survive.
  - ✓ **Fact**: Animals cannot live without plants. Plants give animals food and shelter.
- **Misconception**: Plants don't need animals to survive.
  - ✓ **Fact**: Plants and animals depend on each other. One reason that many plants need animals is for pollination.
- **Misconception**: Engineers never look to nature to come up with design solutions.
  - ✓ **Fact**: Engineers often use nature as a guide, mimicking different plant or animal structures to serve a particular function in a design solution.



A Breakdown of the Lesson Progression:

1

Butterfly Life Cycle

Students begin this unit by focusing on how butterflies undergo metamorphosis as they move through their life cycle. Students observe the different stages of painted lady butterflies as they develop and grow.

2

Butterfly Structure and Function

Once students observe how butterflies change as they grow, they create a model of an adult butterfly, exploring the relationship between a butterfly's different body parts and its ability to get what it needs from the environment to survive.

3

Engineering Hand Pollinators

In the third lesson, students apply what they have learned about plants, animals, and pollination to design a hand pollinator that mimics the body structures of a pollinator to move pollen from one flower to another.

Unit 6: Plant and Animal Relationships

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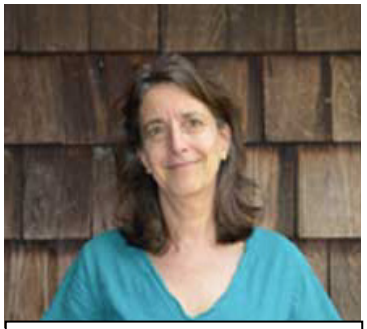
Unit 6:

Plant and Animal Relationships

Unit Overview:

When caterpillars turn into butterflies or moths, they undergo a dramatic transformation. They change from a worm-like animal that crawls on leaves and branches into a winged animal that flies from flower to flower.

Martha Weiss wondered whether butterflies and moths can remember things they learned when they were still caterpillars. Weiss is a scientist who studies insect behaviors and plant and animal relationships. She designed an experiment to test the memory of one kind of moth, and discovered that the moths retained memories from when they were caterpillars.



This is Martha Weiss.

In this unit, students continue to learn about living things, focusing on animals. They begin by observing the metamorphosis of a butterfly and then model the parts of a butterfly that help it survive in its environment. They end by applying what they know about pollination to design a self-pollinating technology.

Unit Goals:

1. Construct an argument with evidence about what animals need to survive and grow, including food and water.
2. Use observations to explain how the different parts of an animal work together to help it survive.
3. Develop a prototype that pollinates plants by applying knowledge of how pollinators move pollen.

Applying Massachusetts Science and Technology/Engineering (STE) Standards:

This unit covers the following **Massachusetts STE Standards**. Each standard includes where it is found in the unit, as well as how it applies the relevant disciplinary core ideas (listed in orange). **Note: Science and engineering practices are listed separately because multiple practices are incorporated into every unit.*

Grade-Specific Standards:

2-LS2	**Ecosystems: Interactions, Energy, and Dynamics**
2-LS2-3 (MA).	**Develop and use models to compare how plants and animals depend on their surroundings and other living things to meet their needs in the places they live.** **Interdependent Relationships in Ecosystems:** In Lessons 1 and 2, students analyze the body parts of butterflies to explore how they pollinate plants. In Lesson 3, students use what they know about plant structures and pollinators to design a model hand pollinator. Lessons 1, 2, and 3

ETS1	**Engineering Design**
2.K-2-ETS1-3.	**Analyze data from tests of two objects designed to solve the same design problem to compare the strengths and weaknesses of how each object performs.** ▪ **Optimizing the Design Solution:** Students use what they learn when they test their first prototype to make improvements to create their second and third prototypes. Lesson 3

Science and Engineering Practices

Students use the following science and engineering practices in the unit's lessons.

Lesson 1: Butterfly Life Cycle

2. Developing and using models

- Students create a diagram of the painted lady butterfly at each state in its life cycle to see how it changes as it moves from birth to death.

3. Planning and carrying out investigations

- Students use their magnifying glasses to observe the painted lady caterpillars as they progress through each stage of their life cycle.

4. Analyzing and interpreting data

- Students record the date the caterpillars arrive, the date they start to hang from the top of the container, and the dates for the pupa and adult stages.

6. Constructing explanations (for science) and designing solutions (for engineering)

- Students use their observations to help them construct an explanation about how butterflies are living things because they grow and change over time.

7. Engaging in argument from evidence

- At the end of the butterflies' life cycle, students come together as a class to respectfully argue about what they observed and concluded as a result of their observations.

8. Obtaining, evaluating, and communicating information

- Students use information from the student reader and their own observations to evaluate what butterflies need to survive—such as air, water, and food—and how butterflies are different from plants.

Lesson 2: Butterfly Structure and Function

2. Developing and using models

- Students create butterfly models to help them answer the following question: "How do a butterfly's external parts help it survive in its environment?"

6. Constructing explanations (for science) and designing solutions (for engineering)

- Students use their models to construct a verbal explanation about how each body part they modeled has a specific function that helps the butterfly survive, including finding food and shelter and avoiding predators.

7. Engaging in argument from evidence

- Students present their butterfly model to the class, using what they know about the needs of all living things to describe how the butterfly's body parts help it grow and meet its needs.

8. Obtaining, evaluating, and communicating information

- Students use information from the trade book, student reader, and their own model to communicate with their peers and the teacher about how animals such as butterflies use their external body parts to survive.

Lesson 3: Engineering Hand Pollinators

1. Asking questions (for science) and defining problems (for engineering)

- Students summarize a problem presented in an engineering scenario, which is that insects are not pollinating the flowers in Kia's garden. Students then identify the correct solution criteria (the requirements of the solution) and solution constraints (ways the solution is limited).

2. Developing and using models

- Students draw a visual model (scientific diagram) of their chosen prototype solution. Students use their diagram as a guide for creating their hand pollinator prototype.

3. Planning and carrying out investigations

- Once students build their hand pollinator prototype, they test it to determine how well it solved the problem, meeting the criteria within the constraints.

4. Analyzing and interpreting data

- Students collect and analyze data on how many pollen grains they could pick up with each of their prototype solutions, looking for evidence in their data about which prototype best solved the problem.

6. Constructing explanations (for science) and designing solutions (for engineering)

- Students use the data they gather from their first prototype solution to

improve their second prototype so that it better solves the problem. They repeat this process with a third prototype. Students then evaluate their prototypes to explain how well the prototypes solved the problem given the criteria and constraints of the problem.

7. Engaging in argument from evidence

- Student teams present to the class their explanation about whether they would refine (change) or replicate (use/keep) their prototype design. Different teams engage in argument about which features best solved the problem, as well as any challenges they encountered.

8. Obtaining, evaluating, and communicating information

- Students use information from their readers and class dialogue to design a prototype that can pollinate plants by transferring grains of pollen from one flower to another. They then communicate their results to the class, drawing conclusions about how people can solve problems with technology.

Unit 6 Pacing Guide Example

All KnowAtom units are designed to take approximately one month. Lessons may span one or two weeks. This pacing guide provides one example for how to break down the lessons in this unit over a month. **Breakdown in this guide is based on 30- to 40-minute class periods.** Communities that have longer or shorter class periods or schedules where science class occurs more frequently can modify this guide accordingly.

Any days in this guide that appear unused take into account months with holidays, vacations, times when an experiment, engineering, and/or investigation takes longer to complete, and/or days when science class does not occur.

Unit 6: Plant and Animal Relationships*				
Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Week 1				
Non-Science Day	**Lesson 1** **Start:** As a class, read the trade book during circle time and have a dialogue to gauge student comprehension. **Final Goal:** Complete trade book reading and circle-time dialogue.	**Lesson 1** **Start:** As a class, read Section 1 of the KnowAtom student reader. **Final Goal:** Transition to Socratic dialogue.	**Lesson 1** **Start:** Socratic dialogue. **Final Goal:** Set up the butterfly caterpillars in the observation habitat. Students carry out ongoing observations.	**Non-Science Day**
Week 2				
Non-Science Day	**Lesson 2** **Start:** As a class, read Section 2 of the KnowAtom student reader. **Final Goal:** Transition to Socratic dialogue.	**Lesson 2** **Start:** Socratic dialogue. **Final Goal:** Transition to the investigation.	**Lesson 2** **Start:** Students create butterfly models. **Final Goal:** As a class, discuss student models, wrap up the investigation, and debrief.	**Non-Science Day**

Week 3				
Non-Science Day	**Lesson 3** **Start:** As a class, read Section 3 of the KnowAtom student reader. **Final Goal:** Transition to Socratic dialogue.	**Lesson 3** **Start:** Socratic dialogue. **Final Goal:** Transition to the engineering problem/scenario.	**Lesson 3** **Start:** Students carry out the problem through possible solutions steps of the engineering process. **Final Goal:** Discuss student possible solutions.	**Non-Science Day**
Week 4				
Lesson 3 **Start:** Students carry out the diagram and build steps of the engineering process. **Final Goal:** Test Prototype 1.	**Lesson 3** **Start:** Students improve their designs, build and test Prototypes 2-3. **Final Goal:** Teams collect test data for Prototypes 2-3.	**Lesson 3** **Start:** Teams complete "refine or replicate" steps of engineering process. **Final Goal:** As a class, discuss the results of the engineering challenge, wrap-up/de-brief.	**Non-Science Day**	**Non-Science Day**

*Order butterfly caterpillars for Lesson 1. See Lesson 1 for ordering details.

Science Words to Know:

Use the blank concept map visual to connect vocabulary once the unit is complete. An example concept map is displayed in Appendix 3.

1. **abdomen** – the back segment of an insect where the stomach is

2. **antennae** – body parts of insects that are used to smell, touch, and taste things

3. **larva** – an insect's young, worm-like form; a caterpillar for butterflies and moths

4. **pupa** – the inactive stage of an insect when it changes; does not eat

5. **head** – the front segment of an insect where the antennae, mouthparts, and eyes are found

6. **life cycle** – the stages an organism passes through on its way from birth to death

7. **metamorphosis** – when a living thing completely changes its form from one stage to the next in its life cycle

8. **thorax** – the middle segment of an insect where the legs and wings are found

Teacher Background

How a Butterfly Changes as It Grows

Weiss was curious about the memory of butterflies and moths because they undergo a complete metamorphosis. **Metamorphosis** happens when a living thing completely changes its form from one stage to the next in its life cycle. A **life cycle** is the stages a living thing goes through on its way from birth to death.

The life cycle of a butterfly includes four stages. In the first stage, an adult female lays tiny, round eggs scattered or clustered together on a host plant that will later become food for her offspring. Every type of butterfly or moth egg takes a different amount of time to hatch.

When the eggs hatch, larvae emerge. The **larva** is an insect's young, worm-like form. The larvae of butterflies and moths are caterpillars. The caterpillar exists to eat, only taking breaks to defecate or shed its skin (molt) and grow larger.

