BUTTERFLIES

Taking Science to the Backyard

Blue Butterfly
Lycaenidae

OMAHA'S HENRY DOORLY ZOO

PROJECT DIRECTOR

Elizabeth Mulkerrin
Director of Education, Omaha's Henry Doorly Zoo

PROJECT STAFF

Julie Anderson
Curriculum & Instruction Supervisor,
Omaha's Henry Doorly Zoo

Emily Brown
Program Manager, Omaha's Henry Doorly Zoo

Leah Woodland
Outreach Manager, Omaha's Henry Doorly Zoo

Laura Howard
Homeschool Manager, Omaha's Henry Doorly Zoo

Roger Cattle
Nocturnal Manager, Omaha's Henry Doorly Zoo

Berniece Grewcock Butterfly and Insect Pavilion Zoo Keepers
Omaha's Henry Doorly Zoo

DESIGN

Sara Veloso
Design and Interpretive Manager,
Omaha's Henry Doorly Zoo

Crystal Weaklend
Graphic Designer, Omaha's Henry Doorly Zoo

Carli Cominoli
Graphic Designer, Omaha's Henry Doorly Zoo

ACADEMIA SCIENTIARUM NEBRASKENSIS NEBRASKAE SERVIENS JAN. 30, 1880

The Nebraska Environmental Trust
preserving NATURAL NEBRASKA™ for future generations

New Guinea Birdwing
Ornithoptera priamus

INTRODUCTION

Worldwide, there are nearly 17,500 species of butterflies, grouped into five families: Hesperiidae, Papilionidae, Pieridae, Lycaenidae, and Nymphalidae. Close to 750 species inhabit the United States and Canada, most notably the Monarch and Regal Fritillary can be found in Nebraska.

Approximately 3% of butterfly species are threatened with extinction. This decline in butterfly populations is attributed primarily to habitat loss due to urbanization and agriculture. As populations continue to decrease, a growing need to closely monitor species is developing. Because there is little distinction between some types of butterflies, identification and classification proves to be a challenge. Very few Lepidopterists (scientists who study butterflies and moths) exist; therefore monitoring population sizes and ranges of butterfly species is a daunting task.

Nationwide, butterfly counting events have become popular for families, schools, and hobbyists alike. Not only do they provide a valuable learning experience, but they also allow individuals to partake in citizen science. By participating, citizen scientists are able to provide researchers with useful data. Lepidopterists are able to utilize information collected from butterfly counts to pinpoint regions or species of interest for additional studies.

Omaha's Henry Doorly Zoo has begun the Nebraska Butterfly Conservation and Education Project. Central to this project is an opportunity for educators and students to become citizen scientists by monitoring butterflies and sharing their findings with the community. We are dedicated to inspiring youth, educators, and families to explore butterflies in their neighborhood. Through your participation, it is our goal to spark an interest, enthusiasm, and commitment to butterfly conservation. Our hope is that this curriculum will afford greater opportunities for discussions, problem solving, sharing of resources, and inquiry.

Omaha's Henry Doorly Zoo
Education Department

TABLE OF CONTENTS

HIGHLY CLASSIFIED

VOCABULARY
- Taxonomy
- Classification
- Binomial Nomenclature
- Dichotomous Key

OBJECTIVES
- Understand classification is the arrangement of objects, organisms, or information into groups with one or more characteristics in common
- Discover the reasons for scientific classification
- Understand scientific nomenclature groups all organisms on the basis of characteristics they have in common
- Learn how to create a classification system

BACKGROUND
Taxonomy, or scientific classification, is a system used to classify all living things. The system used today, called the Linnaean system of binomial nomenclature, was developed by Swedish naturalist Carl von Linnè, also known as Carolus Linnaeus, (1707-1778). He separated animals and plants according to specific physical similarities and then gave a name to each species. Using Latin and Greek words, Linnaeus's system classifies organisms using seven main levels or categories, which are organized from most general to most specific. These levels are: Kingdom, Phylum, Class, Order, Family, Genus, and Species.

A dichotomous key is a tool that can be used to classify objects. In science, a dichotomous key is used to identify a particular specimen (a particular chemical, an insect, a tree, or even a rock). Dichotomous means "divided in two parts." Therefore, this key uses a series of yes or no questions to place objects into groups. There are many layout styles for a dichotomous key, including graphical and written. The following are two basic samples.

Figure 1

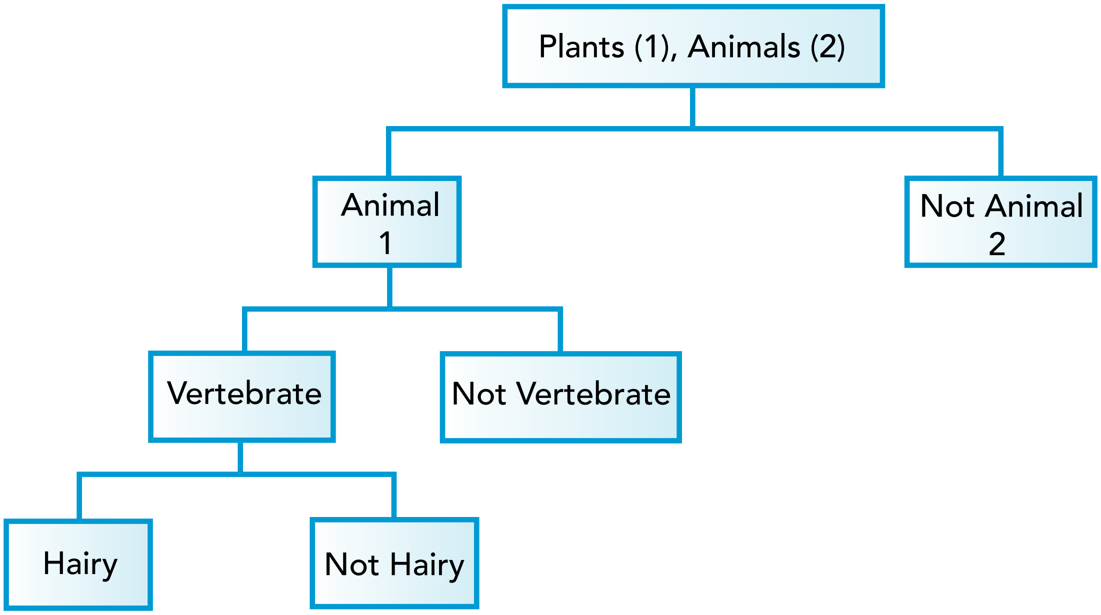
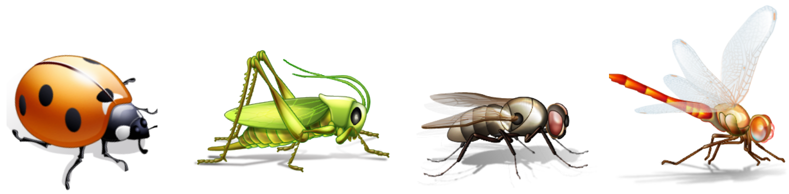


Figure 2



1	**a.** wings covered by an exoskeleton - go to step 2 **b.** wings not covered by an exoskeleton - go to step 3
2	**a.** body has a round shape - ladybug **b.** body has an elongated shape - grasshopper
3	**a.** wings point out from the side of the body - dragonfly **b.** wings point to the posterior of the body - housefly

Butterfly identification and classification is no simple task. Literally thousands of butterfly species exist, with some species showing little distinction from others. "Taxonomy is a science of shifting names and much discussion. Within a field of study, not all scientists agree on a particular taxonomic arrangement of species."[1] **Butterflies are classified in the Kingdom: Animalia, Phylum: Arthropoda, and Order: Lepidoptera.**

[1] Opler, Paul A., Kelly Lotts, and Thomas Naberhaus, coordinators. 2011. Butterflies and Moths of North America. Bozeman, MT: Big Sky Institute. http://www.butterfliesandmoths.org/ 27 February 2011.

Butterfly Classification

MATERIALS

•Butterflies & Moths of Nebraska Field Guide (www.omahazoo.com/conservation)
•Blank paper
•Writing utensil

ACTIVITY PREP

Cut out individual butterflies from the Butterflies & Moths of Nebraska Field Guide. You will need 1 set for each group of 2-3 students.

PROCEDURE

1. Discuss general classification with students. *What does classification mean? Why do we classify things?* Specifically related to natural sciences, we use classification to organize the organisms we know, to see how organisms are related to each other, and to help identify unknown organisms. Classification makes things easy to find, to study, and to talk about. *How do students use classification every day?* They may think of files on their computers, phone lists on their cell phones, food items such as breakfast, lunch or supper, winter vs. summer clothing, etc.
2. Students will now attempt to sort a variety of butterflies into the taxa, Family. The proper names of the butterfly families are not of concern at this point.
3. Allow students to work as pairs or in small groups. Give each group a set of butterflies. Allow students to use their own observations to sort butterflies based on common physical characteristics. *What types of characteristics might they look for?* Student comments may include color, size, wing shape, body size, etc. Do not correct answers or ideas. The point of this activity is for students to act as researchers who are attempting to create a usable and easily understood classification system. Have students record their observations and rationale for placing each butterfly where they did.
4. Once the butterflies are sorted have students create a dichotomous key for their butterflies. Students should be familiar with anatomy and key words used to describe parts of a butterfly. See Figure 3 for a labeled diagram.
5. Have student groups trade dichotomous keys and practice keying the butterflies using the other group's classification. End with a class discussion about students' dichotomous keys.

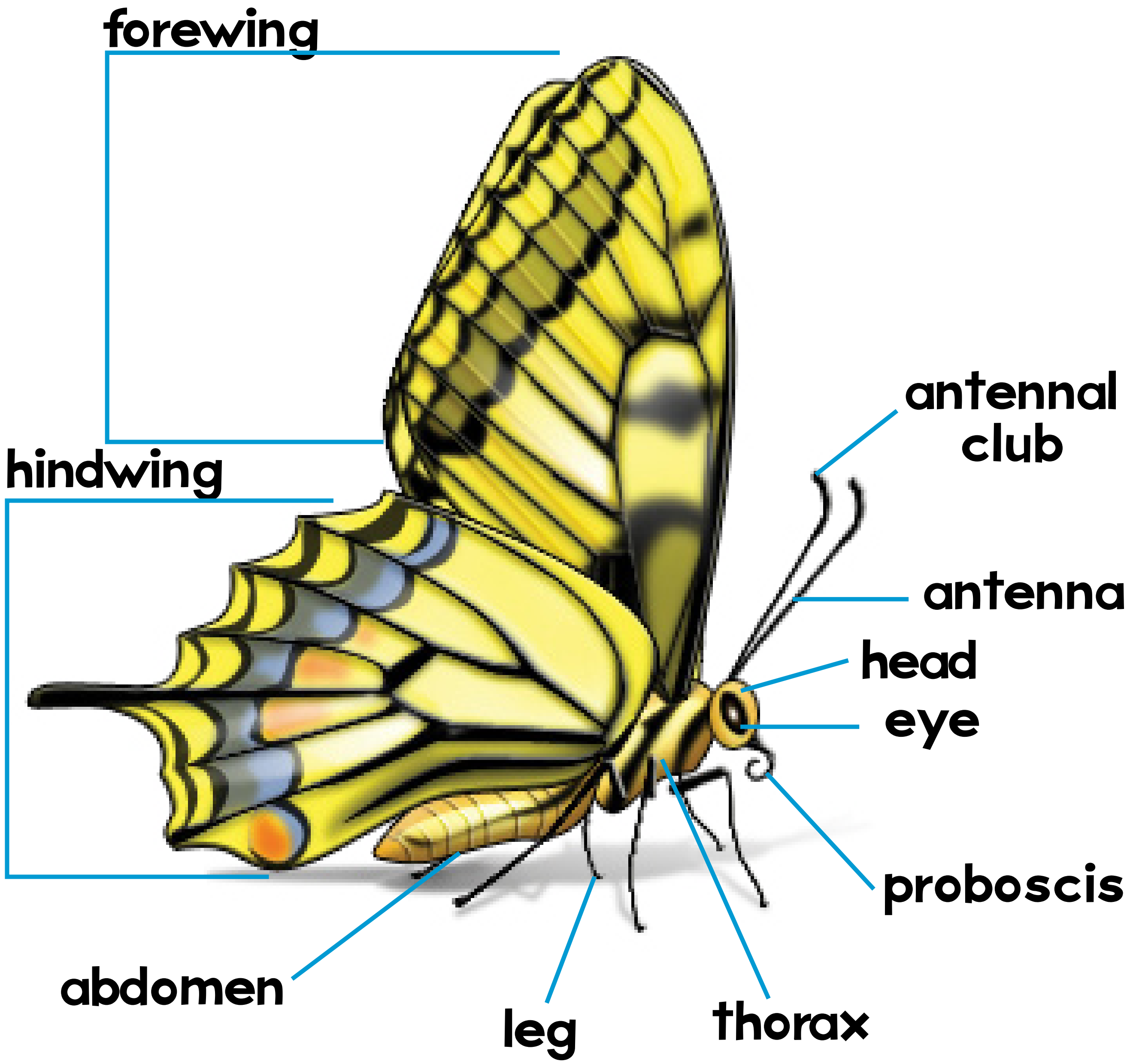
AT THE ZOO

Visit the Berniece Grewcock Butterfly and Insect Pavilion at Omaha's Henry Doorly Zoo and practice classification by viewing live butterflies and other insects and arachnids. The Omaha Zoo Butterfly & Moth Identification guide can be downloaded at www.omahazoo.com/conservation.

EDUCATOR NOTE:

Have students practice basic classification by sorting groups of similar objects. An assortment of pasta and grains, shoes, or nuts, bolts, and nails works well for this activity.

Figure 3


forewing
hindwing
antennal club
antenna
head
eye
proboscis
abdomen
leg
thorax

Who am I?

COMPARING INSECTS & ARACHNIDS

VOCABULARY

- Insect
- Arachnid
- Head
- Thorax
- Abdomen
- Compound Eye
- Antennae

OBJECTIVES

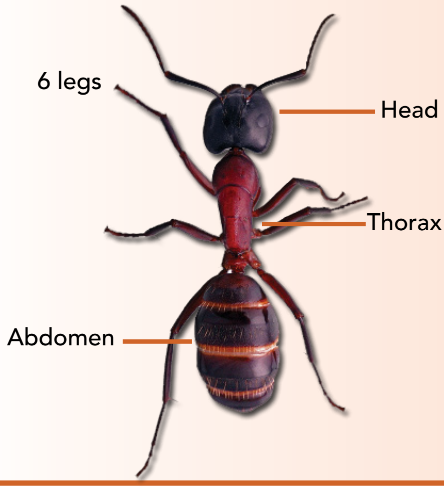
- Develop an understanding of the parts of an insect and an arachnid
- Discover differences between insects and spiders

BACKGROUND

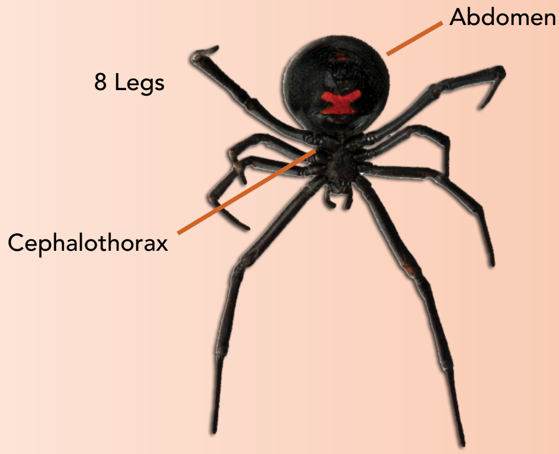
Many differences exist between insects and spiders. Below is a chart comparing basic characteristics.