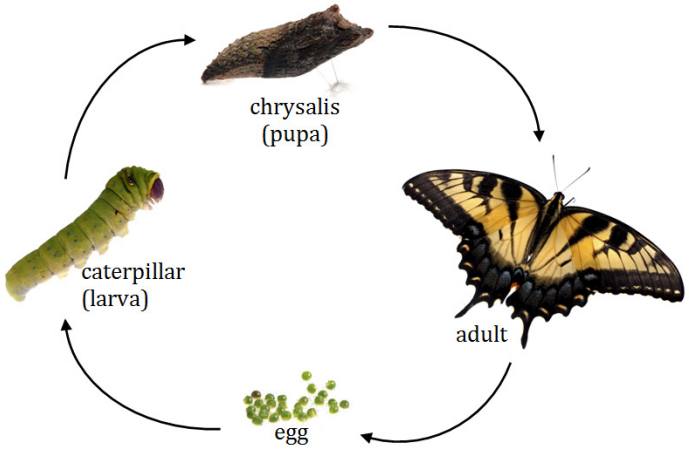
When the caterpillar finishes growing, it encloses itself in a protective skin (called a chrysalis for butterflies) and becomes a pupa. The **pupa** is the inactive stage of an insect and it doesn't eat, but inside, the entire structure of the caterpillar is changing. Its organs are breaking down, and it is re-forming into a butterfly or moth.

The adult butterfly or moth emerges from the pupa swollen and shriveled. It takes a few hours to expand and dry its wings. Although the wings are hard, they are still light, flexible, and strong enough to keep the insect's body in the air. The wings are also covered with thousands of tiny hairs that give the butterfly or moth its color pattern. It is then ready to fly, mate, and lay eggs, starting the life cycle over again.

The changes that butterflies and moths go through are so dramatic that Weiss uses the analogy of making soup. "The caterpillar turned to minestrone and those ingredients that made up the caterpillar were completely reorganized into a butterfly that threw away the leftovers that it didn't need from the soup and was off," Weiss told NPR in a 2008 interview.

Body Structures of a Butterfly

Weiss and a team of researchers wanted to know whether memories were kept during this metamorphosis. They conducted an experiment in which they exposed a group of caterpillars to a specific smell. At the same time as they were exposed to the smell, the researchers gave the caterpillars a brief shock so they learned to associate the smell with the shock. It didn't take long for the caterpillars to avoid that specific smell.



A butterfly's life cycle includes a metamorphosis.

The researchers then let the caterpillars move through their life cycle, becoming pupa. Five weeks later, moths emerged. Researchers sprayed the same smell, and the moths avoided it, just as they had as caterpillars. This told the researchers that the moths still had the memory of the shocks created when they were caterpillars.

Butterflies have different parts to help them survive.

Moths and butterflies don't have noses to detect smells. Instead, they use **antennae**, which are thin, wispy structures on their heads that they use to smell, taste, and touch things around them. Moths and butterflies also have large compound eyes for seeing.

Butterflies and moths also have a straw-like tube called a proboscis that they use to suck in nectar, which is the preferred food choice of many butterflies and moths. The proboscis is long and curled, and it unfurls when butterflies reach deep into plants to get nectar.

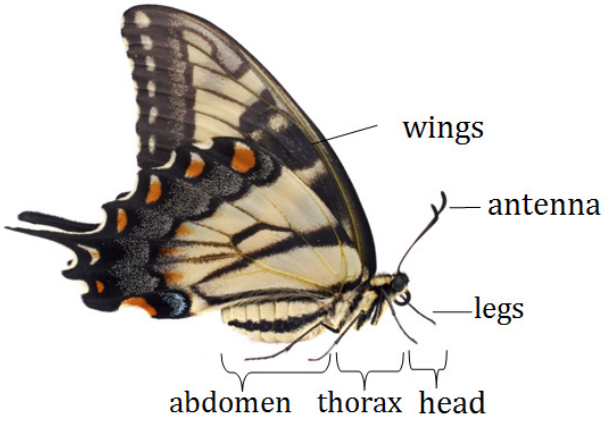
Butterflies are Insects

Butterflies and moths are kinds of insects. Like all insects, they have three body segments, six legs, and an exoskeleton.

The three body segments are the head, the thorax, and the abdomen. The **head** is the front segment of an insect. It holds an insect's antennae, eyes, and mouthparts, including the proboscis.

The middle segment of all insects is called the **thorax**. The thorax holds the insect's six legs and its wings. Some insects have one pair of wings, while other insects have two pairs. Butterflies and moths can hear sounds with their wings. The back segment is the **abdomen**, and it is where the insect's stomach is.

All insects also have an exoskeleton, which is a hard covering that covers their entire body like skin, and protects and supports them.



the body parts of a butterfly

Butterflies and moths are both pollinators. As they stand on flowers to eat, pollen gets on their legs and body. When they fly to another flower, pollen drops off, making new seeds.

Butterflies aren't as good of pollinators as bees or moths are because pollen doesn't stick as well to them. Moths are better pollinators because they collect pollen with their mouth-parts.

Structures of Pollinators

Bees are useful pollinators.

Bees are among the most effective pollinators. Honeybees play an important role in agriculture because they pollinate the flowers of one third of all fruits and vegetables that we eat. They contribute to more than $14 billion of U.S. crop production, pollinating crops of almonds, blueberries, melons, broccoli, and apples. Because of their important role in the food chain, there are an estimated 2.4 million honeybee colonies in the U.S. today. Two-thirds of those colonies travel the country each year pollinating crops and producing honey and beeswax.

Bees have different body parts that collect pollen.

Bees have different body structures that make them such effective pollinators. They are covered with many small hairs, making them fuzzy so pollen sticks to them as they eat the nectar of flowering plants. Female bees also have a basket on their back legs for holding pollen.

Some birds are also pollinators. Hummingbirds are one kind of pollinator. They have long, thin beaks that they use to reach their beaks into flowers to get nectar. Pollen gets on their faces, and then drops off when they fly to another plant.

Hummingbirds are also pollinators.

Lesson 1: Butterfly Life Cycle

Objective: Students raise a class set of butterfly caterpillars to observe how they change throughout their life cycle.

Materials:

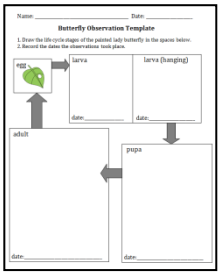
Consumable

A. Goggles – 1 per student
B. "Butterfly Observation Template" – 1 per student (student reader)
C. Butterfly larvae (caterpillars) – (LIVE MATERIAL)
D. Safety pins – 3 per class (teacher use)

Non-Consumable

E. Butterfly observation habitat – 1 per class
F. Magnifying glasses – 1 per student
G. Book: "A Butterfly's Life" by Dona Herweck Rice
H. Living Things Grow Visual – (not shown)
I. How a Butterfly Grows Visual – (not shown)

A 

B 

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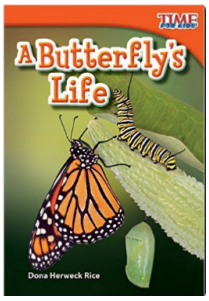
G 

Teacher Preparation:

- Download visuals from the KnowAtom Interactive website.
- In this lesson, students carry out ongoing butterfly observations as they observe caterpillars transform into

butterflies. Move onto the next lesson after the butterfly habitat has been set up with the caterpillars.

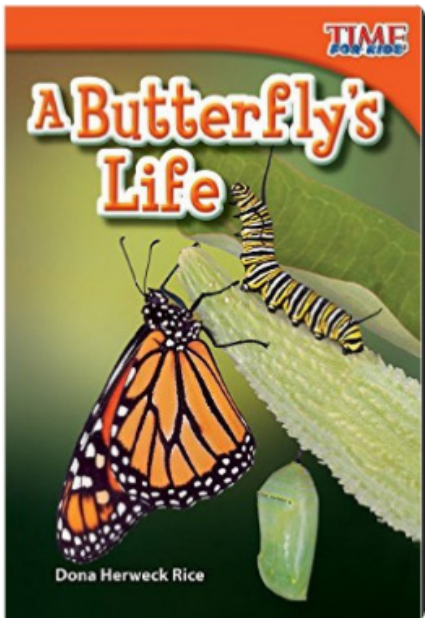
- Go to the KnowAtom Interactive website to fill out a live materials request form to order caterpillars for your class. Allow a minimum of <u>two weeks</u> for shipment and delivery. Live materials are only shipped on Mondays. In some cases, extreme weather conditions (storms or low temperatures) can delay butterfly arrival by an extra week.
- When the caterpillars arrive, set up the butterfly habitat with your class:
  - The painted lady caterpillars will arrive in a small container. Caterpillars should be kept in their container until they change into their chrysalides. Keep the container upright and out of direct sunlight during this time. The caterpillars will have adequate food for survival and do not need water.

  - The caterpillars will attach themselves to the paper at the top of the container when they change into chrysalides.
  - When all larvae have changed, remove the paper with chrysalides attached from the container. Carefully pin the paper several inches above the floor of the butterfly observation habitat using safety pins. If any chrysalides detach in the process, gently place them on a paper towel on the habitat floor.

  - Place the butterfly observation tent on a table where it will not be disturbed. Clean sticks can be added to the habitat for butterflies to rest on. The butterflies will emerge after 7-10 days.

<u>Circle-Time Dialogue</u>:

Read aloud Dona Herweck Rice's "A Butterfly's Life." This book uses big pictures and simple sentences to introduce readers to a butterfly's life cycle. Ask questions such as:



1. What is the main topic of the book, and what details support this main topic? [*The main topic is to describe how a butterfly changes as it grows. This topic is supported with pictures that show each change, as well as a description of the change.*]

2. How do all of the pictures in the book help to support the main topic? [*The pictures show visually how much a butterfly changes from the time it is born to the time it becomes an adult.*]

3. There is a picture on page 11 of a pupa. What does this picture tell us? [*The picture shows us what a pupa looks like. We can also see the outlines of a butterfly inside it. This is because the caterpillar has changed into a butterfly inside the pupa.*]

4. What happens to the butterfly once it breaks out of the pupa (pages 13-16)? [*Adult butterflies fly around and they eat all day. They also lay new eggs that will become butterflies.*]

Student Reading Preparation:

- Read Section 1 of the student reader together as a class before the Socratic dialogue and activity portion of the lesson. Model how to read closely for understanding. For example:
    - Emphasize connections between examples in the reading and broader concepts. For example, ask why a certain example was used to support the reading's main point.
    - Use "why" and "how" questions to connect ideas in the reading to student experiences.

Socratic Dialogue:

- The Socratic dialogue serves as the bridge between the nonfiction reading and the activity portion of the lesson.
- The example Socratic dialogue describes one possible progression of ideas to engage students in higher order thinking. Blocks are used to divide the dialogue according to key organizing concepts. They are not meant to indicate how much time a dialogue should take; length of time may vary depending on the subject matter and student understanding of the concepts. Note that in a Socratic dialogue, the teacher is not the only one asking questions and challenging ideas. Students should be actively engaged in proposing questions, challenging assumptions, and using evidence to support their arguments. *Not sure how to set up a Socratic dialogue? Check out www.knowatom.com/socratic for an in-depth look at how to hold a next generation Socratic dialogue in the classroom.*

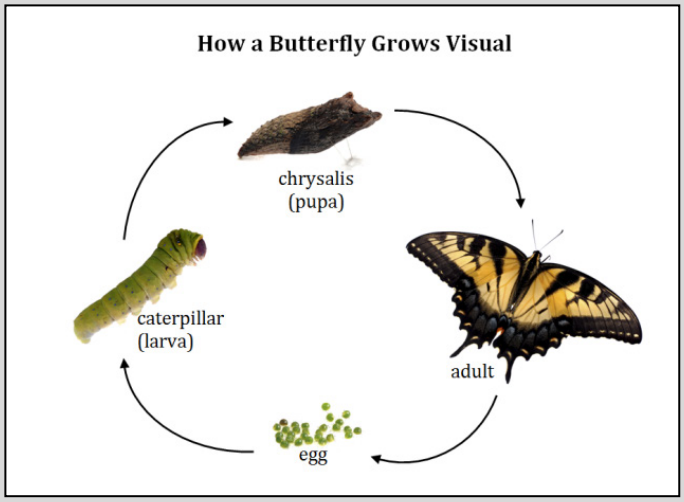
Block 1: Butterflies Change

1. Display *Living Things Grow Visual*. Begin a dialogue with students that connects the last unit, which focused on what plants need to grow, with this lesson, which focuses on the changes that butterflies experience as they grow.

- **Big Idea 1:** Coach students toward the idea that one of the reasons we know that butterflies are living things is that they grow as they move through their life cycle. For example:
  - *Ask one student what happens to people as we grow. (As we grow, our body parts, such as legs and arms, get bigger but they don't change their form. Children have the same basic body form as adults.)*
  - *Ask another student how the top photo in the visual supports this argument. (The photo shows children of different ages. They all look similar. They have arms and legs, similar noses, eyes, mouths, etc. The biggest difference is their size—the oldest child is bigger than all of the other children.)*
  - *Ask another student how the way that people grow is different from how butterflies grow. (Butterflies and moths go through a complete change as they grow. A young butterfly doesn't look like an adult butterfly.)*
  - *Ask the first student how the plants in the last unit grew. (The plants began as seeds. With enough air and water, the seed grew roots, a stem, and leaves.)*

- *Ask another student what is happening in the bottom photo of the visual. (The bottom photo shows a plant growing from a seed to an adult plant. The plant grows new parts as it gets bigger.)*
- *One at a time, provide multiple students with the chance to respond to this question so that students are connecting their observations of plant growth with the idea that animals such as butterflies also change as they grow.*

2. Display *<u>How a Butterfly Grows Visual</u>*. Have a dialogue with students about how the life cycle of a butterfly has four stages: egg, larva, pupa, and adult.



- **<u>Big Idea 2</u>:** Coach students toward the idea that unlike people or plants, butterflies go through **metamorphosis**, which happens whenever a living thing completely changes its form from one stage to the next in its life cycle. For example:
  - *Ask one student how a caterpillar is connected to a butterfly. (Caterpillars are the young form of butterflies. Caterpillars are **larvae**, which are young, worm-like forms of insects. Over time, the caterpillar will turn into a butterfly.)*
  - *Provide multiple students with the chance to respond to this question if students are struggling to explain the relationship between a caterpillar and a butterfly.*
  - *Ask another student what has to happen before a caterpillar can turn into an adult. (The caterpillar has to*

become a pupa. It does this after it grows big enough, by covering itself with a protective skin.)

- *Ask the first student what happens during the pupa stage. (Even though we can't see what is happening just by looking at the pupa, inside the pupa all of the parts of the caterpillar are changing as it develops the parts to become a butterfly.)*
- *Ask another student how a butterfly looks different from a caterpillar. (The caterpillar looks like a worm. It crawls on things. The butterfly doesn't look like a worm. It has wings so it can fly.)*

<u>Investigation</u>: **Butterfly Observations** (ongoing)

1. This investigation should take place when the butterfly caterpillars arrive and they have been set up in the classroom (see section in the "Teacher Preparation" for more information). Students use their magnifying glasses to observe the painted lady caterpillars in the containers as they progress from caterpillar to pupa. Once the caterpillars have pupated, students can observe them in the butterfly observation habitat.

2. As the caterpillars change, students use their "Butterfly Observation Templates" to diagram each life cycle stage observed. For the larva stages, record the date the caterpillars arrive and the date they start to hang from the top of the container. Record the dates for the pupa and adult stages as well. Move onto the next part of the lesson as the butterflies continue to change and grow. Students revisit their Butterfly Observation Templates to add a new diagram each time the caterpillars complete a life cycle stage.

NOTE: The little balls that appear all over the cup are caterpillar excrement, called frass. Caterpillars shed their exoskeletons several times. You may see small black balls of exoskeletons in the cup or attached to the end of the chrysalis. Students may also notice that the chrysalis quivers or trembles when they watch it closely. These movements discourage predators in nature. The reddish fluid that butterflies expel when they emerge from their chrysalises is called meconium. It's a waste product left over from metamorphosis.

Handling Note: The butterflies will emerge from their chrysalises in approximately 7 to 10 days. It takes the butterflies an hour or two to dry off and stretch their wings. When their wings harden, butterflies are ready to fly. Sometimes a butterfly doesn't emerge completely from its chrysalis. In these cases there is nothing you can do to help. Depending on the regulations in your state, the butterflies can be released outside (if weather permits). If not, keep the butterflies in their habitat to observe and feed. Butterflies can live as long as a month or more indoors.

<u>To feed butterflies:</u>
Create "nectar" with 1 teaspoon of sugar dissolved in ½ cup tepid water in a small cup. Roll a 5"x 7" piece of paper towel to make a wick long enough to hang over the edge of the cup. You may also feed them fresh fruit. Slices of orange or watermelon are best.

<u>Wrap-Up</u>:

Begin a dialogue with students to review their observations of the painted lady butterflies as they moved through their life cycle. For example:

- Ask one student if they were surprised by any of their observations. [*Answers will vary. The main goal is to get students talking about their observations. For example, students may have been surprised to see the pupa vibrate or that the butterfly's wings are very weak when they first emerge from the pupa.*]
- One at a time, provide multiple students with the chance to respond to this question.
- Ask another student what they observed caterpillars doing for the majority of time. [*They eat.*]
- Ask the first student why caterpillars eat so much. [*They need to store enough food to get them through the pupa stage since they cannot eat as pupae.*]
- Ask another student how they knew when the caterpillars were about to change into chrysalides. [*They attached to the paper at the top of the container and didn't move anymore*.]
- Ask the first student what happened when it was time for the chrysalides to turn into butterflies. [*The chrysalides got darker. When it was time for the butterflies to emerge, the chrysalides opened and the butterflies came out. They had to hang for a couple of hours while their wings dried and straightened out.*]
- Ask another student how adult butterflies get the energy they need to survive. [*They eat flower nectar using their proboscis.*]

Name: _____ Date: _____

Butterfly Observation Template

1. Draw the life cycle stages of the painted lady butterfly in the spaces below.
2. Record the dates the observations took place.

egg

larva

date:_____

larva (hanging)

date:_____

adult

date:_____

pupa

date:_____

Lesson 2: Butterfly Structure and Function

Objective: Students create model butterflies to examine how their external structures help them survive in their environment.

Materials:

Consumable

A. Goggles – 1 per student
B. Colored paper sheets – 2 per student
C. Pom-poms – 2 per student*
D. Black foam sheets – 1 per student
E. Black pipe cleaners – 3 per student
F. Yellow pipe cleaners – 1 per student
G. White poster paper – 1 per student

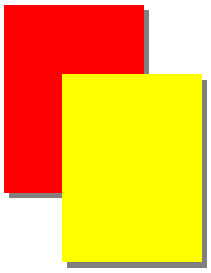
Non-Consumable

H. Parts of a Butterfly Visual – (not shown)

Teacher Tool Kit

I. Scissors – 1 per student
J. School glue – 1 per student
K. Markers – shared
L. Invisible tape – shared

A 

B 

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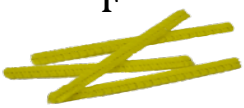
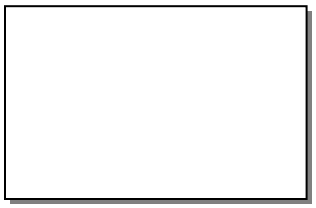
F 

G 

I 

J 

K 

L 

* Pom-pom colors may vary from what is shown.

Teacher Preparation:

- Download visuals from the KnowAtom Interactive website.

- Arrange several pick-up stations for students to collect materials during the butterfly model investigation in the lesson:
  - Pick-Up Station 1: colored paper (two different colors), white poster paper, and black fun foam sheets
  - Pick-Up Station 2: scissors, school glue and invisible tape
  - Pick-Up Station 3: pipe cleaners (black and yellow), pom-poms, and markers

Student Reading Preparation:

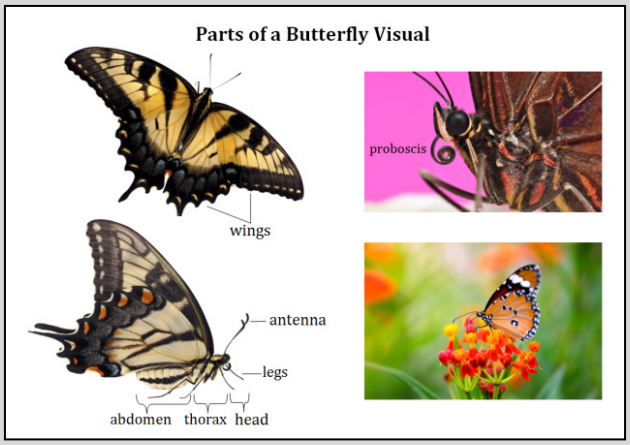
- Read Section 2 of the student reader together as a class before the Socratic dialogue and activity portion of the lesson. Model how to read closely for understanding. For example:
  - Emphasize connections between examples in the reading and broader concepts. For example, ask why a certain example was used to support the reading's main point.
  - Use "why" and "how" questions to connect ideas in the reading to student experiences.

Socratic Dialogue:

Block 2: Structure and Function of Butterflies

1. Display *Parts of a Butterfly Visual*. Continue the dialogue from the last lesson, focusing on how butterflies have specific parts that help them get what they need from their surroundings.

- **Big Idea 3:** Coach students toward the idea that



because they are animals, butterflies have body parts to help them survive in their environment. For example:

- *Ask one student what food butterflies eat. (Many butterflies eat nectar that flowers make. Nectar is a sugary liquid.)*
- *Ask another student what body part helps butterflies eat nectar. (They use a body part on their head called a proboscis. The proboscis has a tube shape. It is curled.)*
- *Ask the first student how the shape of the proboscis lets butterflies get nectar. (It is long so it lets butterflies reach deep in the plant to get nectar.)*
- *Ask another student how nectar helps butterflies survive. (Food gives butterflies energy, which all living things need to survive. Nectar also gives butterflies the water they need to survive.)*
- *Ask the first student how butterflies find food. (Butterflies have **antennae** on their heads, which they use to smell, taste, and touch things. They also have big eyes for seeing. They use their eyes and antennae to help them find food.)*
- *Ask another student where the antennae, eyes, and proboscis are located on butterflies. (They are located on the **head**, which is the front segment of all insects.)*
- *Ask the first student what other body part helps butterflies eat once they find food. (Butterflies use their legs to taste things. They also use their legs to stand on flowers as they eat.)*
- *Ask another student where the legs are found on a butterfly. (The legs are found on the thorax, which is an insect's middle segment.)*
- *Ask the first student where the food goes in a butterfly's body once it eats. (The food goes to the stomach, which is in the back segment of an insect, called the **abdomen**.)*

Investigation: Butterfly Models

SAFETY: Students must wear goggles during this activity.