INSECTS	SPIDERS
3 body parts (head, thorax, abdomen)	2 body parts (combined head and thorax, abdomen)
6 legs	8 legs
4 wings	No wings
2 compound eyes	Multiple simple eyes
Some insects are able to produce silk	All spiders have the ability to create silk
2 antennae	No antennae

Insects have 3 Body Parts



Spiders have 2 Body Parts



Who am I?

MATERIALS

- Magnifying glasses
- Clear jars or other type of container to catch and observe insects, spiders and other bugs
- White board or chalk board
- Tape
- Paper or journal
- Writing utensil
- Who am I? worksheet (page 11)
- Insect Diagram (page 13)
- Spider Diagram (page 13)
- Resources on insects and spiders

PROCEDURE

1. Explain to students that they will be going outside in search of insects. Give each student a collection container and explain that each person should carefully capture at least one specimen.
2. Have students bring their insects back to the classroom and observe them closely. They should sketch their animal and record any observations, paying close attention to the body parts (i.e. number of legs, etc.).
3. Have students determine what type of animal they have (insect, spider or other) using the Who am I? worksheet. They should compare and contrast the answers from their worksheet to the Insect and Spider diagrams on page 13 to determine what type of animal they found.
4. Create a "T" chart on the board with 3 columns. Label each column with one of the following: insects, spiders and other. For younger students, place a copy of the insect and spider diagrams provided on page 13 next to the corresponding word.
5. One at a time, have students bring their sketches to the chart and tape their sketch under the column that they feel their animal fits. Have the student explain their decision and guide changes if needed.
6. Review the characteristics of insects compared to spiders and other bugs.
7. At the end of the lesson, release the animals where they were found, away from foot traffic.

EDUCATOR NOTE:

- You may consider having students use a camera to record what insects, spiders and other bugs they find. This could be done at home if class time is limited. Students can then bring the pictures to class and use those in the "T" Chart.
- In addition to the "T" Chart, have students graph the numbers of different insects they found using their sketches. Label the y-axis, "Number of Each Type" and the x-axis, "Type of Animal."
- For younger children, there are two songs available, "Head, Thorax, Abdomen!" and "I'm Not an Insect," on page 12 to help them remember the differences between insects and spiders.

AT THE ZOO

Visit the Berniece Grewcock Butterfly and Insect Pavilion at Omaha's Henry Doorly Zoo to identify insects and spiders. Have students make observations about differences in behavior, habitats and adaptations. Then head outside to the Butterfly Garden surrounding the building and look for evidence of insects and spiders.

Who am I?

Name: ______________________

Discover what type of animal you have by answering the questions below.

How many legs does your animal have?

- ☐ 6 legs ☐ 8 legs ☐ More than 8 legs

How many body parts does your animal have?

- ☐ 2 body parts ☐ 3 body parts ☐ Other

Does your animal have wings?

- ☐ Wings ☐ No wings

Does your animal have antennae?

- ☐ 2 antennae ☐ No antennae

My animal is a…

- ☐ Insect ☐ Spider ☐ Other

How can you find out more about what type of insect, spider or other animal you have?

HEAD, THORAX, ABDOMEN!

Sung to the tune of "Head, Shoulder, Knees, and Toes"

Lyrics
Head, Thorax, Abdomen… Abdomen
Head, Thorax, Abdomen…Abdomen
6 legs, 2 Antennae, and Compound Eyes
Don't forget the ones with wings… Ones with wings!

Actions
Head: hands on head
Thorax: hands on stomach
Abdomen: point to rear and shake
6 legs: show 6 fingers (three on each hand)
2 Antennae: with index finger wiggling above head
Compound Eyes: hands cupped like "c" around eyes
Wings: interlock hands at thumbs and wiggle fingers

I'M NOT AN INSECT!

Sung to the tune of "I'm a Little Tea Pot"

Lyrics
I'm not an insect
Guess Again
Just 2 body parts
And 8 long legs

With many simple eyes
And no wings
Now you see
A spider is me!

Actions
Line 1: shake head "no" while holding up pointer finger and moving it side to side
Line 2: hands out to the side, palms up, and shrug shoulders
Line 3: hold up two fingers
Line 4: hold up 8 fingers (four on each hand)
Line 5: point to eyes
Line 6: interlock hands at thumbs and wiggle fingers
Line 7: point index finger away
Line 8: point to yourself

INSECT DIAGRAM

SPIDER DIAGRAM

One of These Things is Not Like the Other: Comparing Butterflies and Moths

VOCABULARY
- Antennae
- Butterfly
- Moth

OBJECTIVES
- Develop a better understanding of butterflies and moths
- Compare and contrast a butterfly and a moth

BACKGROUND
Butterflies and moths belong to the order Lepidoptera and the class Insecta. Both have antennae, three body parts (head, thorax, and abdomen), and six legs. Butterflies and moths also have four wings (a set of forewings and a set of hindwings), which are covered with scales. Although butterflies and moths are quite similar, there are specific characteristics and behaviors, which help distinguish between the two. These characteristics are outlined in the chart below.

	BUTTERFLY	MOTH
COLOR	Typically bright	Typically dull (provides camouflage)
ANTENNAE	Thin with a clubbed tip	Feathery appearance
RESTING STANCE	Wings erect and held together	Wings open over back
PUPA	Chrysalis - usually exposed and attached to a leaf or twig	Cocoon - usually protected by soil, leaf litter, or bark
ACTIVE	Usually diurnal (day)	Usually nocturnal (night)

BUTTERFLY ANTENNAE

MOTH ANTENNAE

BUTTERFLY PUPA

MOTH PUPA

BUTTERFLY RESTING STANCE

MOTH RESTING STANCE

MATERIALS

- Cardstock
- Construction Paper
- Scissors
- Pipe Cleaners
- Aluminum Foil
- Butterfly and moth pictures (page 18)

ACTIVITY PREP

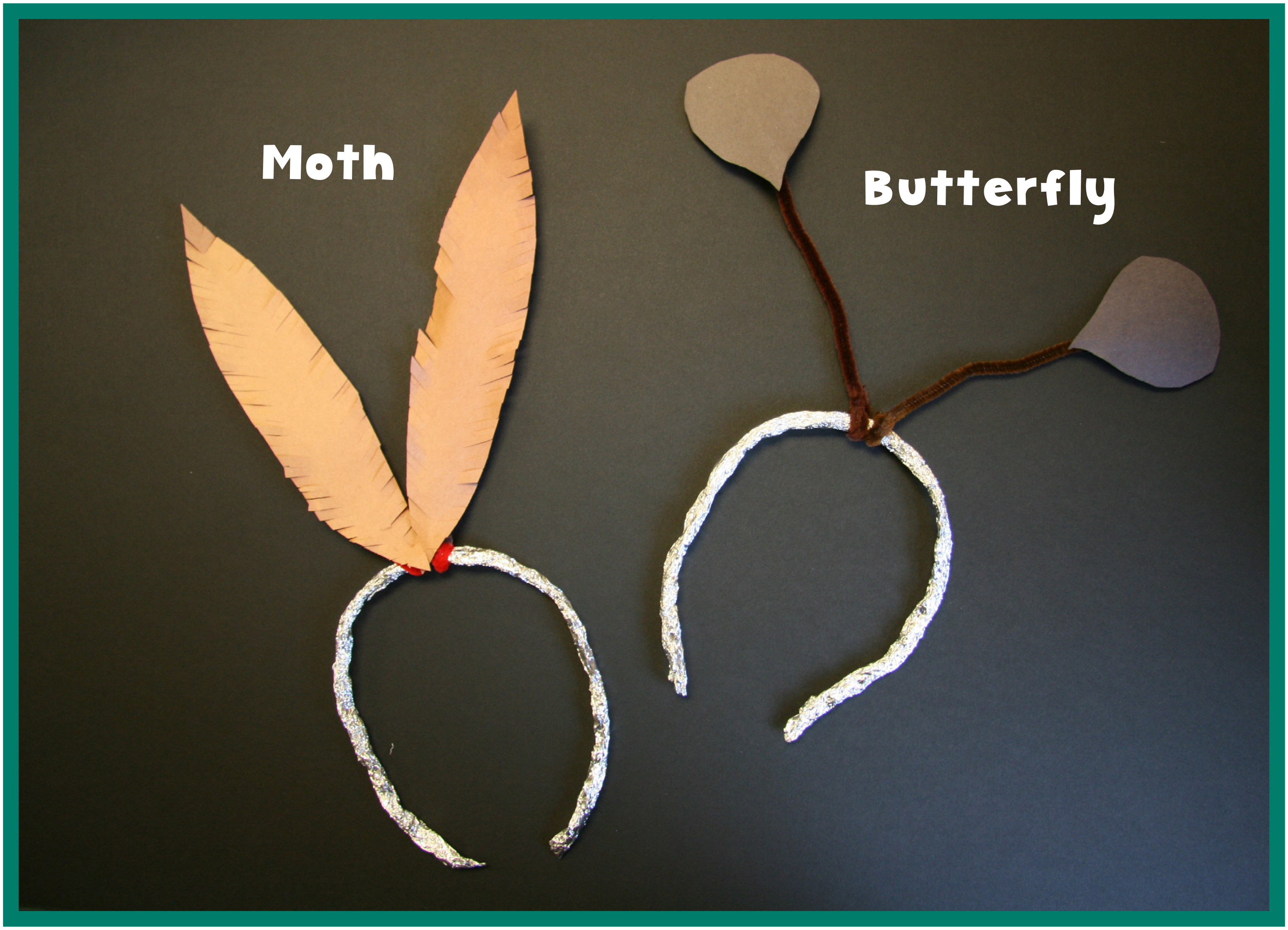
1. Cut a teardrop shape out of cardstock to create the knob of a butterfly antenna. You will need enough templates for half of your class.
2. Cut an oval out of a piece of cardstock that is a little longer than the length of a pipe cleaner. You will need enough templates for the other half of your class.
3. Lay out an assortment of construction paper for students to choose from.

PROCEDURE

1. Explain to students that they will be making antennae.
2. Pass out the teardrop and oval shape templates to students randomly. (Students will not make both types of antennae. Pass out the templates evenly).
3. Students will need to choose a piece of construction paper, then trace their shapes twice, and cut them out.
4. Pass out two pipe cleaners to each student. Instruct students with teardrop shapes to tape the pointed end to a pipe cleaner. Repeat with the other teardrop shape.
5. Instruct students with oval shapes to cut fringes into their shape (similar to a moth's antennae). Then, tape one pipe cleaner down the middle of the oval shape (lengthwise). Repeat with the other oval shape.
6. Pass out two pieces of aluminum foil (3"x12") to each student. Instruct students to roll and twist the pieces of aluminum foil into a headband.
7. Next, have students wrap the bare ends of their pipe cleaners around the aluminum foil to create antennae and put them on.
8. Once all students are wearing their antennae ask them to look around at each other. Discuss the following questions with them. *Do we all have the same type of antennae? How are our antennae alike and different? If we were insects, do you think we would all be the same type of insect?*
9. Next, explain to the students that some of them are butterflies and some of them are moths. Display the butterfly and moth diagrams.
10. Using the diagrams, discuss the differences between the butterfly and moth antennae with students. Next, have the students look around at each other again and ask them, *who is a butterfly and who is a moth?*
11. Turn students' attention back to the displayed diagrams of the butterfly and moth. Ask them, *do you see any other difference?* More than likely students will point out the bright colors of the butterfly and the dull colors of the moth; if not, draw their attention to this.

EDUCATOR NOTE:

- If time and weather allow, go outside looking for butterflies and moths. Bring a large clear container or a butterfly cage to temporarily hold any you may find. Provide students with magnifying glasses and allow them to take a closer look at what you find and determine if it is a butterfly or moth. Make sure to release all insects after the activity where they were found and away from foot traffic.
- Have students work in pairs to create a two-voice poem comparing and contrasting butterflies and moths. To introduce the activity, have a volunteer help you read the poem "Honey Bees" from the book *Joyful Noise: Poems for Two Voices* by Paul Fleischman, which shares the perspectives of a worker bee and a queen bee on "beehood." Discuss the concept of the two voice poem with students and as a group, model how to write a two voice poem. Ask students to suggest two animals that are quite similar, but different at the same time and create a two voice poem as a class. Have groups read their poems out loud to the class.



Example - Butterfly and Moth antennae model. Instructions on page 16.

Butterfly

Moth

Wings-n-Things

BUTTERFLY ANATOMY

VOCABULARY

- Head
- Thorax
- Abdomen
- Proboscis
- Inference
- Compound Eye
- Antennae
- Hindwing
- Forewing

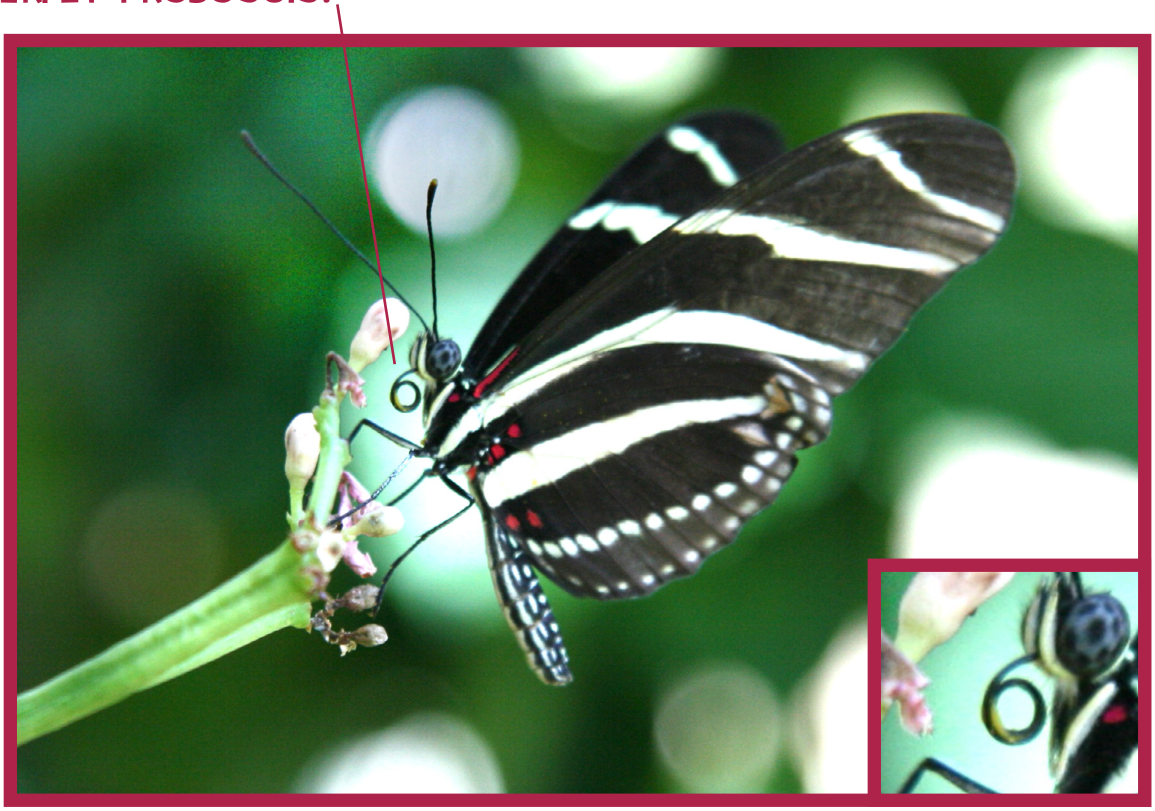
OBJECTIVES

- Develop an understanding of butterfly anatomy
- Recognize that a butterfly is an insect
- Demonstrate knowledge of butterfly anatomy

BACKGROUND

Butterflies belong to the order Lepidoptera, in the Insecta class. Butterflies are considered insects because they have a head, thorax, and abdomen. They also have six legs, antennae, and four wings. The head of the butterfly includes; two antennae, two eyes, and a proboscis. Butterflies use their antennae for balance during flight, as well as to feel and smell. A butterfly's eyes are compound, meaning they contain numerous lenses and see in many separate units, much like looking through a kaleidoscope. Butterflies lack teeth and mandibles. Instead, most butterflies feed through a long tube, called a proboscis, which unrolls when the butterfly eats. Essentially, the butterfly feeds through a straw, thus their diet is completely liquid. The thorax, middle body segment, includes the butterfly's wings and six legs. Butterflies have a set of forewings (front two wings) and a set of hindwings (rear two wings). The abdomen contains the butterfly's reproductive, respiratory, circulatory, and digestive systems.