1. Frame the investigation by briefly explaining that students will create butterfly models to explore the following question: "How do a butterfly's external parts help it survive in its environment?" Students can use Section 2 in their student readers for reference when identifying and modeling different body parts/structures of a butterfly.

2. Stand by the materials stations and explain how the materials will be used and the amount each student will receive. Students will go to stations to collect the materials they will use at their desks.

Pick-Up Station 1:

- white poster paper – 1 per student
- colored paper sheets (yellow and red)– 1 each per student
- black foam sheets – 1 per student

Pick-Up Station 2:

- scissors – 1 per student
- school glue – 1 per student
- invisible tape – shared

Pick-Up Station 3:

- black pipe cleaners – 3 per student
- yellow pipe cleaners – 1 per student
- pom-poms – 2 per student
- markers – shared

Explain that each student will:

- Use the available materials and tools (glue, scissors, markers, and tape) to create a butterfly model on the poster paper.

1. Use Section 2 in the student reader to help you identify the different parts of a butterfly.
2. Use a marker to label the parts of the insect and create a title for the model on the poster.

NOTE: Students do not need to use every available material in their models. Encourage students to look at the available materials at the pick-up stations to determine which materials could be used to best represent their butterfly's external structures. In this investigation, avoid offering direct guidance for how to use the different materials. This will enable students to think through the development of their own models independently and give them more ownership over the process.

For teacher reference, here are some examples for how students can use the available materials:

- Black foam sheets can be used to represent the butterfly's body segments (head, thorax, and abdomen) or other unique structures.
- Black pipe cleaners can be used to represent legs and antennae.
- Yellow pipe cleaners can be used to represent the proboscis.
- Pom-poms can be used to model eyes.
- Colored paper can be used to represent wings.
- Markers can be used to add specific features (spots, stripes, colors) or different textures (hairs) to the model.

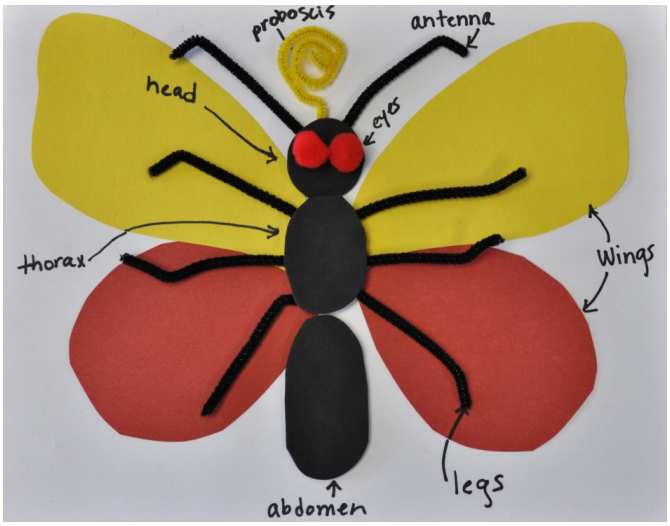


Photo shows one example of a student butterfly model.

3. Students collect their materials from the pick-up stations to create their models. Circulate throughout the classroom to ask questions to gauge student thinking as they model their butterfly with the available materials. Students can use the diagrams in Section 2 of their student reader for reference as they label each structure. Differences in student models are expected and encouraged.

4. When the butterfly models are complete and the body structures are labeled, students can write a description on their poster next to each labeled structure that briefly describes how the structure helps the butterfly survive in its environment. For example

- Eyes help the insect see.
- Legs help the insect move.
- Antennae help the butterfly feel, smell, and taste.
- The proboscis helps the butterfly drink nectar from flowers.

If needed, students should use their student reader for information about the functions of different structures.

<u>Wrap-Up</u>:

1. Begin a dialogue with students to review their butterfly models. For example:

- Ask one student to present their butterfly model to the class, describing the different parts on their model. [*Answers may vary depending on the specific model, but the main parts include the three segments (head, thorax, and abdomen); six legs; wings; antennae; eyes; and proboscis.*]
- Ask another student to present their butterfly model, highlighting similarities and differences with the first student's model.

2. Continue the dialogue with students, focusing on the relationship between each part and what the butterfly needs to survive. For example:

- Ask one student how they shaped their proboscis, and why they chose that shape. [*The proboscis has a curled tube shape. This allows the butterfly to reach into flowers to get nectar.*]
- Ask another student to model how the proboscis can reach into flowers. [*If students used a pipe cleaner, they can uncurl it so it stretches out, and they can see that it is long.*]
- Ask the first student why it was important to include antennae on the butterfly. [*The antennae are how the butterfly senses its environment, using them to taste, touch, and smell.*]
- Ask another student why it was important to include legs and wings on the butterfly. [*The wings and legs are how the butterfly moves around, which is important for finding food and shelter.*]

Lesson 3: Engineering Hand Pollinators

Objective: Students apply what they know about the structure of insects and pollination to design a hand pollinator for squash plants that mimics how insects pollinate plants.

Materials:

Consumable

A. Goggles – 1 per student
B. "Engineering #2" – 1 per student (student reader)
C. Paper clips – 5 per student
D. Cotton swabs – 4 per student
E. Craft sticks – 3 per student
F. Straws – 2 per student
G. Pom-poms – 2 per student
H. Cotton balls – 2 per student
I. Pipe cleaners – 2 per student
J. Fasteners – 1 per student
K. Clay – 1 piece per student
L. Plastic cups – class set
M. Felt – 1 per student
N. Squash Flower Test Templates – 1 per student
O. Flower Template – 1 per test tube (teacher use)

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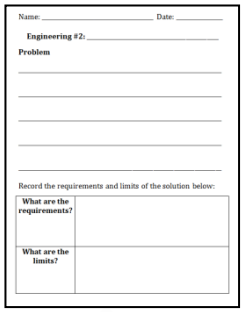
B 

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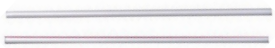
F 

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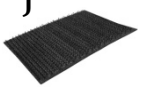
J 

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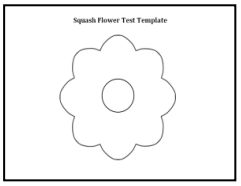
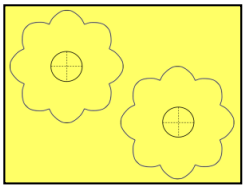
N 

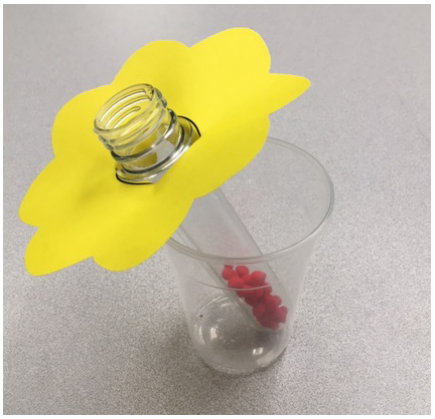
O 

Non-Consumable
P. Mini pom-poms – class set
Q. Plastic test tubes – class set
R. Engineering Scenario #2 Visual – (not shown)
S. Pollinators Visual – (not shown)

Teacher Tool Kit
T. Scissors – 1 per student
U. Invisible tape – 1 per team

Teacher Preparation:

- Download the visuals from the KnowAtom Interactive website.
- Set up the squash flower models for the lesson:
  1. Cut out the flower outlines from the yellow Flower Templates.
  2. Cut along the dotted lines in the center of the each cut-out flower outline.
  3. Slide one test tube through each cut-out in the flower outlines. Tape the flower cut-outs to the test tubes. These are the squash flower models.



  4. Add approximately 40 mini pom-poms to each test tube to represent pollen grains.
  5. Put each test tube in one plastic cup. Position the squash flower models near the front of the class or in another area where they can be easily accessed.
- Arrange several pick-up stations for students to collect materials to use at their desks during the lesson. For example:

- Pick-Up Station 1: goggles, student readers, invisible tape, and scissors
- Pick-Up Station 2: paper clips, cotton swabs, and craft sticks
- Pick-Up Station 3: straws, pom-poms, cotton balls, and pipe cleaners
- Pick-Up Station 4: fasteners, clay, felt, and Squash Flower Test Templates

Student Reading Preparation:

- Read Section 3 of the student reader together as a class before the Socratic dialogue and activity portion of the lesson. Model how to read closely for understanding. For example:
  - Emphasize connections between examples in the reading and broader concepts. For example, ask why a certain example was used to support the reading's main point.
  - Use "why" and "how" questions to connect ideas in the reading to student experiences.

Socratic Dialogue:

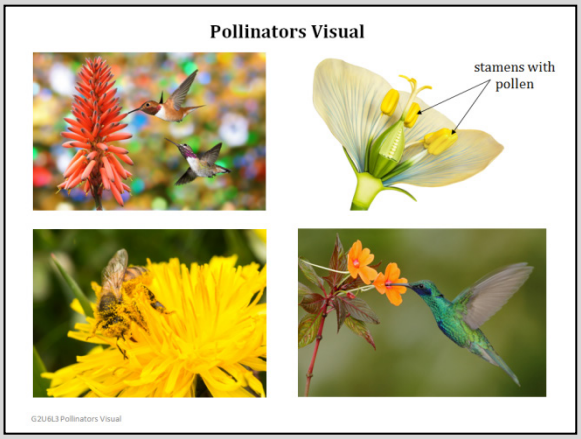
Block 3: Applying Knowledge of Pollination

1. Begin a dialogue with students that directs them toward thinking about how engineers can use what they know about different scientific concepts to design technologies that solve problems.

- **Big Idea 4:** Remind students that scientists and engineers are different, although they are connected. For example:
  - *Ask one student how engineers are different from scientists. (Engineers solve problems by designing technologies. Scientists answer questions using data from experiments.)*
  - *Ask another student to add to the first student's answer and to give an example of a problem that an engineer might solve. (There are many possible answers. For example, in*

the second unit of the year, students solved a problem of erosion washing away a hillside. They designed a prototype to solve this problem.)

2. Display *Pollinators Visual*. Continue the dialogue with students, bringing together what they have learned about the structure of plants, the need for pollination, how certain animals are pollinators, and engineering.