BUTTERFLY PROBOSCIS:



Zebra longwing
Heliconius charithonia

Wings-n-Things

MATERIALS

- Butterfly specimens
    - Specimens can be ordered on-line or collected outdoors; please be respectful of nature and collect only deceased butterflies
    - Refer to "How to Spread a Butterfly" on page 71 for instructions on preserving butterflies
- Microscope or magnifying glasses
- Journal
- Writing utensil
- Butterfly Anatomy Diagram (page 23)

PROCEDURE

1. Collect and preserve enough butterfly specimens for students to observe individually or in small groups.
2. Pass out microscopes or magnifying glasses and specimens. Explain to students that they will examine their butterfly closely using the tools provided.
3. Students should select one body part at a time (i.e. antennae) to examine closely under the microscope. After careful investigation, they should sketch the body part in detail in their journal and make an inference to the possible function of that part. This should be recorded in their journal next to their sketch.
4. Students should continue examining, sketching and making inferences for the other major body parts of the butterfly specimen.
5. After students have finished, ask them to share their observations and inferences with the class for discussion. *What did you observe? What evidence led you to your conclusion about the function of the body part? How did prior knowledge about butterflies guide your inferences?*
6. Continue to facilitate meaningful discussions and ask students, *how could we find more information on butterfly anatomy?*
7. After students have brainstormed ways that they can gather more information to verify their observations, assign each group a body part to research in more depth.
8. Have groups report back to the class with what they discovered. *What is your body part called? Was your original inference about this body part correct? How do you think lepidopterists (scientists that study butterflies) discovered the purpose of your butterfly part?*
9. Using the butterfly diagram, review the anatomy and function of each part.

continued...

AT THE ZOO

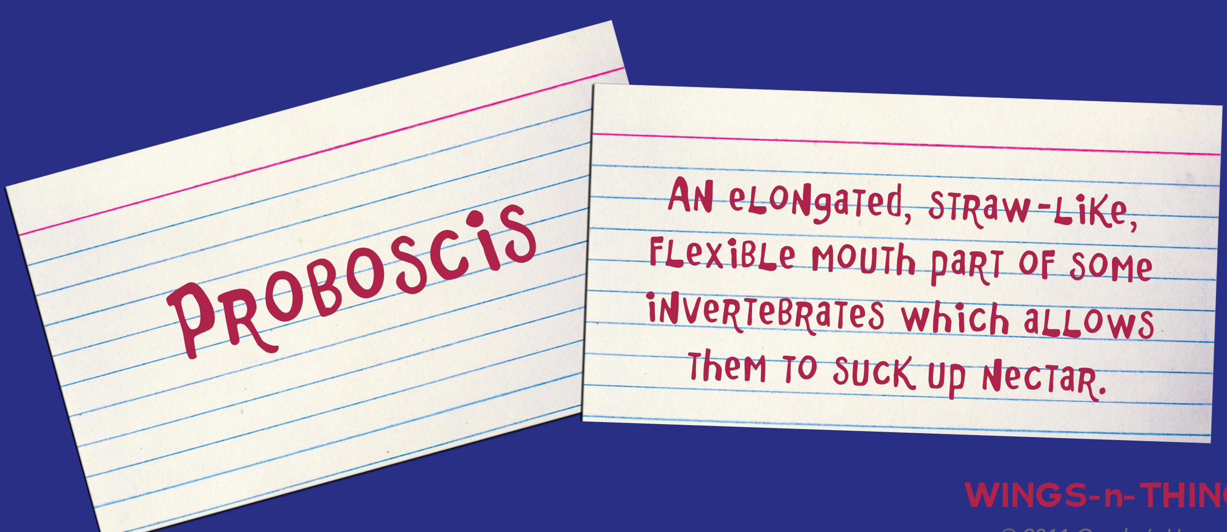
Visit the Berniece Grewcock Butterfly and Insect Pavilion at Omaha's Henry Doorly Zoo. Here, students have the opportunity to observe a variety of butterfly species up close. Bring magnifying glasses so students can observe the butterflies and their natural behavior in more detail. Watch butterflies eat at feeding stations and examine how they use their proboscis or investigate if certain species have food preferences. The possibilities are endless!

EDUCATOR NOTE:

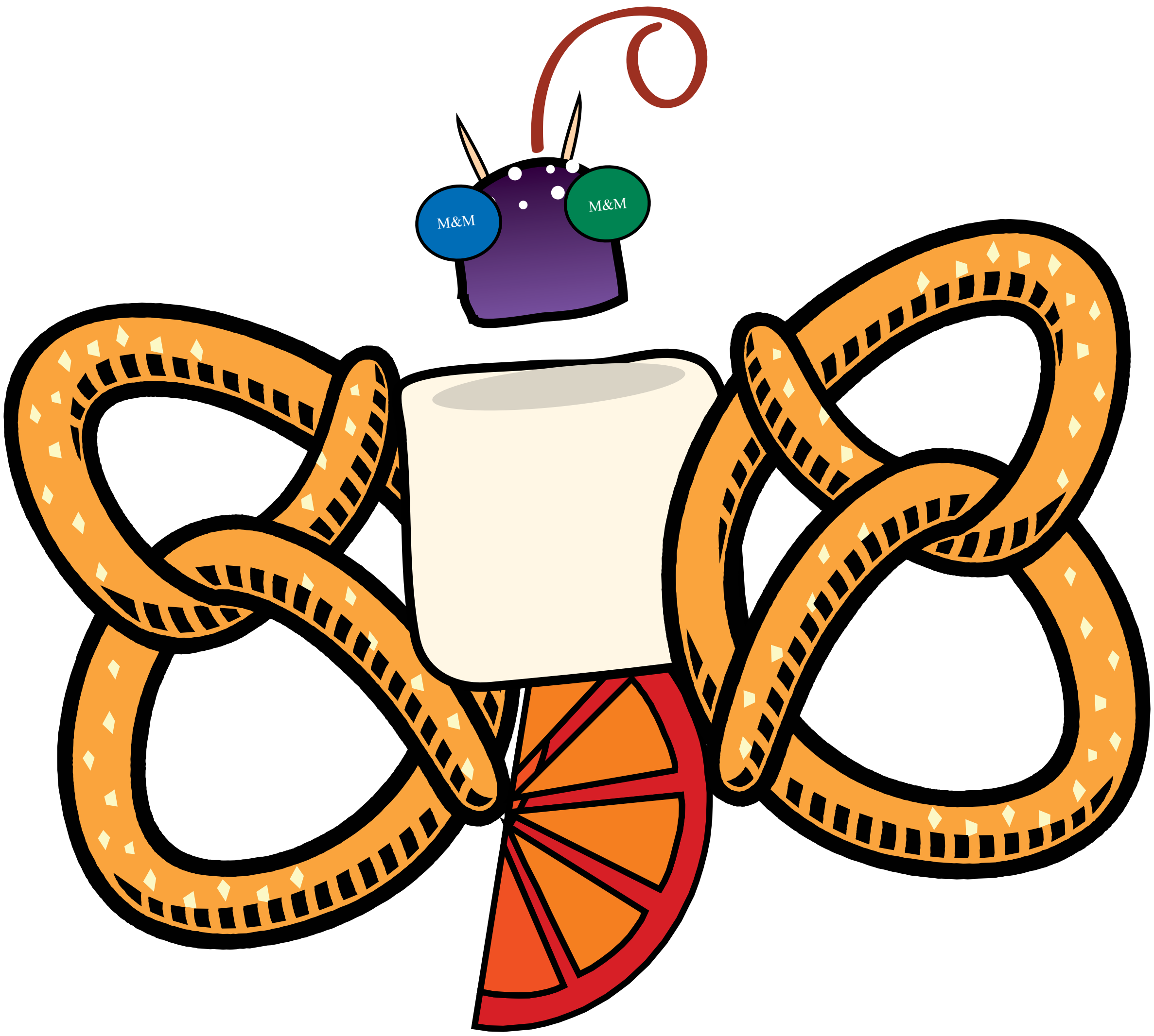
- To help students remember the parts of a butterfly, have them create a concentration game. Using index cards and knowledge gained from the previous activity, students should write each butterfly body part on an individual card. Next, students should write a description of each body part on another card to create matches. Group students together and allow them to play the game. Students must turn over two cards. If they turn over a body part and its correct description then they have found a match.

- As a fun snack and a way to remember butterfly anatomy, have students model butterflies out of candy. You will need the following supplies for the activity:
    - Gumdrops (head)
    - Marshmallows (thorax)
    - Orange candy slices (abdomen)
    - Black shoelace licorice (legs)
    - Red shoelace licorice (proboscis)
    - Mini M&Ms (compound eyes)
    - Large Pretzel twists (wings)
    - White frosting (glue for the candy)
    - Toothpicks (hold head, thorax and abdomen together)

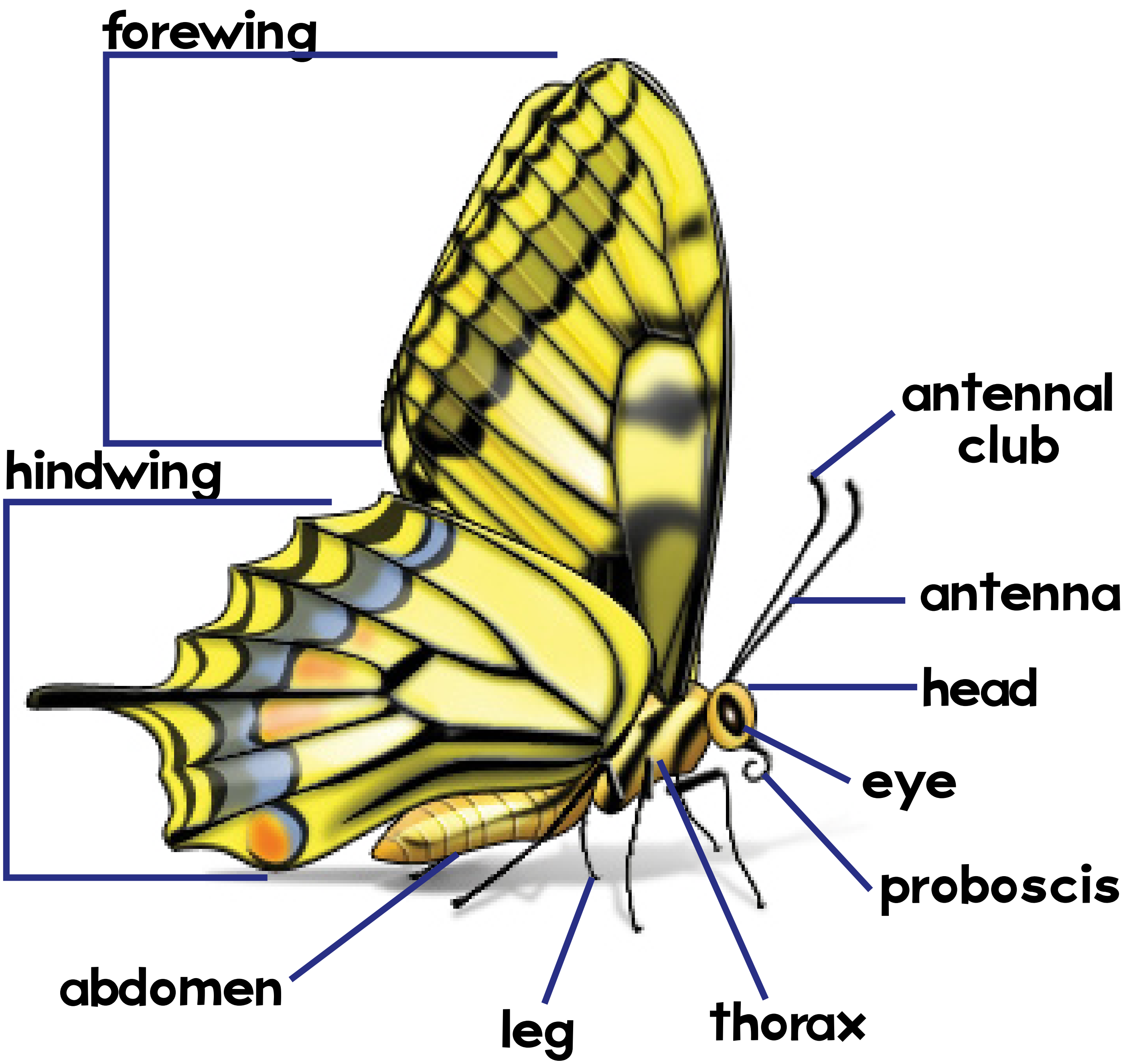
See the diagram on page 22 to help you assemble the candy butterfly.



Candy Butterfly



Butterfly Anatomy Diagram



Come Fly with Me

TECHNICAL WRITING

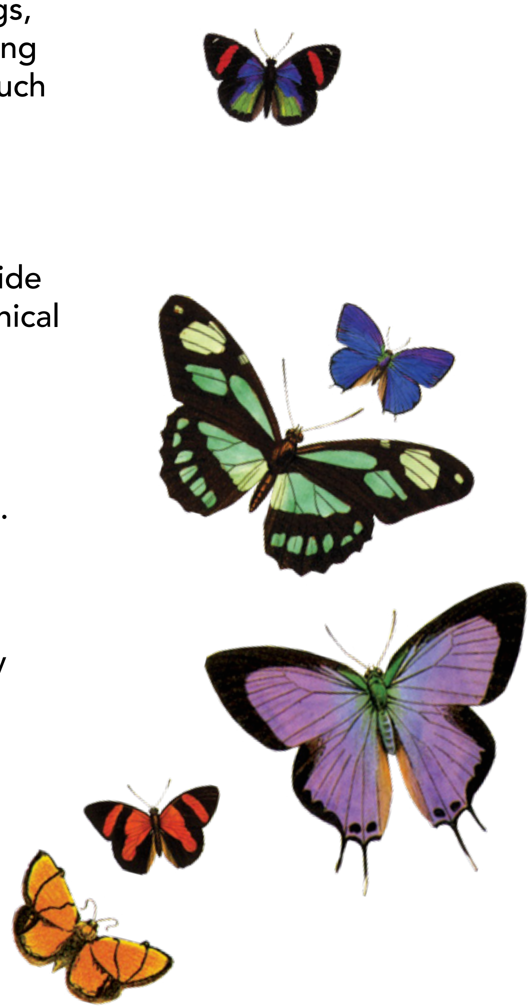
VOCABULARY
- Technical Writing

OBJECTIVES
- Develop an understanding of technical writing
- Create a technical writing piece from which another person is able to construct a product or identify an object
- Use observation skills to identify butterfly and moth species

BACKGROUND
Researchers and hobbyists use many identification tools to identify a species. These tools may include; location where the insect was found, size, color, markings on wings, overall shape of wings, and others. With the advent of the digital camera, identifying butterflies and moths has become somewhat easier and much more cost-effective for researchers. However, technical writing, sketching, and communication are all important in relaying information.

Technical writing is an explicit form of writing used to provide instructional information for readers. Researchers use technical writing to communicate information and relay research. Whether scientists work in teams or alone, all communicate extensively.

Thousands of butterfly and moth species exist in the world. While many species look very different from one another, some species appear to be incredibly similar. Properly recording and monitoring butterflies helps researchers and conservation groups direct conservation efforts where they are needed.



Thank you to Rachel Bottlinger for assisting with development of portions of this lesson.

Data Analysis & Technical Writing Introduction

Complete before visiting Zoo
In this activity, students will explore how to effectively communicate with their classmates using technical writing skills.

MATERIALS

- Overhead to display technical writing pieces or copies to distribute
- ½ butterfly wing (page 32)
- Markers or crayons
- Paper
- Writing utensil

ACTIVITY PREP

1. Create two technical writing pieces on how to make a peanut butter & jelly sandwich. One should be poorly written to the point the students will not be able to identify the product. The other should be well written so the students will be able to recognize the product. Note: you may choose to write your pieces on a different item so long as when students read the well written piece, they will easily be able to identify the product.
2. Color two ½ butterfly wings, making them different designs. Label them 1 and 2.
3. Set your two colored wings in a place where the students cannot see them while you are introducing the activity.

PROCEDURE

1. Introduce the activity by distributing or displaying the poorly written piece of technical writing. Have the students read the passage. When they are finished reading ask them the following questions. *What would be produced if someone followed the instructions in this piece? What is wrong with this written piece?*
2. Display or distribute the well written piece and have the students read the passage. After they are finished ask them again, *what would be produced if someone followed the instructions in this piece? How do you know what the product would be? What key pieces of information would help you to construct the product? Why is technical writing important? How do good technical writing skills serve scientists and the community?*
3. Next, explain to students that you have designed one side of a butterfly wing. They will need to generate the matching side by using technical writing.
4. Divide the class in half. Assign one half of the class to work on wing 1 and the other half of the class to work on wing 2. Make sure that the two wings are only visible to the students working on them.
5. Tell students that right now they are working as the recorder. It is the recorder's job to use his/her technical writing skills to explain how to color the ½ butterfly wing so that it matches the other side presented to them.
6. Once students have had ample time to create their technical writing pieces bring them back together as a large group and pair students from opposite groups together.
7. Explain to the students that they need to exchange their technical writing piece with their partner. Now they will all be the designer and will need to create a butterfly wing that matches the one described in the technical writing piece.

PROCEDURE continued...

8. After students have created their butterfly wings, present your two designed wings for students and facilitate a discussion with your class about the activity. *When you were a designer did you recreate an exact replica of the model described? When you were a recorder, were you able to successfully communicate to your partner how to build this model? What made it easier to design your model? What was challenging about this activity? If you were to do this activity again, what would you do differently? How do good technical writing skills serve scientists and the community?*

AT THE ZOO

The following activities can be done at Omaha's Henry Doorly Zoo year-round, around your school, or any other area where butterflies or moths may be found. Please be sure to check Butterfly and Insect Pavilion operating hours, as they may vary from Zoo operating hours. Groups of 20 students or less are advised inside the Butterfly and Insect Pavilion due to space restrictions.

Data Analysis & Technical WRITING at the Zoo

MATERIALS

- Paper
- Writing Utensil
- Omaha Zoo Butterfly & Moth Identification guide (download at www.omahazoo.com/conservation)

PROCEDURE

1. Before your visit to the Zoo, explain to students that they will be completing another technical writing activity at the Zoo in the Berniece Grewcock Butterfly and Insect Pavilion. They will be required to develop a technical writing piece about a butterfly. The piece should be written so that another person would be able to identify the butterfly.
2. Take the students to the Butterfly and Insect Pavilion and allow them to observe the butterflies for a few minutes.
3. Next, have the students pick a butterfly and tell them they have 10 minutes to create their technical writing piece.
4. After 10 minutes take the students out of the Butterfly and Insect Pavilion. Pair the students together and have them exchange their technical writing pieces.
5. Explain to the students that when they return to the Butterfly and Insect Pavilion they will read their partners piece and identify the butterfly. Partners should stay together in order to verify butterfly identification.
6. After completion of the activity, discuss the importance of technical writing in the research field.

EDUCATOR NOTE:

Consider creating a 3D object out of materials such as pipe cleaners. After recorders have written their technical piece on your 3D object, provide designers with the same building materials and have them duplicate the object.

Data Analysis & Technical DRAWING at the Zoo

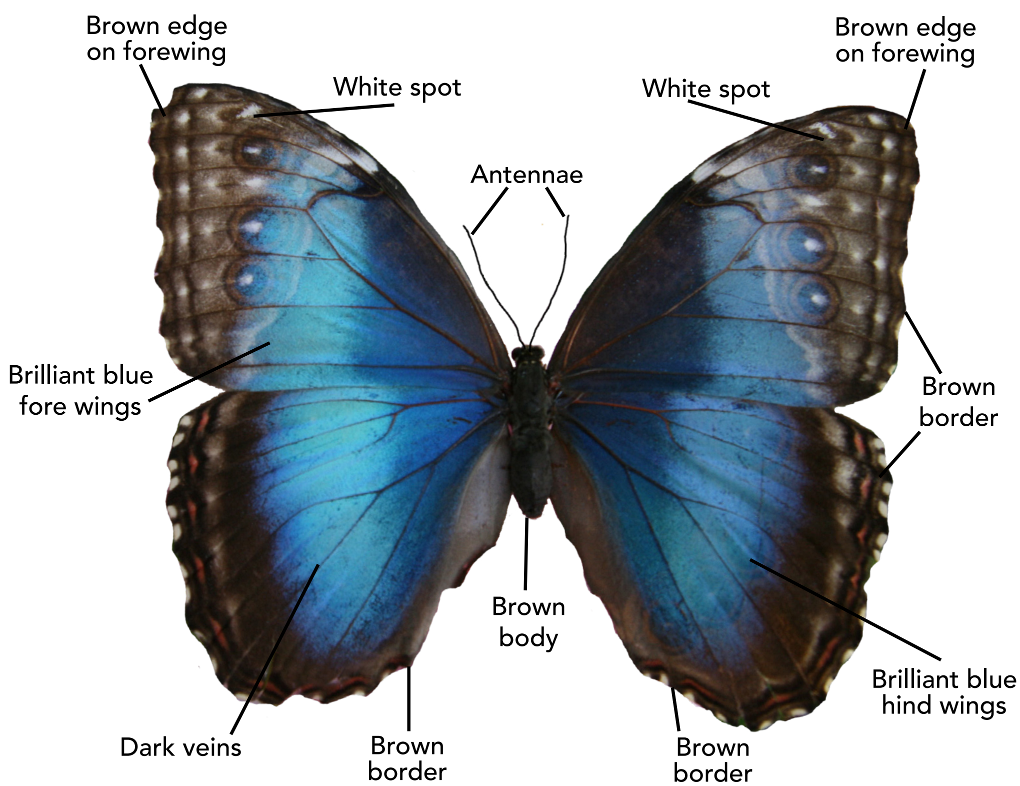
MATERIALS

- Colored Pencils
- Come Fly with Me Worksheets (page 28 & 29)
- Omaha Zoo Butterfly & Moth Identification guide (download at www.omahazoo.com/conservation)
- Clipboard

PROCEDURE

1. In this activity, students will work to identify individual butterfly species. *Do students think this might be a simple activity? What are some characteristics you might look for when identifying butterflies?* Answers may include shape, wingspan, opened or closed wing color, markings on wings, etc.
2. Students will be sketching butterflies or moths in this activity. *Why might it be important to get as many details in as short of time as possible? How can a detailed description help identify a butterfly? How is technical writing/sketching important to research?*
3. Have students work in groups of 2-4. Each student should closely observe 1-2 butterflies or moths. Using the Come Fly with Me worksheets, instruct students to make a sketch of their observations and also write a detailed description.
4. Students should then exchange sketches/descriptions with each other. Hand out the Butterfly Identification chart. Students should attempt to identify their partner's butterfly using only the sketch and description.

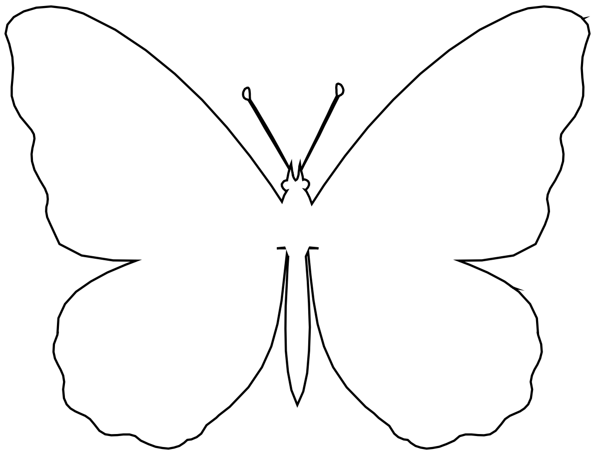
Blue Morpho Diagram

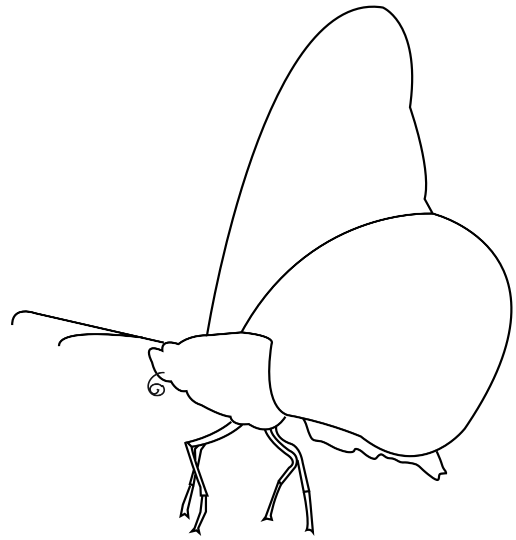


(Color may vary between photo and live butterfly)

COME FLY WITH ME

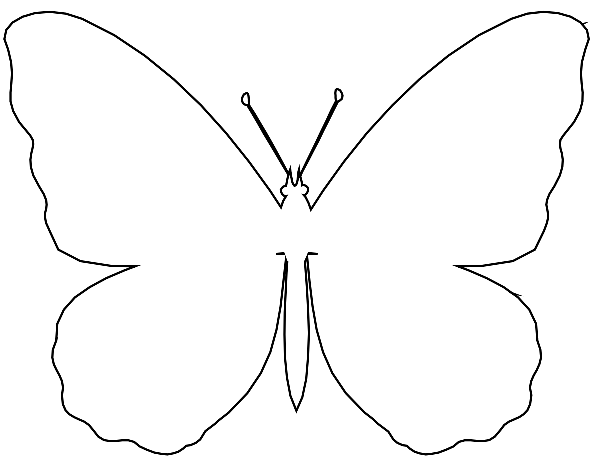
While closely observing a butterfly or moth, make a sketch using the outlines below. You can reshape the wings or body as needed. Get as many details as you can. Write a description of the butterfly or moth.

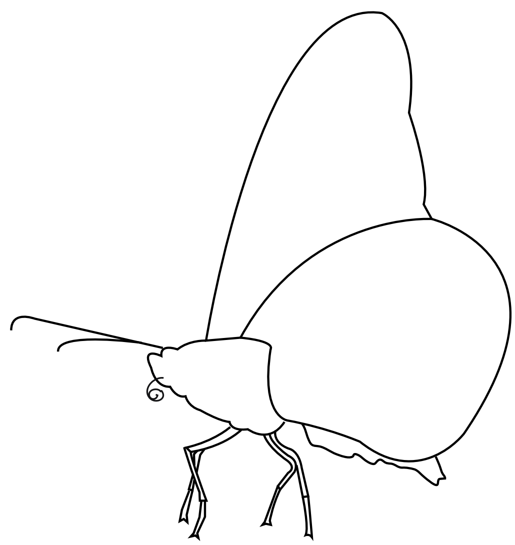




Butterfly or Moth (circle one)

Description:





Butterfly or Moth (circle one)

Description:

Come Fly with Me continued...

1. Use the chart to identify the butterfly based on the characteristics you observed and sketched.

Identity of Butterfly/Moth 1: ___________________________

Identity of Butterfly/Moth 2: ___________________________

2. What details did you key in on to help make the identification?

3. What challenges did you experience during this activity?

4. What challenges might a scientist experience while studying butterflies or moths?

Seeing Double:
BUTTERFLY SYMMETRY

VOCABULARY
- Symmetry

OBJECTIVES
- Uncover how math is found in nature
- Develop an understanding of the concept of symmetry
- Design a symmetrical butterfly

BACKGROUND
Animals can be used in many ways to discuss mathematical concepts. Symmetry is one math concept that is easily found amongst wildlife. Symmetry in biology is the balanced distribution of duplicate body parts or shapes. Many animals are symmetrical in some way. Most exhibit bilateral symmetry, meaning they can be divided in half, with both halves being a mirror image of the other. The beautiful design of a butterfly's wings is a great demonstration of bilateral symmetry.

Madagascan Sunset Moth
Chrysiridia rhipheus

MATERIALS
- Construction paper
- Paint
- Paint brushes
- Variety of butterfly pictures
- Stickers
- Markers or crayons
- Scissors
- Copies of Butterfly Outline (1 per student) and one enlarged copy of the outline (page 32)

PROCEDURE
1. Give each student a piece of construction paper and ask them to fold it in half. Students should then unfold their construction paper and paint a design on one side. Refold the paper in half with the paint on the inside of the fold and gently press down.
2. Have students open up their paper and ask, *what happened?* Your design is now on the other side of the paper. *Do both sides of the paper look the same?* Explain to them that this is called symmetry.
3. Next, share a variety of butterfly pictures with the students. *Do the butterflies' wings look the same? Do butterflies have symmetry?* Yes, both wings have the same design.
4. Display the enlarged outline of the butterfly from page 32 for students. Note that the enlarged butterfly contains grid squares. Students will not only be demonstrating an understanding of symmetry, but also counting.

PROCEDURE continued...