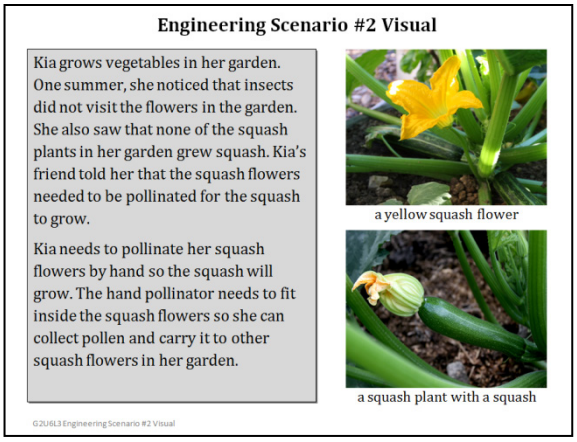
- **Big Idea 5:** Coach students toward the idea that many plants depend on pollination, which means they depend on the animals that pollinate the plants. For example:
  - *Ask one student what would happen to a plant if all of the pollinators suddenly disappeared. (The plant wouldn't be able to make new seeds. Flowers need pollen to make seeds. The pollen is made in one part of the flower (the stamens), and seeds are made in another part (the pistil). Pollinators move pollen from the stamens of one flower to the pistil of another.)*
  - *Ask another student to add onto what the first student said, supporting their argument with additional examples or respectfully contradicting it. Provide the first student with the chance to respond. Redirect if misconceptions arise.*
  - *Ask the first student why it's important that plants make seeds. (The seeds grow into new plants. Without seeds, plants wouldn't be able to continue their life cycle because no new plants would grow.)*
- **Big Idea 6:** Coach students toward the idea that engineers can use what they know about the relationship between plants and their pollinators to design technologies that mimic the structures of those pollinators. For example:

- *Ask one student how a bee's body makes it such a good pollinator. (Bees have fuzzy bodies because they are covered with many tiny hairs, and pollen sticks to these hairs.)*
- *Ask another student what the bee has to do for pollen to stick to it. (Pollen sticks to the bee's body as the bee eats nectar from the flower. It has to come into contact with the pollen for it to stick to its body.)*
- *Ask the first student what other body part the bee has that helps it collect pollen. (It has a pollen basket on its back legs.)*
- *Ask another student how the body parts of a hummingbird, another pollinator, are different from those of a bee. (Hummingbirds have long, thin beaks that they can reach deep into a flower to get nectar. When they do this, pollen gets on their faces and they carry it to other flowers, where it drops off.)*
- *Ask the first student what the examples of the bee and the hummingbird show about the relationship between a pollinator's body parts and its ability to collect pollen. (The pollinator's body parts are what cause it to collect pollen and carry it to new flowers.)*
- *Transition to the engineering lab by asking another student what kinds of things an engineer who wants to design a technology that copies how a pollinator collects and carries pollen from plant to plant would want to think about. (There is no right answer here. The goal is to get students thinking like an engineer. For example, engineers need to think about where the pollen is on the plant. Is it deep inside the plant or out in the open? This will affect the design of the technology. They also need to think about the body parts of a pollinator that capture the pollen. What are the shapes of those body parts? What are their textures? What makes them able to collect pollen?)*

Engineering – Hand Pollinators

SAFETY: Students should wear goggles during this activity.

Engineering Scenario



Display the *Engineering Scenario #2 Visual*. As a class, read and discuss the engineering scenario on the visual: "Kia grows vegetables in her garden. One summer, she noticed that insects did not visit the flowers in the garden. She also saw that none of the squash plants in her garden grew squash. Kia's friend told her that the squash flowers needed to be pollinated for the squash to grow. Kia needs to pollinate her squash flowers by hand so the squash will grow. The hand pollinator needs to fit inside the squash flowers so she can collect pollen and carry it to other squash flowers in her garden."

Problem

Students collect their student readers and turn to the "Engineering #2" sheet. This will be the second time of the year that students engage as engineers in the classroom. They may need to be reminded about what an engineer's role is and why the scenario requires an engineering solution rather than an experiment (because it is presenting a problem that needs to be solved, instead of a question to be answered).

As a class, discuss the scenario to come up with a brief description that accurately summarizes the need/problem. You may need to ask questions about the scenario to get students thinking or elicit their prior experience from the engineering challenge in Unit 2 for this step. Students write the problem summary on their engineering sheets. For example:

- **Problem**: *Insects are not pollinating the flowers in Kia's garden. Kia needs a hand pollinator to pollinate her squash flowers so the squash will grow.*

Once the problem is summarized, move on with the class to describe the criteria (the requirements of the solution) and solution constraints (ways the solution is limited). Students identify the criteria and constraints of the problem in order to define the scope of the problem, which will help them better evaluate the effectiveness of their prototype solutions later on. This part of the engineering process may need more facilitation, depending on students' writing levels. The criteria are taken from the engineering scenario story and the constraints are simply the available materials (which you can point out to the class). Students record the criteria and constraints in the spaces provided on their engineering sheet. For example:

- **Criteria**: *The hand pollinator needs to fit inside the squash flower and move pollen from one flower to another.*
- **Constraints**: *materials*

Once the engineering problem, criteria, and constraints are established, students collaborate as a class or individually to create a title for the engineering challenge that is relevant to the problem. For this engineering challenge, a relevant title could be "Engineering Hand Pollinators" but other titles can be used as well.

NOTE: When students are finished summarizing the problem, use the *Who is an Engineer?* poster to help guide them through the engineering process.

Research

For research, students use their student readers or prior knowledge from discussions to answer the following research questions related to the problem on their engineering sheets:

1. Where is pollen found in plants? [*Pollen is found in the flowers. It is made in a plant's stamens.*]
2. How do animals pollinate plants? [*Some animals eat nectar made by flowers. When they eat nectar, some pollen gets on their bodies. When they fly to another flower, some of the pollen drops off. This is how pollination happens.*]

Survey Available Materials

As a class, survey the available materials. The purpose of the materials survey is for students to observe the quantity and properties of the available materials. As students examine the materials, they should be thinking about the problem and how the properties of the materials could be used to help solve the problem. Stand by the pick-up stations and point out the materials each student will use to create their prototype solution.

Prototype Materials (per student):

- 5 paper clips
- 4 cotton swabs
- 3 craft sticks
- 2 straws
- 2 pom poms
- 2 cotton balls
- 2 pipe cleaners
- 1 piece of fastener
- 1 piece of clay
- 1 piece of felt

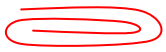
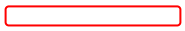
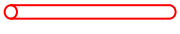
Tools and Test Materials:

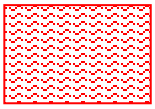
- invisible tape – shared

- scissors – 1 per student
- Squash Flower Test Template – 1 per student

Students record the missing information for each material in the Materials Survey Chart on their engineering sheets. Tools and test materials are not included in the materials survey chart. Students can collect a sample of each material (or look at the materials selection at the pick-up stations) to help them record the following information on their charts:

- a sketch of each material
- properties of each material (e.g., physical properties such as texture (smooth, rough, fuzzy), flexibility (rigid or bendable), shape, length or any other physical characteristics that you notice)

Materials Survey Chart				
Name	**Quantity**	**Sketch**	**Made From**	**Properties**
paper clips	5		metal	small, thin, and bendable
cotton swabs	4		cotton	thin and soft
craft sticks	3		wood	smooth and hard
straws	2		plastic	flexible and smooth

pom poms	2		cotton	round, smooth, and fluffy
cotton balls	2		cotton	round, smooth, and fluffy
pipe cleaners	2		yarn	long, flexible, and fluffy
fasteners	1		nylon	rough
clay	1		clay	smooth and sticky
felt	1		wool	rough

Possible Solutions

At this point in the challenge, students use what they know about the problem (including the requirements and limits), their research about how animals pollinate flowers, and the available materials to come up with several possible solutions to the problem. The possible solutions should focus on design ideas that allow for the effective transfer of pollen from one flower to another. This may be a challenging step in the engineering process for students, but it's an important planning strategy because it allows students to generate many different types of solutions, share those solutions with their

peers, and then select the solution that would be the most effective to build and test.

Since students will not pollinate real flowers in the classroom, briefly show the class one of the prepared squash flower models with the mini pom-pom "pollen" grains in the bottom. Point out that their prototypes need to transfer as many "pollen" grains from the model squash flower to the flower on their Squash Flower Test Template. Students think of at least two different possible designs for a hand pollinator and draw them in the spaces on their engineering sheet. Students may wish to work with a partner during this process.

Circulate throughout the class as students come up with possible solutions. Students share their ideas with you and with each other. Students will sometimes come up with imaginative design ideas that may not be realistic, given the available materials. Ask questions to help students compare their possible solutions and to determine which solution could be accomplished in the classroom. Students may find that a combination of their solutions may work best and change their ideas accordingly. Students circle which design they think will be the most effective before moving on to the next step in the process. Differences in student designs are expected and encouraged. For example:

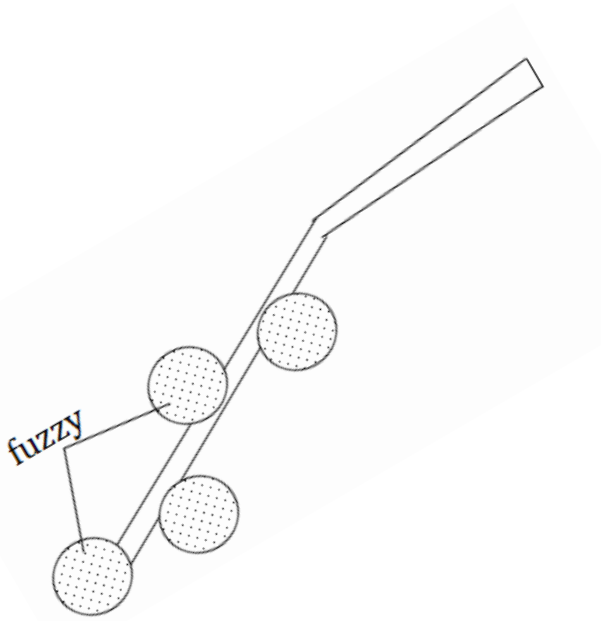
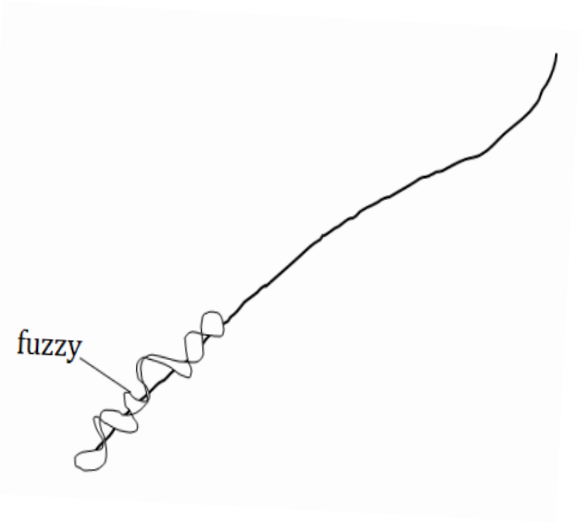
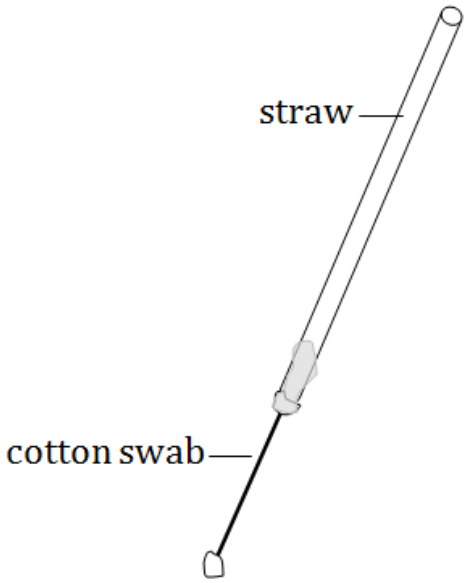
Design #1 Idea	Design #2 Idea
	

Diagram and Build Prototype

Students draw a scientific diagram of their chosen prototype design. The diagram should include labels of the materials used. When diagrams are complete and teacher-reviewed, students collect materials to build their prototypes according to their diagram. Teams can use scissors to modify the shape or length of the materials in their prototypes (if desired); however, they can only work with the quantity of materials that are available to them.