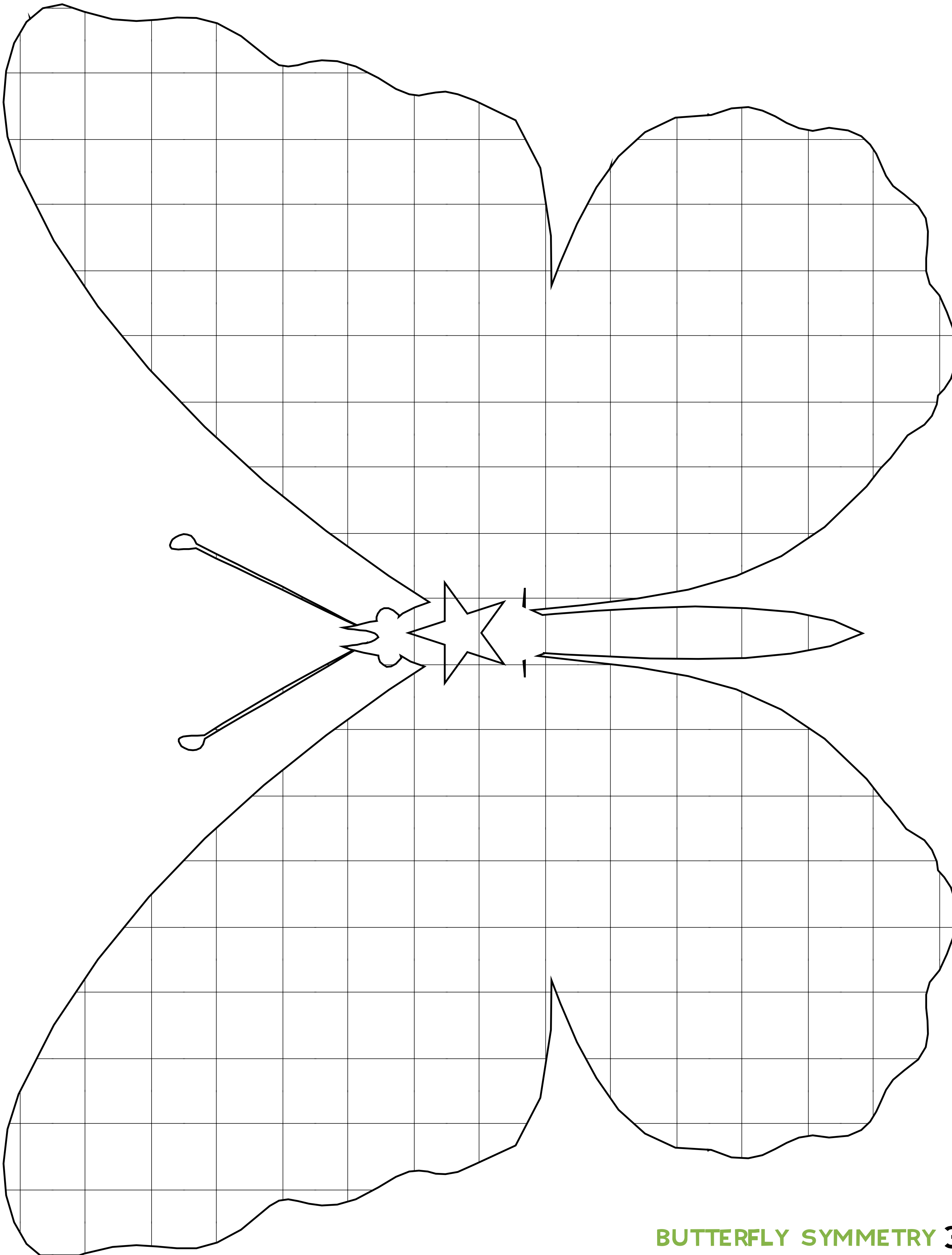
5. Choose a student to come up to the butterfly and place a sticker on one of the squares of the grid. As a class, start at the center mark and count the number of squares over and either up or down until you reach the sticker.
6. Next, the teacher should count the same number of squares over and either up or down on the opposite wing and place the same sticker creating symmetry. *Why do you think I placed the sticker here?* Explain that the wings need to be balanced in order to create symmetry. Repeat as needed to help students understand how to make the butterfly symmetrical.
7. Allow students to decorate the butterfly until you feel they have gained adequate knowledge to create their own symmetrical butterflies.
8. Now, students should take what they have learned and apply it to their own butterfly, creating symmetry. Give each student a copy of the worksheet from page 32.
9. Explain to students that they will be creating their own symmetrical butterfly wings. Students will need to decide on one pattern to use for both wings. Ask students to design and color one wing then copy their same design onto the second wing. As the teacher, you can set guidelines for their pattern. For example, each wing should include one square, one triangle, and one circle.

EDUCATOR NOTE:

As an additional activity, when students have successfully made two symmetrical wings on their own, instruct them to cut their butterfly in half down the body. Take one of the wings and hide it in the room. Place the other wing at the front of the room. Explain to students that they will be completing a matching activity. You have already hidden one wing from each set and it is their job to find its match. Have them work silently in pairs, using sign language (pointing, thumbs up, thumbs down, etc.) to find and match the wings. After they have found a hidden wing, they should find its match at the front of the room. If they have matched the wings correctly, they can place their match at their desk then continue to find another hidden wing. After the game is finished, ask each group to tell you how many pairs of wings they found. *Who found the most number of wings? Who found the least number of wings?*

For older students, discuss planes of symmetry and the different types of symmetry that can be found in animals such as bilateral, radial, and spherical.

Butterfly Outline

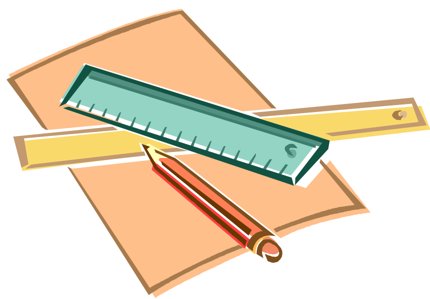


Inch-by-Inch

OBJECTIVES
- Use butterflies as a non-standard measuring tool
- Develop an understanding of the measuring and graphing process
- Practice using comparative language

BACKGROUND
Butterflies can be used in many ways to reinforce important mathematical concepts. The incorporation of butterflies in math can serve as a motivational tool for students to engage in this subject area. Using butterflies as a non-standard measuring unit is a great way to help students learn the basics of measurement. With this method, students use real materials from their environment to participate in an assortment of meaningful measurement activities. Through this exploration students begin to develop an understanding of the measurement process and advance their comparative language skills.

MATERIALS
- Butterfly and Caterpillar Measurement Tools (page 35)
- Writing utensil
- Scissors
- Tape
- Graphing area (examples: white board)
- Rulers



ACTIVITY PREP
1. Pre-cut 2 butterfly measuring tools (located on the Butterfly and Caterpillar Measurement Tools worksheet), for each pair of students.
2. Create a graph to record the students' butterfly measurements. Label the X-axis "Number of Butterflies" and the Y-axis "Number of Students."

PROCEDURE
1. Introduce the activity by showing students different sizes of butterflies.
2. Inform students that they are going to be measuring how tall their classmates are by using butterflies as a measuring tool. Choose one volunteer to demonstrate how students will use the butterflies to measure. Ask your volunteer to sit on the floor and lay down on their back. Using the two butterfly measuring tools, measure your volunteer by starting at their feet and placing one butterfly in front of the other until you reach the top of their head. Then record on one of the butterfly measuring tools the height of your volunteer, i.e. 10 butterflies tall.
3. Divide students into pairs and give each group two butterfly measuring tools. Ask students to find a space in the classroom to measure their partner. When students have finished measuring, ask them to record how many butterflies tall they are on their butterfly measuring tool.

PROCEDURE continued...

4. Gather students as a group and ask them to bring their butterfly measurements with them. Inform students that they will be graphing their measurements as a class. *Were you the same number of butterflies tall as your partner? What do you think our graph will look like?*
5. Ask one student at a time to come up to the front and tape their butterfly where it belongs on the graph. As students continue to graph their measurements, ask questions like, *how many students are eight butterflies tall? How many students are taller than eight butterflies? How many students are shorter than eight butterflies?*
6. When the graph is complete, review the results as a class.

Hairstreak
Lycaenidae

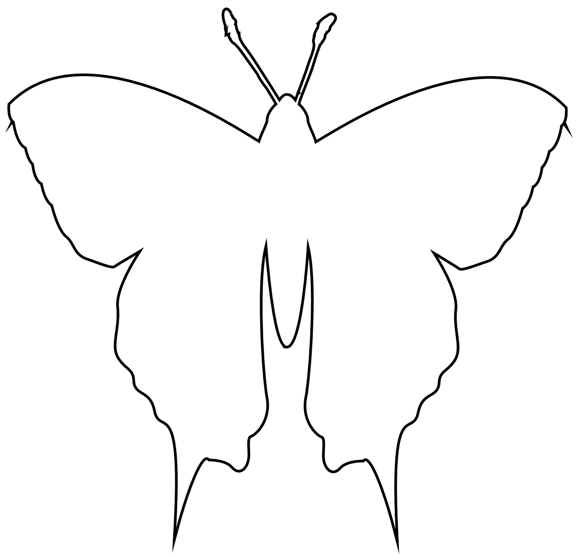
EDUCATOR NOTE:

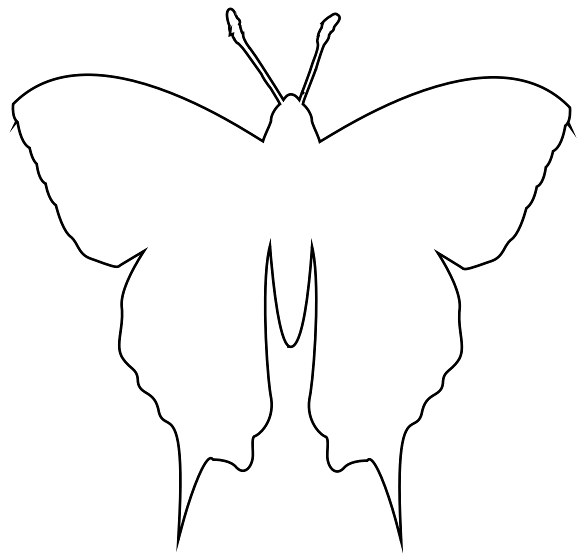
In addition to using butterflies, have students measure in different lengths of caterpillars. Graph how tall the class is in small, medium, and large caterpillars. For older students, use this activity to introduce or reinforce how to work with fractions.

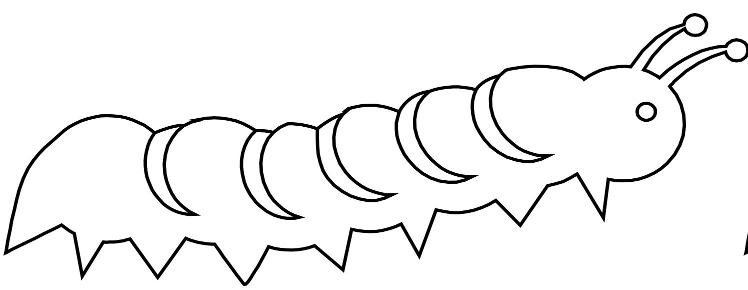
You may also choose to set up your graph with individual student names on the Y-axis and "Number of butterflies tall" on the X-axis. Using this method will allow students to sort by height (for example, arranging the tallest student to the shortest student in class).

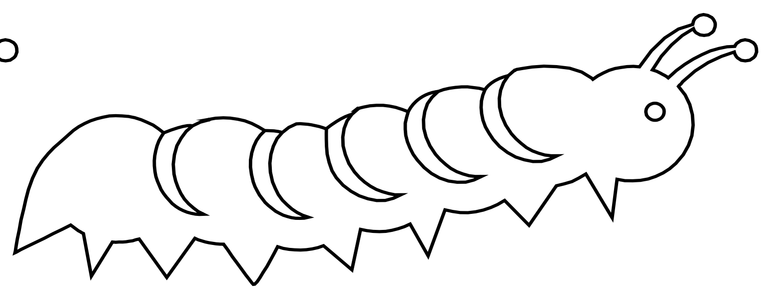
For upper grade levels, have students convert their measurements to centimeters or inches using a ruler.