Prototype Diagram 1



Test

Teams test their prototypes using the prepared model squash flowers and their Squash Flower Test Templates. Teams use the test procedure as a guide for carrying out the proper testing method. Briefly go over the test procedure with the class to ensure they are familiar with how to test their prototypes.

Test Procedure:

1. Use your prototype to pick up pollen from inside one model squash flower.
2. Move the pollen to your desk and place it on the Squash Flower Test Template.
3. Count the number of pollen grains your prototype picked up. Write the number in Table 1.
4. Repeat Steps 1-3 with Prototype 2 and Prototype 3.

NOTE: Point out that any "pollen" grains that fall off prototypes as students move between the model squash flower and their templates should not be counted.

Data

Students record data for each prototype in Table 1. Students count the number of pollen grains their prototype picked up and transferred (carried) to their Squash Flower Templates.

Table 1: Comparing Prototype Pollinators			
	Prototype 1	**Prototype 2**	**Prototype 3**
Number of Pollen Grains Picked Up	2	4	7

NOTE: Example data represent one possible outcome. Student data will vary throughout the class, depending on design.

Refine (improve) or Replicate (keep)

Students use what they learn from testing their first prototype to make improvements when creating Prototype 2. Students should go back to their original prototype diagram and make modifications to represent their second prototype before building and testing it. Students repeat this process for Prototype 3.

Students explain their results from the engineering activity in the "Refine (improve) or Replicate (keep)" (conclusion) section of their lab sheets. Students should be prepared to:

- Identify which prototype best solved the problem.
- Support the effectiveness of the prototype with key data (evidence) from Table 1.
- Recommend if one of the prototype solutions should be further improved or replicated for Kia to use in her garden.

NOTE: This section of the lab has been structured with prompts, but it still requires students to write their responses. Depending on the writing level of your students, you may choose to have students share their data and results together as a class before writing a full response (optional).

Refine (improve) or Replicate (keep)

Use your test data to explain which prototype solution best solved the problem.

Our data show that prototype # _____3_____ best

solved the problem because

it fit in the squash flower and it picked up the most pollen.

It picked up 7 pollen grains.

Based on our data, Kia should _____replicate_____
(refine or replicate)

prototype # _____3_____ to help her pollinate her

squash plant flowers.

<u>Wrap-Up</u>:

1. Begin a dialogue with students to review their prototype solutions, asking them to explain how any modifications positively or negatively affected the prototype's ability to fit into the squash flower models and pick up as many pollen grains as possible. For example:

- Ask one student why they used engineering in the investigation instead of an experiment. [*There was a problem that needed to be solved. The problem was that Kia's squash plants weren't growing squash because insects had stopped coming to her garden.*]
- Ask another student whether they would recommend that either of their prototypes be refined (changed more) or replicated (kept as is). Students should include data from their testing to support their explanation. [*Answers will vary depending on the specific design of each student, but all answers should connect back to the problem, and explain why they would recommend either refining (changing) or replicating (keeping) their prototype. If neither of their prototypes was able to carry pollen from one flower to another, students should recommend refining their prototypes more. If one of their prototypes was able to meet the criteria of the problem, students should recommend replicating their prototype.*]

- Ask the first student to present their decision about whether to refine or replicate one of their prototypes, including data from their testing to support their decision. [*Answers will vary depending on the specific design of each team and their data.*]
- One at a time, ask students to describe any challenges they faced in designing and/or testing their prototype, and how they overcame those challenges.

2. Continue the dialogue with students, reviewing how students applied what they know about pollination to design their prototypes. For example:

- Ask one student how their prototype mimicked animal pollination. [*The prototypes pollinate in a similar way to how animals pollinate. Pollen grains from one flower are carried to another flower, where they are dropped onto the pistil of the flower. This is how pollination occurs.*]
- Ask another student what animal structures they thought about when designing their prototypes. [*Answers will vary depending on design. For example, some students may have thought about the fuzzy bodies of bees, while other students focused on the long, narrow beak of the hummingbird.*]
- One at a time, provide multiple students with the chance to respond to this question as students communicate about their prototype and how they developed it.

Name: _____ Date: _____

Engineering #2: _____

Problem

_____

_____

_____

_____

_____

Record the requirements and limits of the solution below:

What are the requirements?	
What are the limits?	

Research

1. Where is pollen found in plants?

2. How do animals pollinate plants?

Survey Available Materials

Draw a sketch of each material in the chart. Then record 1-2 properties of each material.

Materials Survey Chart				
Name	**Quantity**	**Sketch**	**Made From**	**Properties**
paper clips	5		metal	
cotton swabs	4		cotton	
craft sticks	3		wood	
straws	2		plastic	
pom poms	2		cotton	
cotton balls	2		cotton	
pipe cleaners	2		yarn	

fasteners	1		nylon	
clay	1		clay	
felt	1		wool	

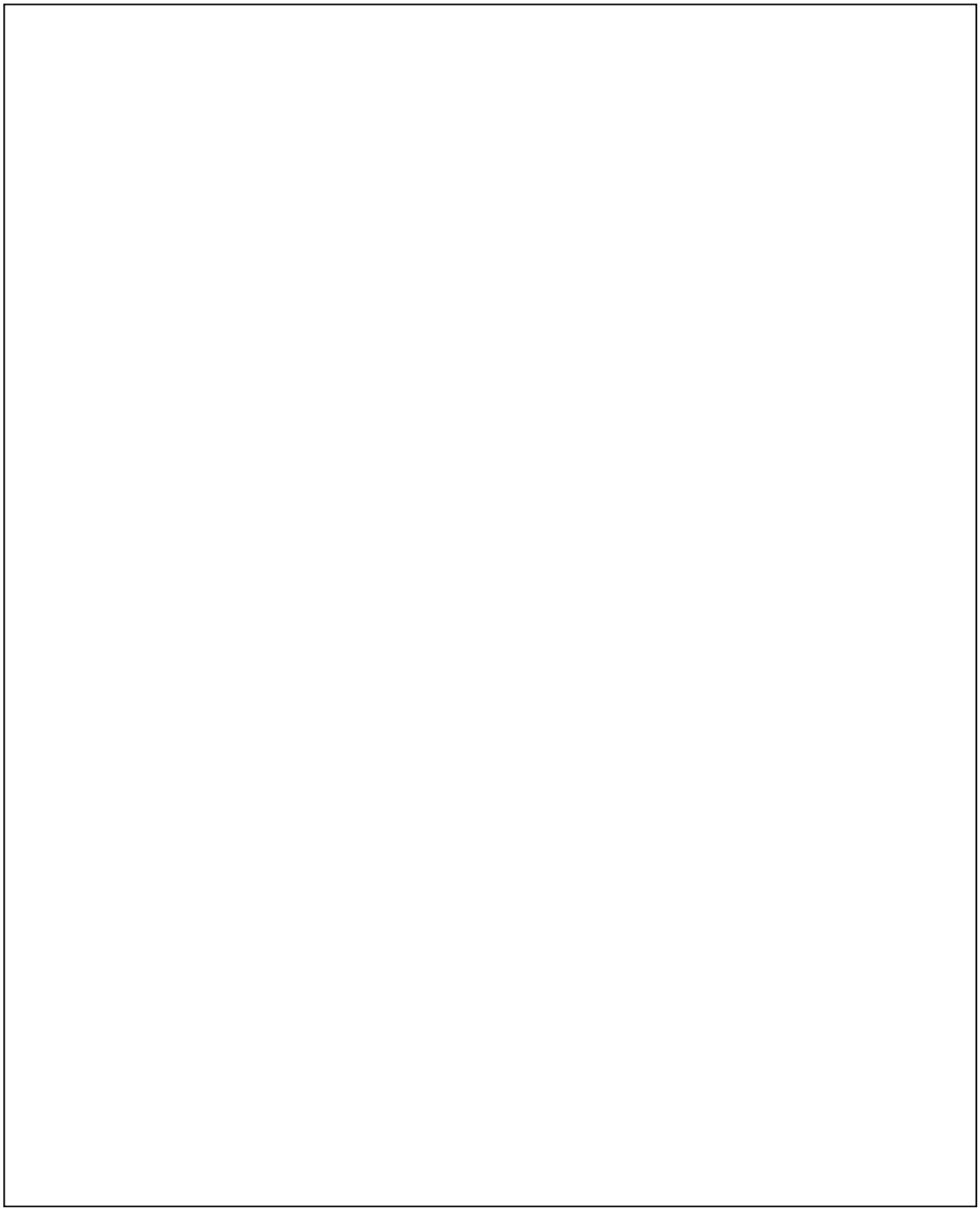
Possible Solutions

Think of two different ideas for a hand-pollinator that you could design. Draw each idea in the boxes below. Circle the design idea that you think will best solve the problem.

Design #1 Idea	**Design #2 Idea**

Diagram and Build Prototype

Draw a diagram of your chosen prototype in the space below. Label each material used in your prototype. Title the diagram.



Test Procedure

1. Use your prototype to pick up pollen from inside one model squash flower.
2. Move the pollen to your desk and place it on the Squash Flower Test Template.
3. Count the number of pollen grains your prototype picked up. Write the number in Table 1.
4. Repeat Steps 1-3 with Prototype 2 and Prototype 3.

Data

Record the number of pollen grains each prototype picked up and carried in Table 1 below.

Table 1: Comparing Prototype Pollinators			
	Prototype 1	**Prototype 2**	**Prototype 3**
Number of Pollen Grains Picked Up			

Refine (improve) or Replicate (keep)

Use your test data to explain which prototype solution best solved the problem.

Our data show that prototype # _____

best solved the problem because

_____

_____

_____

_____

_____

_____

_____

_____

_____

Based on our data, Kia should _____
(refine or replicate)

prototype # _____ to help her pollinate

her squash plant flowers.

Name: _____

Unit 6: Plant and Animal Relationships

Vocabulary Check

Part 1

Look at each picture and read the sentence. Decide which stage of a butterfly's life cycle it is. Circle your choice.

1. It eats all day. Its main goal is to grow as big as it can. It looks like a worm.

a. egg
b. larva
c. pupa
d. adult

2. It doesn't eat. It covers itself with a skin to protect it.

a. egg
b. larva
c. pupa
d. adult

3. What is an example of metamorphosis? (There may be more than one choice.)

a) A puppy gets bigger as it grows.

b) A caterpillar turns into a moth.

c) A caterpillar turns into a butterfly.

d) A girl gets taller as she grows.

4. Why do butterflies need **antennae**?

_____

_____

_____

_____

_____

Part 2

Circle the word that matches the meaning of the phrase.

Phrase	Word Choices	
1. the front segment of an insect where the antennae, mouthparts, and eyes are found	thorax	head
2. the middle segment of an insect where the legs and wings are found	thorax	abdomen
3. the back segment of an insect where the stomach is	abdomen	head

Name: _____

Unit 6: Plant and Animal Relationships

Concept Check

Part 1

1. Read each sentence. Circle **true** or **false.**

- Butterflies and moths look the same when they hatch from an egg as they look when they are adults. **true** **false**
- All living things have life cycles. **true** **false**

2. Fill in each of the blanks with a word from the word bank below:

Word Bank		
food	parts	animal

Butterflies are a kind of _____.

They eat other living things for _____.

Butterflies have different _____

to help them survive.

3. Julie watches a caterpillar. It eats leaves. Why does the caterpillar eat leaves?

a. The leaves are food for the caterpillar. They give it energy.
b. The caterpillar covers itself with the leaves. The leaves turn the caterpillar into a pupa.
c. both a and b.

4. The caterpillar moves through its life cycle. It turns into a butterfly. The butterfly doesn't eat leaves. It drinks nectar from plants. What is true about butterflies?

a. The nectar is food for the butterfly. It gives it energy.
b. The butterfly doesn't need to eat food. It just needs water.
c. both a and b

Part 2

5. Johnnie has a big oak tree in his front yard. Every fall, many acorns fall from the tree to the ground. The acorns are hard. They make a crunching sound under Johnnie's feet.

a. Johnnie is curious. He wonders what acorns are. He researches his question. He learns that acorns are seeds of oak trees.

Why are seeds important for plants?

_____

_____

_____

_____

b. Johnnie observes that squirrels eat acorns. He also sees squirrels bury acorns in the ground.

Why do squirrels need food?

Squirrels eat acorns.

c. Johnnie reads that oak trees cannot grow too close together. They need space to grow. He also reads that squirrels carry acorns to new places. Squirrels use their paws and their mouths to bury acorns in the soil. Squirrels bury acorns to store them. They will eat them in the winter when it is harder to find food. They don't eat all of the acorns they bury. Some of those acorns will grow into new oak trees.

What do squirrels do that helps oak trees survive?

_____

_____

_____

_____

_____

d. Johnnie gets a dog. He sees that squirrels don't come to his yard anymore. He worries his oak tree won't be able to make new trees. Johnnie decides to mimic (copy) squirrels. He thinks about his research into squirrels and acorns.

How can Johnnie use this research to plant a new oak tree?

_____

_____

_____

_____

_____

Unit 6: Appendix 1
Answer Keys

Part 1

1. b. larva [The stage of the butterfly's life cycle that includes eating all day so it can grow as big as it can, when it looks like a worm, is the larval stage. A life cycle is the stages an organism passes through on its way from birth to death. The larva is the second stage of an insect's life cycle, and it is an insect's young, worm-like form. The larval stage for butterflies and moths is a caterpillar. The first stage is eggs, the third stage is pupa, which is the inactive stage when it changes, and the fourth stage is the adult form.]
2. c. pupa [The stage of the butterfly's life cycle when it doesn't eat and it covers itself with a skin to protect it is the pupa stage. The pupa is the inactive stage of an insect when it changes. It does not eat during this stage, and this is when the metamorphosis takes place.]
3. [This question assesses student understanding of metamorphosis. It asks students to choose the sentences that are examples of a metamorphosis. B and C are both examples of metamorphoses: (b) A caterpillar turns into a moth and (C) A caterpillar turns into a butterfly. Both of these choices describe a complete change in the form from one stage to the next in the life cycle. The other two options don't describe a complete change in form. When puppies get bigger as they grow (a) and children get taller as they grow (d), they aren't completely changing their forms.]
4. [Butterflies use their antennae to smell, taste, and touch things around them. They use them to find food and avoid danger.]

Part 2

Phrase	Word Choices	
1. the front segment of an insect where the antennae, mouthparts, and eyes are found	thorax	head
2. the middle segment of an insect where the legs and wings are found	thorax	abdomen
3. the back segment of an insect where the stomach is	abdomen	head

Concept Check

Part 1

1. [This question asks students to read each sentence, and to circle true or false.

- Butterflies and moths look the same when they hatch from an egg as they look when they are adults. **true** **false**
- All living things have life cycles. **true** **false**

It is false that butterflies and moths look the same when they hatch from an egg as they look when they are adults. Butterflies and moths are insects, so they undergo metamorphosis, which happens when a living thing completely changes its form from one stage to the next in its life cycle. During the pupa stage, the parts of the caterpillar are completely rearranged to form a butterfly or moth. It is true that all living things have a life cycle, although the specific stages are different from one kind of organism to another.]

2. [This question asks students to fill in each of the blanks with a word from a word bank:
Butterflies are a kind of animal. They eat other living things for food. Butterflies have different parts to help them survive.]
3. a. The leaves are food for the caterpillar. They give it energy. [Caterpillars eat leaves because caterpillars are animals, so they need to eat other living things for food. Leaves are parts of plants, so caterpillars get energy from the leaves. It isn't true that the caterpillar covers itself with leaves, and that the leaves turn the caterpillar into a pupa. The caterpillar covers itself with a protective skin when it is time to become a pupa, but the leaves aren't part of that process.]
4. a. The nectar is food for the butterfly. It gives it energy. [After the caterpillar moves through its life cycle, turning into a butterfly, it eats nectar from plants because the nectar is food for the butterfly, so the nectar gives the butterfly energy. It isn't true that the butterfly doesn't need to eat food or that the butterfly just needs water. The butterfly needs both food and water to survive. Nectar provides the butterfly with both.]

Part 2

5. This question walks students through a scenario that explores the relationship between plants and animals by focusing on seed dispersal of acorns by squirrels.
   a. [Seeds are important for plants because seeds are young plants inside a protective coat. In the right conditions, seeds grow into new plants.]
   b. [Squirrels need food because food gives all living things energy. Living things need energy to grow and develop. Squirrels are animals, so they have to eat other living things for food.]
   c. [Squirrels carry acorns to new places, and then bury the acorns in the soil using their paws and their mouths. This helps oak trees survive because some of those acorns grow into new trees. The squirrels help new oak trees grow and develop.]
   d. [This question asks students how Johnnie can use his research about squirrels and acorns to plant a new oak tree. There are different ways students can answer this. What's important is that students can apply their knowledge of how squirrels help oak trees grow to this situation. For example: Johnnie can use his hands to carry an acorn to a new place. He can bury it in the soil, just like squirrels do.]

Student Reader Answer Key

Section 1 Review

1. [Caterpillars eat a lot because they need to grow as big as they can. They won't be able to eat as pupa, so they will have to survive on the food they stored as caterpillars.]
2. [Caterpillars are related to butterflies and moths because caterpillars are the larvae stage of a butterfly's and moth's life cycle. Caterpillars turn into butterflies or moths after their pupa stage.]
3. [People don't go through metamorphosis, which happens when a living thing completely changes its form from one stage to the next in its life cycle. As people grow, we get bigger but we keep the same basic parts, such as arms and legs. Butterflies go through metamorphosis because the young form of a butterfly is a caterpillar, and it looks completely different from an adult butterfly.]
4. [The main idea of Section 1 is to describe the life cycle of butterflies as they move from birth to death. This idea is supported with details about each stage of a butterfly's life cycle.]

Section 2 Review

1. [Butterflies need food because all living things need food for energy. Because butterflies are animals, they have to eat other living things for food. This is why butterflies eat nectar from plants.]
2. [Butterflies need shelter to protect them from rain and cold temperatures.]
3. [Butterflies have a proboscis, which is a long, straw-like tube that curls up, to drink nectar from plants. Because it is long, it lets butterflies reach deep into plants to get nectar.]
4. [Butterflies have wings to fly from place to place. They fly to flowers for food. They can also use their wings to find shelter to protect themselves.]
5. [The main idea of Section 2 is that butterflies have different body parts that help them survive and get what they need from their environment. This idea is supported with details of different body parts, including legs, wings, antennae, and the proboscis.]

Section 3 Review

1. [Bees are good pollinators because they have different body parts that collect and hold pollen. For example, they have fuzzy bodies that pollen sticks to. They also have pollen baskets on their legs.]
2. [Bees are useful to people because bees pollinate many fruits and vegetables that people eat.]
3. [Bees are useful to many plants because they pollinate them. This is how those plants make new seeds. Without bees and other pollinators, the plants wouldn't be able to reproduce.]
4. [The main idea of Section 3 is that there are different animals that pollinate plants, and different pollinators have different body parts to help them collect pollen. This idea is supported with examples of honeybees and hummingbirds.]

Unit 6: Appendix 2
Common Core Connections

The following Common Core standards are covered in this unit. Questions for the *Reading Informational Texts* standards provide an example of a question about the nonfiction student reader that links to a specific ELA standard. Additional questions are included in the section reviews. These types of questions can also be used with other texts. Other ELA standards are covered as students work through the reading, class dialogue, and hands-on portion of the lessons.

ELA Standards	Applying ELA Connections to the Student Reader
Writing	
W.2.7. Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).	• In Lessons 1, 2, and 3, students use their nonfiction student readers as research for their butterfly life cycle observations, butterfly model, and hand pollinator prototype.
Reading Informational Text	
RI.2.1 Ask and answer such questions as *who, what, where, when, why*, and *how* to demonstrate understanding of key details in a text.	• Section 1 introduces Martha. Who is she? [*Martha is a scientist who studies butterflies and moths.*] • What question did Martha want to answer? [*Can adult butterflies remember things that happened to them when they were young?*] • Why did Martha have this question? [*Butterflies and moths completely change from the time they are young. Their body parts are completely rearranged as they move through their life cycle.*] • How did Martha answer her question? [*She learned that butterflies and moths do remember things from before they changed. They remembered smells from when they were caterpillars.*]

RI.2.2. Identify the main topic of a multi-paragraph text as well as the focus of specific paragraphs within the text.	• What is the main topic of page 14 in the student reader? [*The main topic of this page is that butterflies have different parts that help them get what they need to survive .*] • What is the focus of the second paragraph on page 14, and how does it support the main point of the page? [*The main point of this paragraph is to describe one body part—the butterfly's proboscis. It supports the main idea because the proboscis helps butterflies eat nectar from flowers, which provides them with food and water.*]
RI.2.3. Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.	• What is the connection between a pollinator's body parts and its ability to pollinate plants (pages 21-22)? [*Different body parts, such as bees' fuzzy bodies and pollen baskets, collect pollen. Other body parts, such as the hummingbird's long beak, allow the pollinator to get what it needs, which causes pollen to stick to them.*]
RI.2.5. Know and use various text features (e.g., captions, bold print, subheadings, glossaries, indexes, electronic menus, icons) to locate key facts or information in a text efficiently.	• What kind of information does the photo on page 21 support? [*The photo shows a bee covered in pollen. We can see the tiny hairs that the pollen is sticking to, which supports the idea that bees have body parts that make them such good pollinators.*]
RI.2.6. Identify the main purpose of a text, including what the author wants to answer, explain, or describe.	• What is the main purpose of this unit: Plant and Animal Relationships? [*The main purpose is to describe how some animals, like butterflies, bees, and hummingbirds, depend on plants for food, and how plants depend on these animals for pollination.*] • What are some questions that the text answers? [*The text answers the questions: How does a butterfly change as it grows? Why do butterflies need flowers? What do butterflies, bees, and hummingbirds all have in common? How do pollinators help plants reproduce?*]