Butterfly and Caterpillar Measurement Tools Worksheet

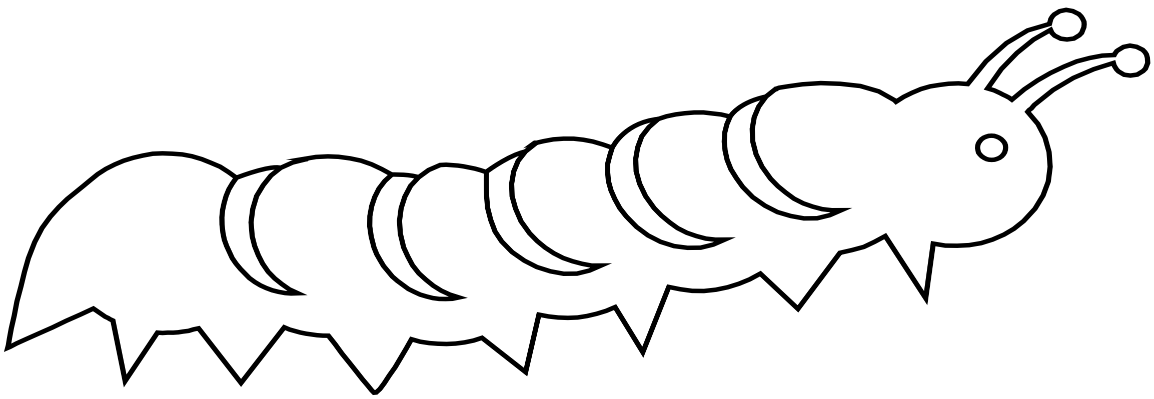


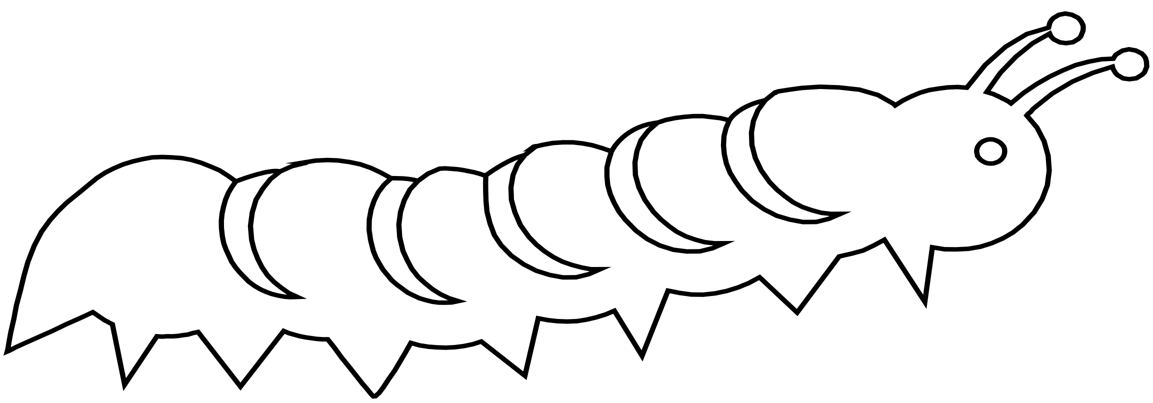




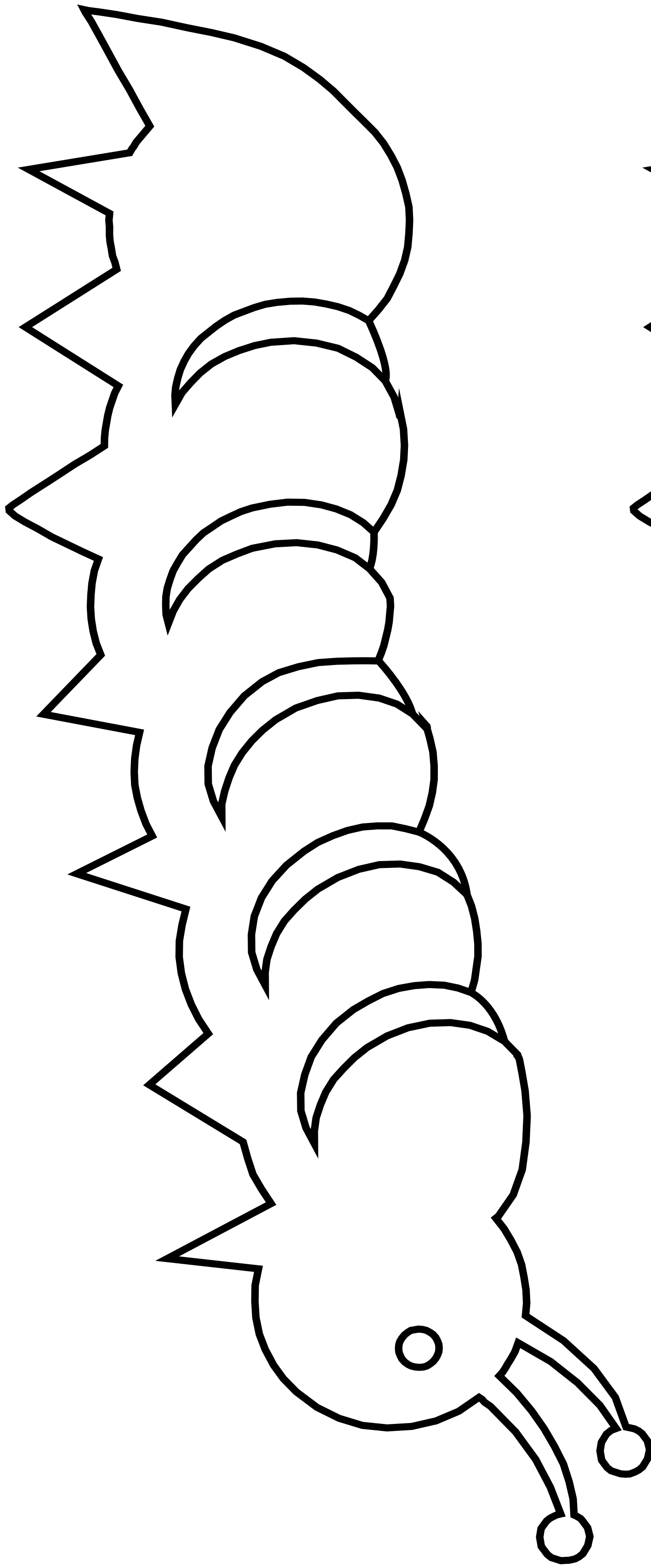


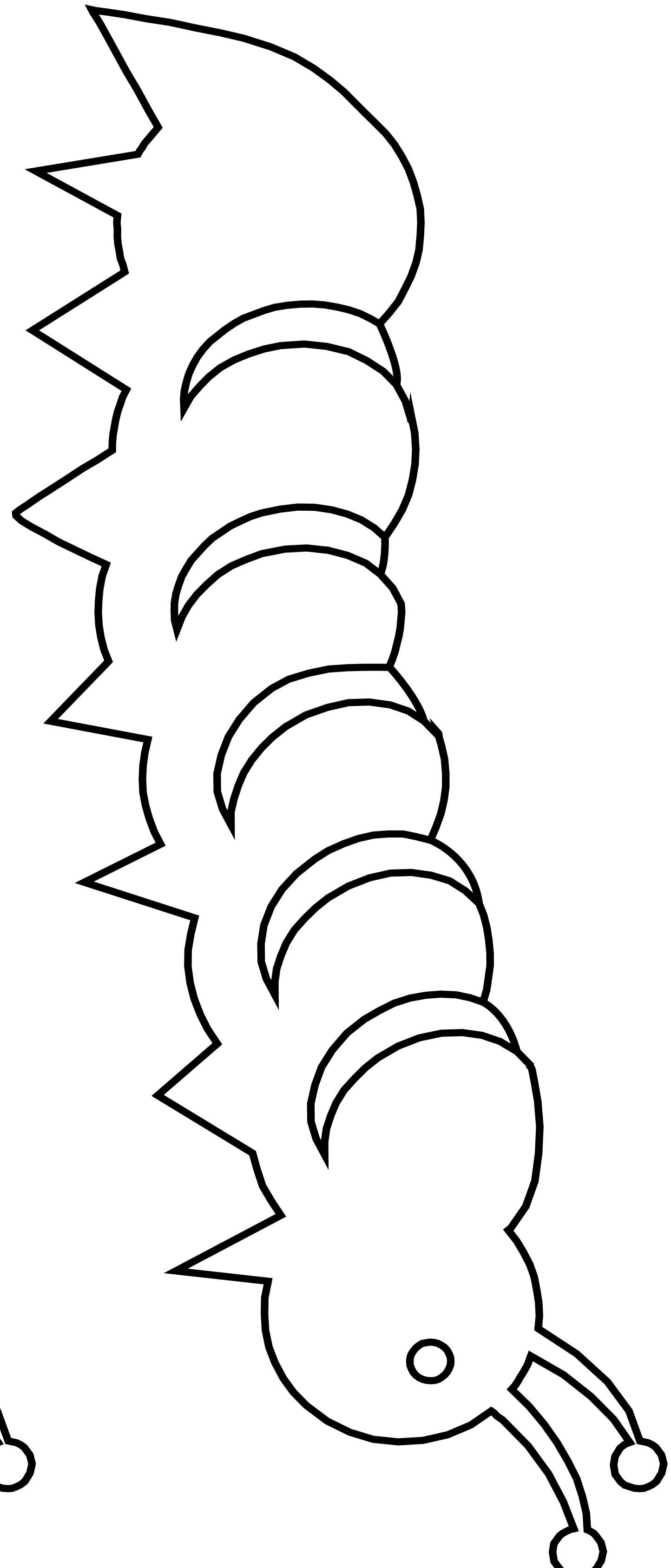
Butterfly and Caterpillar Measurement Tools Worksheet





Butterfly and Caterpillar Measurement Tools Worksheet





Social Butterfly

CULTURE AND SYMBOLISM OF BUTTERFLIES

VOCABULARY
- Symbols
- Symbolism

OBJECTIVE
- Develop an understanding of the use of symbolism

BACKGROUND
What does an apple mean to you? To many Americans it is a symbol that represents teachers. Many cultures assign meaning to different objects and/or organisms, a butterfly being the recipient of many meanings. The Zuni Indians of the American Southwest believe the butterfly represents rain or a rainy summer. According to their beliefs, if a white butterfly flies from the southwest one can expect rain or if the first butterfly is white one could expect a rainy summer. Additionally the Irish and Greeks believe the butterfly represents human souls. The Greeks believed that each time an adult butterfly emerged from its cocoon, a new human soul was born. The Irish believe that butterflies are the souls of the dead waiting to pass through purgatory. In American society today one can often hear the phrases, "I have butterflies in my stomach," and "social butterfly." The former meaning one is nervous. They have the feeling of butterflies flying around in their stomach. The latter meaning one flits around, like a butterfly would from flower to flower, attempting to be seen in all the right places with all the right people in order to increase their success and popularity. Finally, Mexican Indians associate butterflies with flames. It is believed these Indians may have come in contact with many butterflies whose wings were red, orange, yellow, or a combination of all three. These colors most certainly are associated with fire and if the Mexican Indians had seen millions of fire-colored butterflies flying together then it might be possible they had thoughts of a "cloud of flame".

MATERIALS
- Picture of American Flag
- Picture of the Statue of Liberty
- Background information
- Teacher model of assignment
- Pencils
- Paper
- Computers

New Guinea Birdwing Butterfly
Ornithoptera priamus

PROCEDURE

1. Start by showing students a picture of the American flag and the Statue of Liberty. Ask the students, *what do these items represent?*
2. After taking a few answers, explain to students that these items are American symbols. They carry meaning for American people. The flag represents freedom and courage, while the statue represents freedom and a new life for immigrants who see her upon arrival to the United States.
3. Next, explain the idea of symbolism to students and conduct a discussion on other symbols that the students are familiar with, creating a list on the board.
4. Explain to students that many objects/organisms carry symbols. Butterflies carry many different meanings. Share the background information with the students.
5. Next, explain to students that they will be creating their own meanings for butterflies. They will need to choose a butterfly and write an explanation of what that butterfly represents to them. They must also include a picture of the butterfly they chose.
6. Once students have finished, have them share their papers with their peers.

Painted Lady
Vanessa cardui

EDUCATOR NOTE:

If more time allows you may choose to create a power point with American symbols. As you go through each slide have the students talk about what each one means. You may also include other pictures of objects/organisms and allow the students to brainstorm what each of these could represent.

Wings of Change
BUTTERFLY LIFE CYCLE

VOCABULARY
- Lifecycle
- Metamorphosis
- Chrysalis

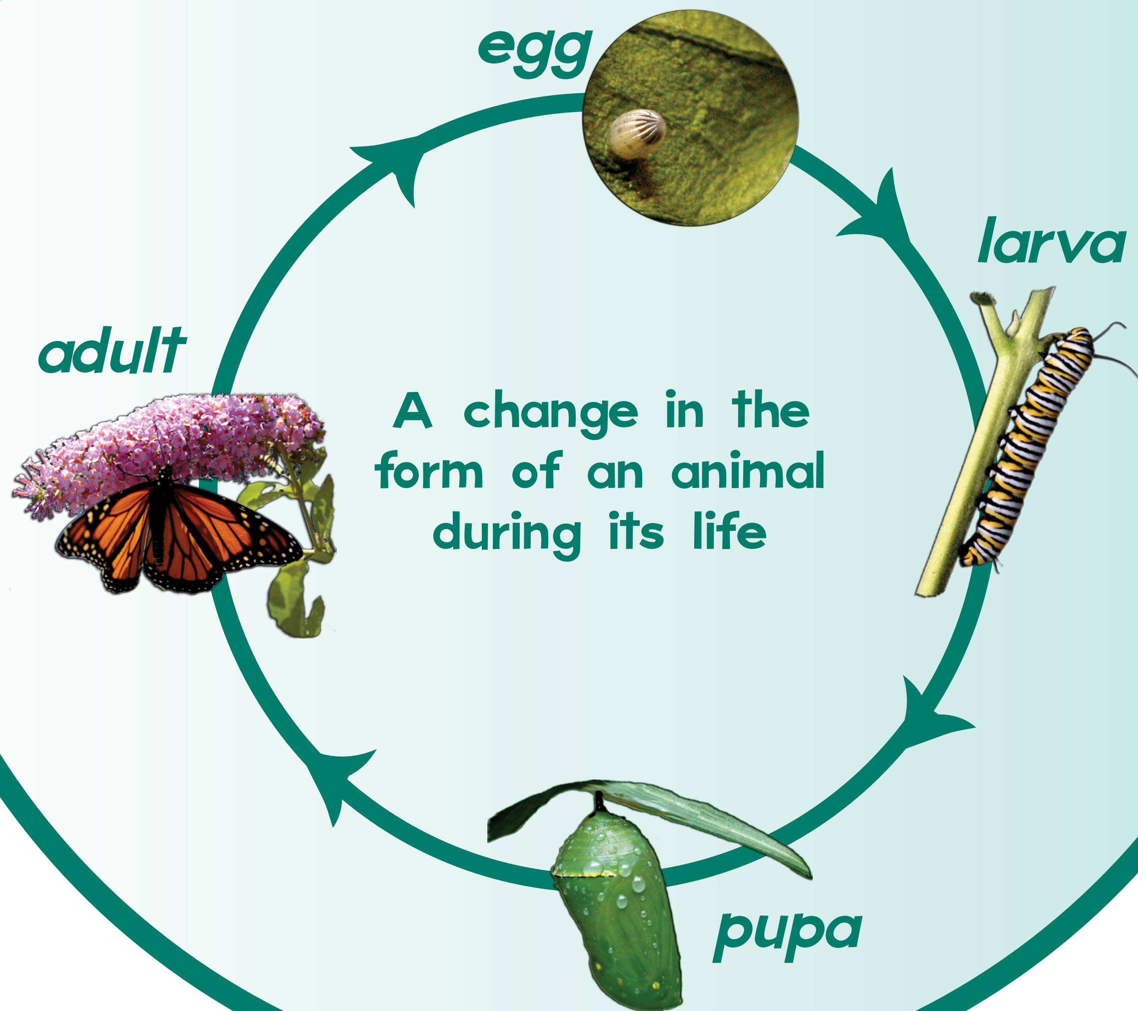
OBJECTIVES
- Develop an understanding that living things grow and change
- Discover the four stages of a butterfly's life cycle
- Imitate butterfly life cycle and practice fine motor skills

BACKGROUND
The butterfly, like most insects, develops through a process called metamorphosis. There are two common types of metamorphosis; incomplete and complete. Grasshoppers, crickets, dragonflies, and cockroaches go through an incomplete metamorphosis. In this process the young, called nymphs, usually look like small adults, but without their wings. Butterflies, moths, beetles, flies, and bees go through a complete metamorphosis. In this process the young, called larva, differ from the adults in appearance and the type of food they eat.

There are four stages in the butterfly life cycle; the egg, caterpillar, pupa, and adult. The adult female butterfly lays her eggs on a host plant. The plant will then become food for the hatching caterpillars. The next stage is the larva, which is called a caterpillar if the insect is a butterfly or moth. Caterpillars spend the majority of their time eating. As they grow they will shed their skin approximately four or five times. The food eaten during this stage will be stored and saved for the adult stage. The third stage is the pupa. The pupa of a butterfly is also called a chrysalis. The length of the pupa stage depends on the species. From the outside it may appear that the chrysalis is not changing, but inside the cells are growing at a rapid pace and becoming the legs, wings, eyes, and other body parts of the adult butterfly. The last stage is the adult. The main job of the adult butterfly is to mate and lay eggs. While some species rely on nectar for energy, others do not feed at all. It is important for the adult female to find the right plant to lay her eggs on since caterpillars cannot travel far to find the right food. Most adult butterflies live two to three weeks.

Owl Butterfly
Caligo memnon

Complete Metamorphosis



Zap!

MATERIALS

- 8 x 8 foot piece of green fabric
- Beige bed sheet
- Desks and chairs
- Colorful scarves, one for each student
- 2 buckets
- Small cotton balls

ACTIVITY PREP

During this activity, students will act out a butterfly life cycle. Set up four stations in your room in chronological order. Each station will represent a stage of the life cycle.

STATION 1, EGG:

Cut one large leaf out of the 8 x 8 foot piece of green fabric. Lay the fabric leaf on the floor.

STATION 2, CATERPILLAR (LARVA):

Place bag of small cotton balls near the leaf. These will be scattered after students "hatch" from their egg.

STATION 3, CHRYSALIS (PUPA):

Using the beige bed sheet, create a "chrysalis" or fort big enough to hold your entire class.

STATION 4, BUTTERFLY:

Place a bucket on each side of the "chrysalis" exit. Fill the buckets with colorful scarfs (one per student).

PROCEDURE

1. Introduce the activity by reading either *The Very Hungry Caterpillar* by Eric Carle or *Waiting for Wings by Lois Ehlert.*
2. Gather students at Station 1 and ask them to sit on the leaf. Explain to students that they will be playing the game "ZAP!" During this game, they will be acting out a butterfly's life cycle. Each time you say, "ZAP!" they will change to the next stage in the life cycle.
3. Think back to when we read our story. *Where did the caterpillar come from?* An Egg. Instruct students to curl up into a tight ball on the leaf. Eggs are very quiet and like to sleep.
   Close your eyes and wait… ZAP! Everyone sits straight up.
   Ask students, *what came out of the egg?* A caterpillar.
4. Since your caterpillars are very hungry, scatter the bag of small cotton balls around the leaf. Instruct students to crawl like a caterpillar and "munch, munch, munch" over to Station 2. As students are munching, inform them that caterpillars like to eat certain types of leaves depending on their species. Continue eating while crawling to Station 3. Stop at the entrance of the Chrysalis. Munch, munch, munch…. ZAP! *What does the caterpillar do next?* Spins a chrysalis.
5. Have students crawl into the chrysalis, kneel on their knees, and clasp their hands tightly above their head. While the caterpillar is inside the chrysalis, it likes to "hang" for a long time. So we hang and wait…. ZAP! *What comes out of the chrysalis?* A beautiful butterfly.
6. Instruct students to grab one scarf out of either bucket before flying out of the chrysalis. Allow students to fly and play around the room at their leisure.
7. If time allows, choose one student to be the leader and "ZAP!" his/her classmates through the life cycle.