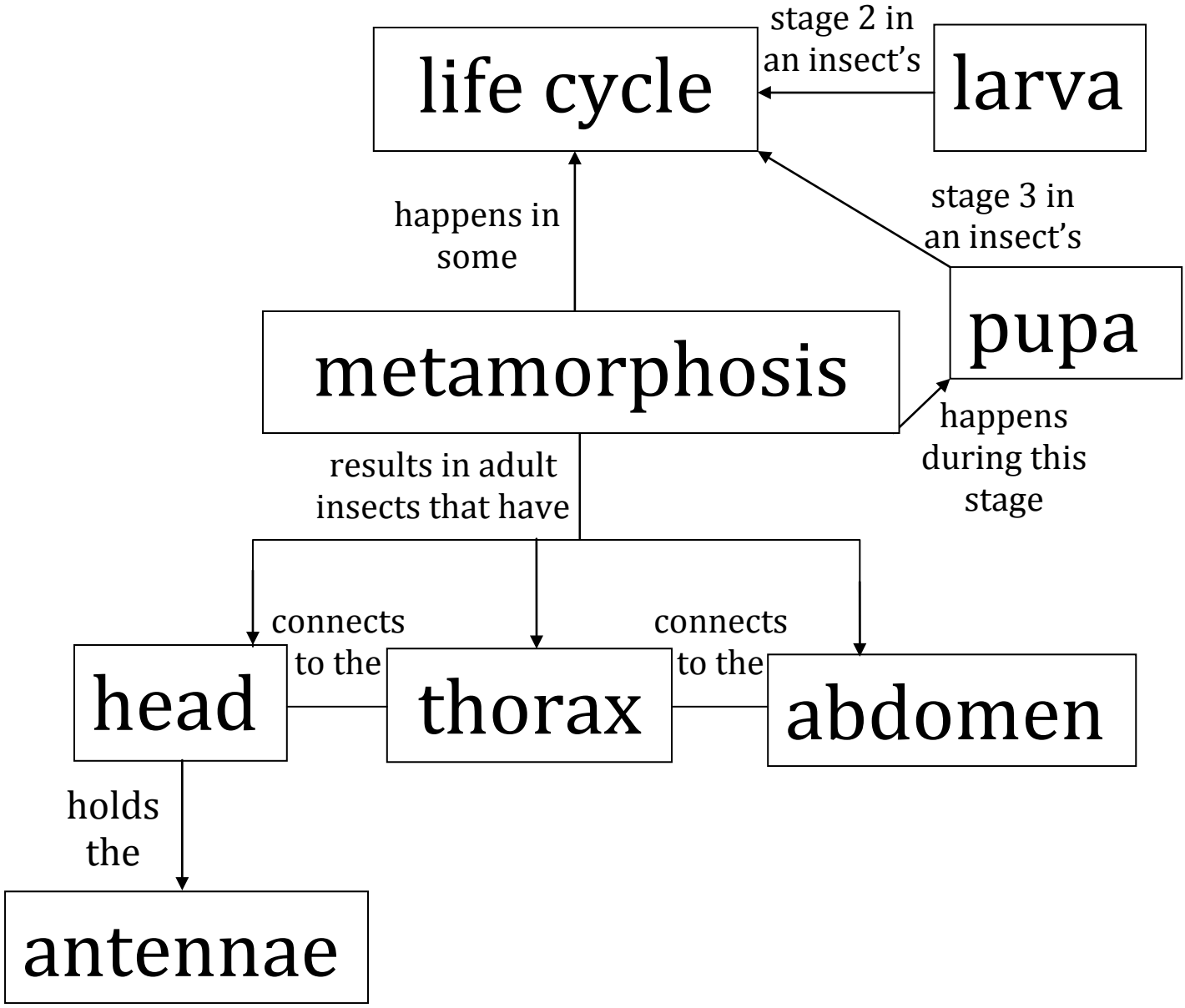
RI.2.8. Describe how reasons support specific points the author makes in a text.	• What reasons are given for why butterflies have antennae (page 12)? [*Butterflies have antennae to see, taste, and touch things around them.*]
RI.2.10. By the end of year, read and comprehend informational texts, including history/social studies, science, and technical texts, in the grades 2-3 text complexity band proficiently, with scaffolding as needed at the high end of the range.	• Students read the nonfiction student reader together as a class, making connections between examples in the reading and broader concepts, as well as individual experiences and observations.
Speaking and Listening	
SL.2.1.A. Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion).	• In Lessons 1, 2, and 3, students engage in Socratic dialogue before beginning the investigations. Students follow agreed-upon rules during the Socratic dialogue portion of the class, as well as during the investigation. The dialogue portion of the lesson models for students how to carry out a dialogue with others, which they use as they work collaboratively during the investigations and engineering lesson.
SL.2.1.B. Build on others' talk in conversations by linking their comments to the remarks of others.	• In Lessons 1, 2, and 3, students build on what other students have said during the Socratic dialogue, responding to the comments of others with their own observations and/or analysis. They practice these same skills in their teams during the investigations, and then come together as a class to review the results of their investigations.

SL.2.2. Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.	• In Lessons 1, 2, and 3, students read the nonfiction student reader together as a class. Students ask and answer questions about what they have read to ensure that there is comprehension of the text.
SL.2.4. Tell a story or recount an experience with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences.	• In Lessons 1, 2, and 3, students practice communicating their ideas clearly, using their own observations, experiences, and examples from the reading to support their arguments presented during the Socratic dialogue, investigations, and wrap-up portions of the lessons.
SL.2.6. Produce complete sentences when appropriate to task and situation in order to provide requested detail or clarification.	• In all of their spoken communications, students practice speaking in complete sentences so their ideas are communicated clearly and precisely.
Language	
L.2.1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.	• In Lessons 1, 2, and 3, students practice writing and speaking using standard English grammar and usage as they move from the Socratic dialogue to the investigation and then the wrap-up.
L.2.3. Use knowledge of language and its conventions when writing, speaking, reading, or listening.	• In Lessons 1, 2, and 3, students practice with the conventions of language as they read the student reader together as a class, contribute to the Socratic dialogue (both speaking and listening), and carry out the investigations/wrap-up portions of the lesson.
L.2.4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 2 reading and content, choosing flexibly from an array of strategies.	• In Lessons 1, 2, and 3, students read the student reader together as a class. Students clarify the meaning of words and phrases they don't understand together as a class or independently.

Use this chart to keep track of how you are connecting science to the rest of your curriculum.

Unit Connections to ELA Common Core	Unit Connections to Math Common Core	Unit Connections to History/Social Studies

Unit 6: Appendix 3
Sample Concept Map



Unit 6: Appendix 4
Support for Differentiated Instruction
Massachusetts STE Standards

Core Expectation	KnowAtom Assessment Strategies	Possible Primary Evidence
2-LS2-3 (MA). Develop and use models to compare how plants and animals depend on their surroundings and other living things to meet their needs in the places they live.	Low Entry Point • Identify what animals need to survive (e.g., food, water, shelter). • Describe how animals (specifically butterflies) depend on plants to give them the food and shelter they need to survive. At Grade-Level Entry Point • Describe the relationship between a plant's parts and a pollinator's parts that allow pollen to be moved from one plant to another. • Apply scientific knowledge to create a model that mimics how certain animals pollinate plants.	• "Butterfly Observation Template" completed by student • "Engineering #2" completed by student • student diagram of a hand pollinator • photos of student developing their pollinator model
2.K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same design problem to compare the strengths and weaknesses of how each object performs.	Low Entry Point • Carry out tests of up to three prototypes and collect data. • Describe what the data reveal about the ability of each prototype to solve the given problem. At Grade-Level Entry Point • Use the data to compare the effectiveness of each prototype, looking for strengths and weaknesses in the design.	• "Engineering #2" completed by student • photos of student testing each of their prototypes • video of student analyzing the strengths and weaknesses of each design

Unit 6: Appendix 5
Materials Chart

	Lesson	Quantity	Notes	Used Again
Unit Kit Consumable				
Goggles	1,2	1 per student	safety	✓
Butterfly larvae (LIVE MATERIAL**)**	1	shared	for observations	
Safety pins	1	teacher use	to hang butterfly pupae	
Colored paper sheets (two colors)	2	2 per student	for butterfly model	
Pipe cleaners (black)	2	3 per student	for butterfly model	
Pipe cleaners (yellow)	2	1 per student	for butterfly model	
White poster paper	2	1 per student	for butterfly model	
Black foam sheets	2	1 per student	for butterfly model	
Pipe cleaners (black)	2 3	3 per student 2 per student	for butterfly model for prototype hand pollinators	
Pom-poms	2 3	2 per student 2 per student	for butterfly model for prototype hand pollinators	
Paper clips	3	5 per student	for prototype hand pollinators	
Cotton swabs	3	4 per student	for prototype hand pollinators	
Craft sticks	3	3 per student	for prototype hand pollinators	
Straws	3	2 per student	for prototype hand pollinators	
Cotton balls	3	2 per student	for prototype hand pollinators	
Fasteners (velcro)	3	1 per student	for prototype hand pollinators	
Clay pieces	3	1 per student	for prototype hand pollinators	
Felt sheets	3	1 per student	for prototype hand pollinators	
Squash Flower Test Template	3	1 per student	for prototype hand pollinators	
Flower Templates	3	teacher use	for creating model squash flower	
Plastic cups	3	teacher use	for holding model squash flowers	
Non-Consumable				
Book: A Butterfly's Life" by Dona Herweck Price	1	teacher use	for circle-time dialogue	
Butterfly Observation Habitat	1	1 per class	for observing butterflies	
Magnifying glasses	1	1 per student	for observing butterflies	
Mini pom-poms	3	class set	for model squash flower "pollen"	
Test tubes (no caps)	3	class set	for modeling squash flowers	
Teacher Tool Kit				
Markers	2	shared	for butterfly model	✓
School glue	2	1 per student	for butterfly model	✓
Scissors	2, 3	1 per student	for butterfly model and prototypes	✓
Invisible tape	2, 3	1 per team/2	for butterfly model and prototypes	✓

Hand-outs			
Student readers	1, 3	1 per student	for "Butterfly Observation Template" and "Engineering #2" sheets
Visuals	Download		
Lesson 1	Living Things Grow Visual, How a Butterfly Grows Visual		
Lesson 2	Parts of a Butterfly Visual		
Lesson 3	Who is an Engineer? Visual, The Problem of Pollination Visual		