Life Cycle Plate

Adding the Life Cycle Plate as an extension to Zap! will help further your student's understanding of the butterfly life cycle.

MATERIALS

- Butterfly Life Cycle Plate labels (page 45)
- Paper plates
- Kix® cereal
- Green construction paper
- Shell pasta
- Rotini pasta
- Bow-tie pasta
- Scissors
- Glue

PROCEDURE

1. Each student should have one of the following:
    a. Life Cycle Plate worksheet
    b. Paper plate
    c. Green leaf
    d. Kix® cereal
    e. Shell pasta, Rotini pasta, and Bow-tie pasta
2. Instruct students to cut out the labels for each stage of the life cycle found on the worksheet and lay materials out in front of them on their desk.
3. Students will glue each stage of the life cycle onto their paper plate. *What materials represent the first stage of the butterfly life cycle?* Instruct students to glue the green leaf at the top of their paper plate then glue the Kix® cereal on top of their leaf. Underneath the leaf, instruct students to glue the "Egg" label from the worksheet onto their paper plate.
4. Repeat step 3 for the caterpillar (rotini pasta), chrysalis (shell pasta), and butterfly (bow-tie pasta). Each stage of the life cycle plate should be placed clockwise in chronological order.

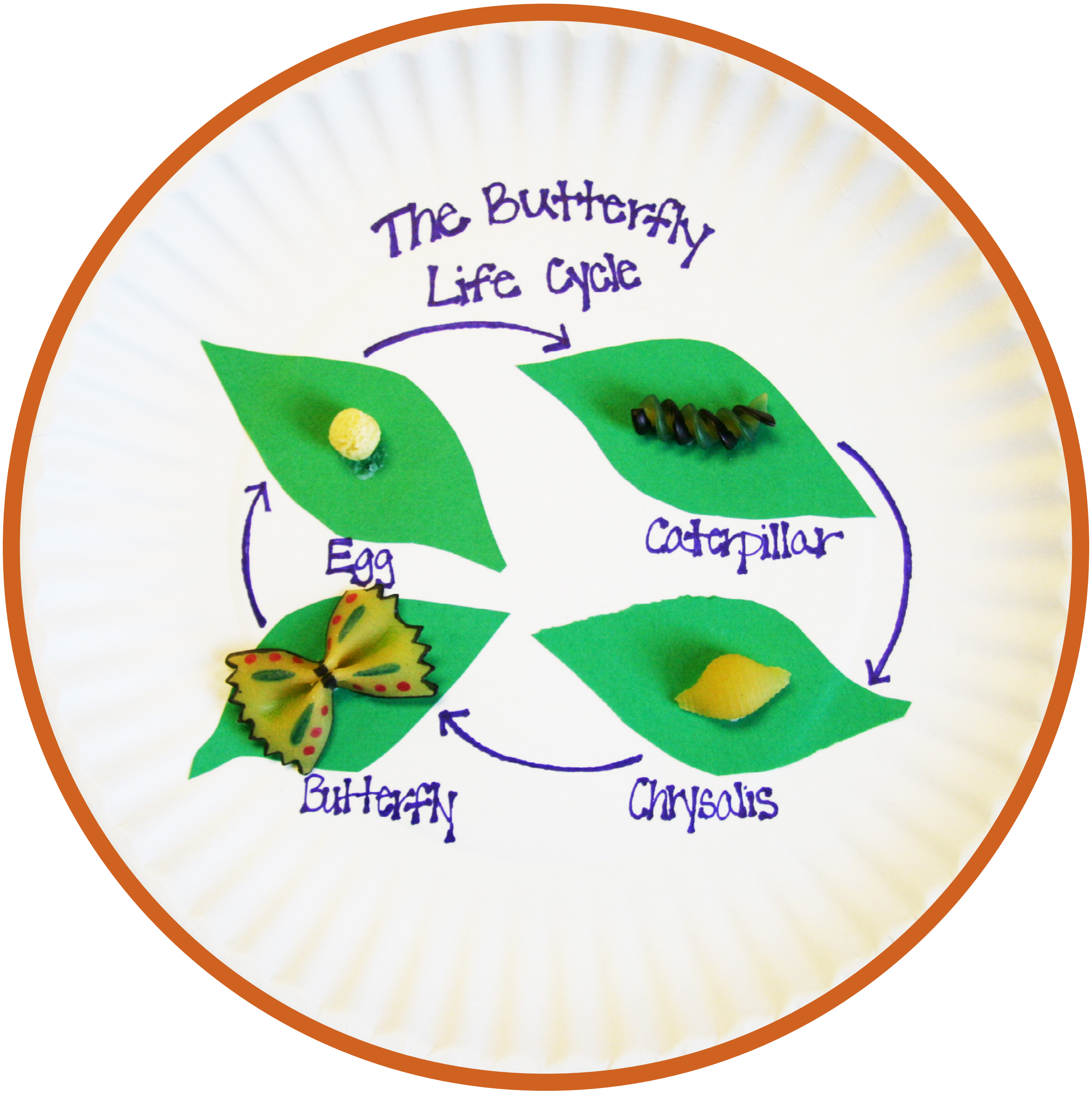
AT THE ZOO

Visit the butterfly garden and Butterfly & Insect Pavilion at Omaha's Henry Doorly Zoo and have students search for all of the butterfly life cycle stages.

EDUCATOR NOTE:

As an age modification for Zap!, introduce the idea that caterpillars eat specific plants based on their species by providing a variety of colored cotton balls. Divide students into groups based on the colors you have selected. There should be a group of students assigned to each color of cotton balls. Explain that they are only allowed to pick up the cotton balls that match their color.

Life Cycle Plate Example



Butterfly Life Cycle Plate

LABELS:

Butterfly Lifecycle

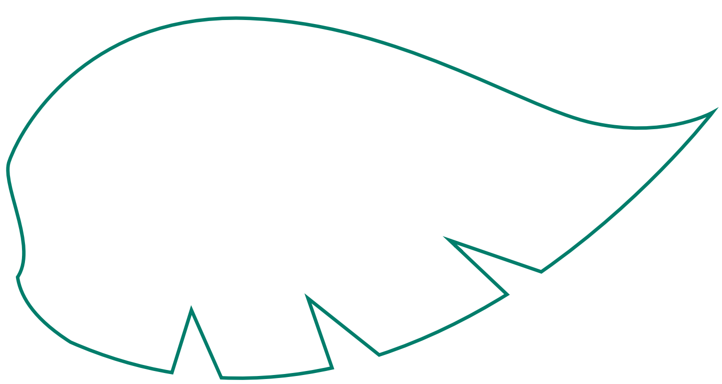
Egg

Caterpillar

Chrysalis

Butterfly

LEAF TRACE:



Beautiful Pollinators

VOCABULARY

- Anther
- Cross-pollination
- Nectar
- Pistil
- Pollen
- Pollinate
- Self-pollination
- Stamen
- Stigma
- Style

OBJECTIVES

- Learn and understand the process of pollination
- Discover how butterflies aid in the pollination of plants

BACKGROUND

According to the U.S. Forest Service, nearly 80% of all flowering plants and 75% of crops rely on animals in order to be pollinated.[2] Insects, such as bees and butterflies play a vital role. A decline in their populations would have an enormous impact not only on plant populations, but also on the economy. We have seen these effects already with the decline of bee populations due to Colony Collapse Disorder.

To understand why insects, like butterflies, are vital to the health of our economy and plant populations, it is essential to understand how pollination occurs. Pollination takes place when sticky pollen grains from the anther (male) of a flower are transported to the stigma (female), which is also sticky. If pollination occurs, seeds are formed and dispersed. Plants can be self-pollinated or cross-pollinated; however, the latter of the two must occur between plants of the same species. Cross-pollination occurs when the stigma of a flower receives pollen from the anther of another flower of the same species. Self-pollination occurs when the stigma of a flower receives pollen from its own anther. Cross-pollination is more beneficial for flowers, because it increases the genetic diversity of the species.

Flowering plants rely on outside sources to transfer their pollen. Pollen can be carried in the wind or water, but many times it is transported by animals, called pollinators. Butterflies, bees, bats, and birds are examples of a few pollen carriers. As butterflies feed on nectar from flowers, they inadvertently pick up pollen as their legs brush against the anther. Therefore butterflies, along with other pollinators, play an important role in cross-pollination and are vital to the health and genetic diversity of plants.

[2]U.S. Forest Service. Celebrating Wildflowers. 2010. http://www.fs.fed.us/wildflowers/pollinators/butterflies.shtml. 9 March 2011.

Pollination Stations

MATERIALS

- Q-tip
- Cotton balls (1 per student)
- Flower Anatomy worksheet (page 48 & 49)
- 5 small paper cups
- 5 different colors of chalk dust
- Flower Outline (page 50)

ACTIVITY PREP

1. Before class, make 5 copies of the Flower Outline on different colors of paper and cut them out.
2. Grind up colored chalk that matches each of the paper flowers. Place each color of chalk into a different cup.
3. Place the paper flowers around the classroom. In the center of each flower, place the cup with matching ground up chalk.

PROCEDURE

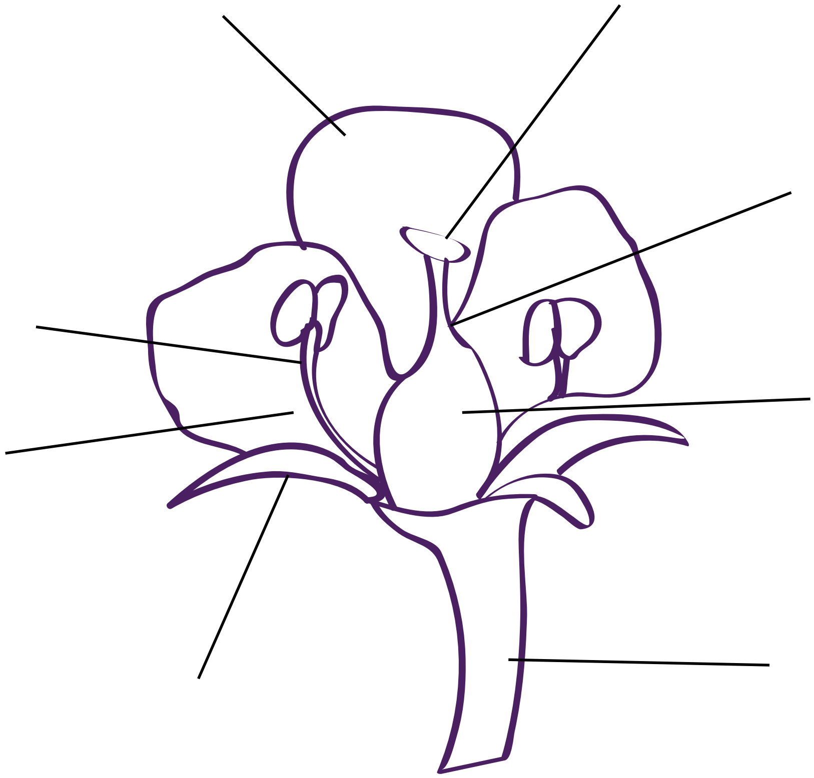
1. Hand out the Flower Anatomy worksheet to each student. Begin by taking students outside to an area with flowering plants (if this is not available, a flowering house plant will work). With the Q-tip, gently swab pollen from a flower and show students. *What is the yellow powder on the Q-tip?* Explain to students that this is pollen, which is found in all flowering plants. Pollen is used by plants to reproduce.
2. Discuss the anatomy of a flower on the worksheet, using the plant to point out the real parts. Discuss with students the role that each part of the flower plays in pollination. *How does the pollen from one plant get transferred to the stigma of another plant?* Brainstorm ways that this may happen.
3. Back in the classroom, give each student a cotton ball. Explain that they will be "butterflies" collecting nectar from the different "flowers" around the room.
4. Butterflies should fly to a flower and dip their finger in the cup of chalk to collect "pollen" (the cup represents the anther). Students should then wipe the chalk off onto their cotton ball (representing the stigma of the flower).
5. Butterflies should then go to another flower and repeat step 4. Continue this activity until each butterfly has made it to all flowers.
6. Lead a follow-up discussion, asking the following questions:
   - *What do the chalk dust, cup, and cotton ball represent?* The chalk dust represents pollen and the cup represents the anther, which holds pollen. The cotton ball represents the stigma, which receives pollen.
   - *How do butterflies pollinate flowering plants?* Butterflies unintentionally pick up pollen on their legs and other body parts while eating nectar from flowers. When they fly to another flower, some of that pollen can rub off on the stigma.
   - *Why are butterflies so important to flowering plants?* Plants are unable to transfer pollen to other plants and therefore, rely on other sources like butterflies.
   - *Are there other ways that pollen can be transferred?* Yes, pollen can be transferred by wind, water, and other animals.

EDUCATOR NOTE:

For younger children, consider laying a large sheet of white butcher paper on the floor. At one end of the paper, add colored chalk that has been crushed into powder. Let the children take turns being "butterflies" stepping in the pollen (chalk). Have students walk across the paper so they are able to see chalk dust that has been tracked on their feet. Explain that this is similar to how butterflies track pollen.

Name:__________________________________

Flower Anatomy



1. Describe how pollination occurs.

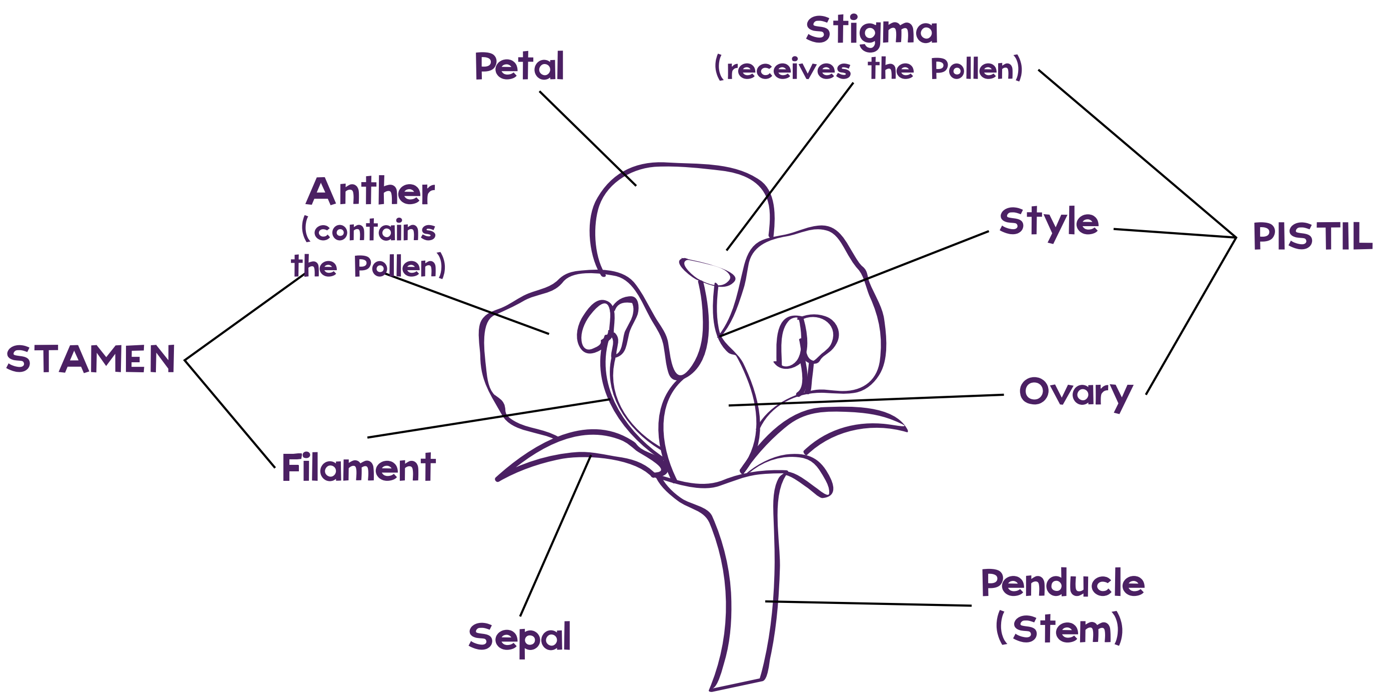
2. Describe how animals aid in pollination.

3. Describe why flowers are brightly colored.

Name:______________________________

Flower Anatomy

Color the different parts of the flower.

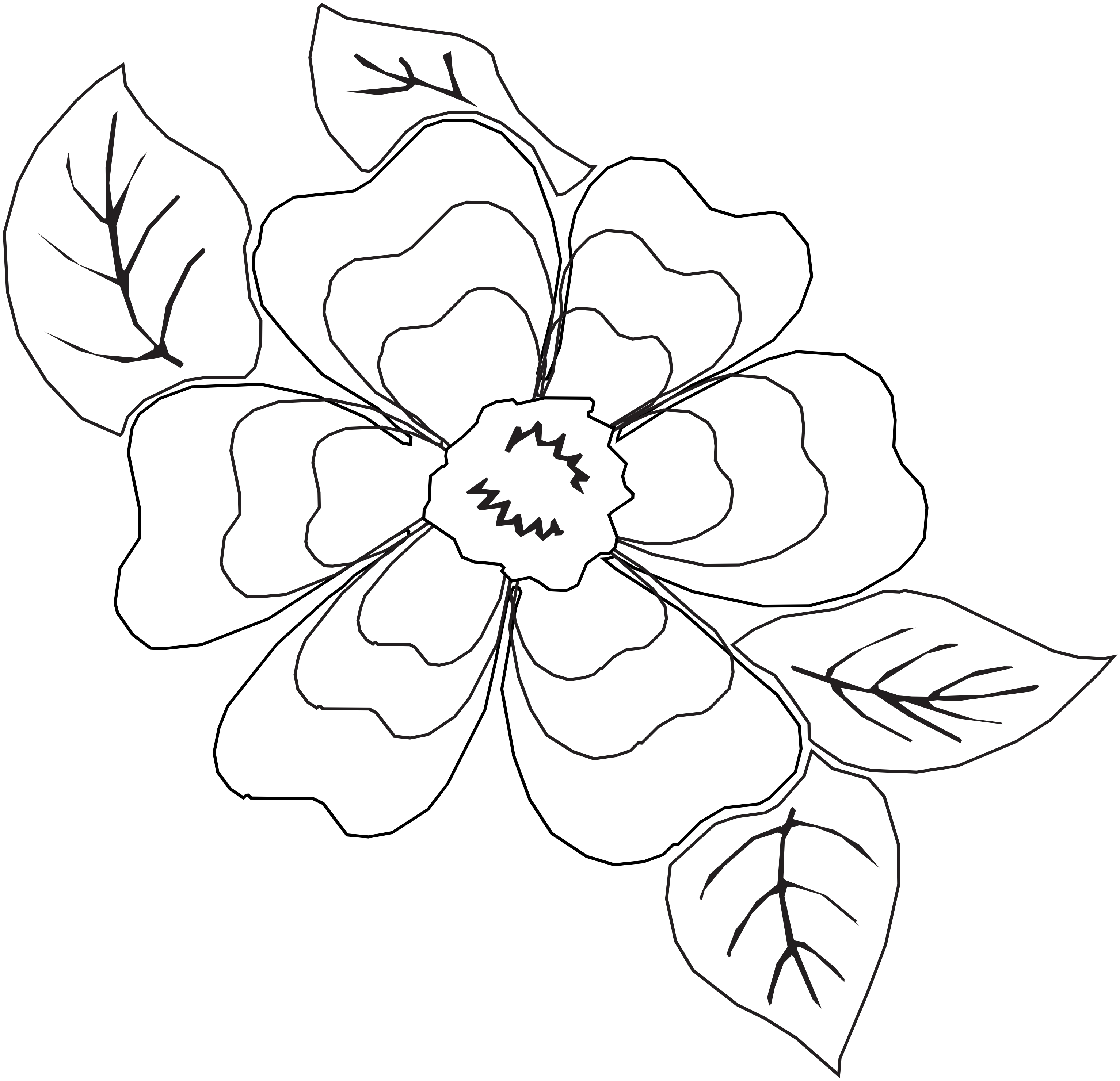


1. Describe how pollination occurs.

2. Describe how animals aid in pollination.

3. Describe why flowers are brightly colored.

Flower Outline



The Power of the Pollinator
EXPLORING HAND POLLINATION

VOCABULARY
- Hand pollination
- Colony Collapse Disorder (CCD)

OBJECTIVES
- Learn the process of hand pollination
- Learn the importance of pollinators

The Power of the Pollinator
The importance of insect pollination to agriculture is clear. "It's tricky to calculate what a pollinators work is truly worth; some economists put it at more than $200 billion globally a year."[3] And the quiet role pollinators play in our diets often goes unnoticed. It is estimated that one out of every third bite of food exists because of pollinators.

The large scale of modern-day farming and decline in suitable habitat has made it difficult for wild pollinators to keep up with the job of pollinating hundreds to thousands of acres of crop. Many commercial crops (at least a hundred in the U.S.) now rely on managed, domesticated European honeybees to complete the task of pollination. These domesticated honeybee hives have been faithfully trucked up and down highways since the 1950s. It's hard to imagine how the job would get done without pollinators, both wild and managed. In the winter of 2006/2007, the worry of a pollinator decline became a reality when bees began to disappear—by the millions. One-third to one-half of all hives in the U.S. crashed, with up to 90% colony loss. Without a trace, bees simply disappeared from the hives, leaving only the queen and a few stragglers. This became known as colony collapse disorder (CCD).

Although CCD is not completely understood, there are ways to help all pollinators. Key to preventing pollinator decline is to keep pollinators as healthy as possible by improving nutrition and reducing stress – possible through habitat improvement and decreased reliance on chemicals. Three-fourths of the plants on the planet rely on animals for pollination. Without enough pollinators, we would need to rely on other methods of pollination. A few areas of the world have turned to pollination by means of the human hand. "Sichuan, China, an example of an area that has lost its pollinators through indiscriminate use of pesticides and overharvesting of honey, now pollinates pear and apple trees by hand. Every spring, thousands of villagers climb through fruit trees hand-pollinating blossoms by dipping 'pollination sticks' (brushes made of chicken feathers and cigarette filters) into plastic bottles of pollen and then touching them against each of the tree's billions of blossoms."[4] Hand pollination is a costly process. If honeybees were to disappear from the U.S., it would cost an estimated $90 billion per year to replace them with human pollinators. The future of our food supply rests on tiny pollinators. It is up to us to ensure that they have a healthy future.

Related Video
Nature| Silence of the Bees may be viewed online or purchased from www.pbs.org.

[3] Holland, Jennifer S. "Gold Dusters." National Geographic. Web. 15 Sep. 2011. http://ngm.nationalgeographic.com/2011/03/pollinators/holland-text.
[4] Manriquez, Analia. "China-Hand Pollination." ApiNews. 17 Dec. 2010: n. page. Web. 15 Sep. 2011. http://www.apinews.com/en/news/item/12780-china-hand-pollination.

MATERIALS

- Potted flowers of the same species (make sure that the flowers you choose have both male and female parts such as daffodils, amaryllis, lilies, Wisconsin Fast Plants®, etc.)
- Small paintbrushes
- Journals
- Writing utensil
- Flower Anatomy Worksheet (pages 48 & 49)

PROCEDURE

1. Discuss the importance of pollinators with students. *How much of the food we eat and the clothing we wear come from pollinators? How much do we rely on pollinators? What would happen if pollinator species began to decline or even disappear? How would life change? What if humans had to pollinate plants by hand?* Discuss areas that have had to do this and why.
2. Split students into groups and give each group 2 plants. You may choose to acquire 2 or more different species of flowers to pollinate. Later in the lesson, this will allow students to observe differences in development after the flowers are pollinated. Remember, cross-pollination can only occur between flowers of the same species.
3. Explain to students that they will become the pollinators. Using acquired knowledge of how pollination occurs, have students gently collect pollen from the anther using a small paintbrush. Then, deposit pollen onto the stigma of a different flower and vice versa. *What type of pollination is this?* Cross-pollination. *What would we need to do if we wanted to self-pollinate the flowers?* Collect pollen from a flower and transfer to the stigma of the same flower.
4. Have students observe the flowers daily. In their journals, students should keep detailed notes. Explain to students that they should also use drawings as a tool to record changes in the flowers, particularly in the reproductive parts. Depending on the type of flowers used, observations may last several weeks.
5. After students have recorded measurable observations, lead a discussion about their findings. *What changes occurred to the petals? What changes occurred to the reproductive parts of the flower? Why do you think this happened?*
6. Next, let students cut open the ovary of the flower and make observations. *What is inside?* Students should observe seeds that developed inside the ovary after pollination. Instruct students to record observations in their journals and sketch the ovary and seeds.

EDUCATOR NOTE:

- **Have students create a list of food they eat and clothing materials they wear each day. Then, have them research whether their list contains items made possible because of a pollinator. They will be surprised to find out how much of what we eat and what we wear would be limited by a deficit of pollinators.**

- **Investigate the alien world of pollen. Have students collect pollen from the large variety of plants found in your area, or search "pollen micrographs" for internet images. Examine your pollen specimens under the compound microscope, some types can even be viewed with a hand-lens. Let students guide their learning, questions will naturally arise.**

Smells Like Home

FINDING HOST PLANTS

VOCABULARY

• Host Plant

OBJECTIVES

• Understand how a female butterfly identifies the correct host plant for her eggs
• Discover how butterflies taste and smell

BACKGROUND

Butterflies heavily rely on their senses to gather information about their environment. In particular, their sense of smell and taste are highly developed, which helps them to locate nectar and mates. Chemoreceptors located across the bodies of butterflies allow them to detect and react to different chemicals. The antenna contain many of these receptors, which allow them to smell. Butterflies also have a high concentration of chemoreceptors in their feet, which allow them to taste.

These senses are extremely important for a female butterfly who must carefully decide where to lay her eggs. Different species of butterfly larva (caterpillars) are adapted to only eat certain plants, called "host plants." Using senses of smell and taste, a female butterfly will land on a leaf and begin drumming her feet against the plant. This releases juices from the plant, which the female can taste by using specialized chemoreceptors on her feet. Once the butterfly has found the correct plant she will lay her eggs.

MATERIALS

• Film canisters (one per student)
• Construction paper
• Cotton balls
• Scissors
• Variety of scents

ACTIVITY PREP

1. Poke holes in the tops of the film canisters.
2. Place a variety of scents in the film canisters, labeling each canister and creating a key. Scents may be used more than once.
3. Cutout a variety of flowers in different colors and shapes and label them with corresponding numbers to the film canisters (1 per student).
4. Lay out the flowers around the room. Make sure to place the flower so the label is on the bottom side.
5. Place the scent from the flower's corresponding number on a cotton ball and place it in the middle of the flower.

PROCEDURE

1. Hand each student a film canister and explain that inside each one there is a scent. In addition, the flowers they see laid out around the room have cotton balls that match these scents. Tell the students that it is their job to find the flower that has their matching smell.

PROCEDURE continued...

2. When students have found their matching smell they need to raise their hand and have you check their flower to see if they are correct.
3. Once students have found their matching flowers or have been given plenty of time to attempt to find their flowers bring them back for a discussion.
4. Explain to students that they have just completed a similar process to what female butterflies go through to find the correct plant on which to lay their eggs. Explain that female butterflies need to find the correct plant to lay their eggs on because certain caterpillars are adapted to eat specific types of plants. This is called the butterflies host plant.
5. Tell students that they have found their "host" flowers. Ask them, *what sense helped them to do so?* Tell them that butterflies also use a sense to find their host flower, but it is a different sense. *What sense do you think they use?*
6. Explain to students that butterflies use their sense of taste to find their host plants.

AT THE ZOO

Visit the Butterfly Garden at Omaha's Henry Doorly Zoo and observe what plants specific butterflies visit most frequently. *Can you find evidence of eggs or caterpillars in the area? How do you know?*

EDUCATOR NOTE:

If you are unable to visit Omaha's Henry Doorly Zoo to expand your lesson, visit a local garden or an open field to make observations.

Eat This, Not That

VOCABULARY

- Mimicry (Müllerian & Batesian)
- Warning signal
- Predator
- Pavlovian learning
- Microevolution
- Natural Selection

OBJECTIVES

- Model and test the theories that accompany Müllerian mimicry
- Provide students with a hands-on opportunity to model natural, biological processes regarding predator-prey interactions
- Learn about the order Lepidoptera (specifically the larval stage)

BACKGROUND

Over the past several years the public has witnessed a "metamorphosis" in the amount of research surrounding one of the world's most important group of pollinators-butterflies. However, before we are able to appreciate the gifts of adult Lepidoptera, we must focus on the larvae that give rise to these magnificent creatures. While parasites are the primary cause of death for larvae, many birds are also included in their list of enemies. However, the predators of adult monarchs are more often studied than that of the caterpillars. The ability and desire of birds to eat these larvae contribute to a theory known as "bird-powered evolution".[5] Many studies have shown that, "predatory birds can act as agents of frequency-dependent selection."[6] In an effort to combat this predation many larvae possess combinations of cryptic coloration and unpalatable tastes, which is the primary focus of this lesson. This bitter taste is the result of a set of poisons known as "cardenolides" that are obtained from the plants that larvae eat. For most butterflies, including the local and possibly most well-known Monarch butterfly, this plant is the milkweed and the effects of the aforementioned toxins depend on both the amount that the predator eats as well as the level of toxicity of the plant.[7] When animals, like the monarch, develop these traits that make it disadvantageous for a predator to eat it, it is not uncommon for other organisms to use mimicry and attempt to look like the unpalatable species, although they themselves are actually palatable. In the case of the monarch butterfly, the organism that is doing the mimicking is the Viceroy butterfly. Because it looks almost identical to the Monarch, predators either believe it to be the poisonous Monarch, or at least associate its coloration and patterns with the effects of that poison. By using pastry replicas of larvae, students will be able to test Müller's belief that, "predators need to attack a fixed number of defended inedible prey before learning to avoid them completely" and perform an experiment to hypothesize what that fixed number may be.[8] At the conclusion of this experiment, students will have produced data and graphs that represent the interactions between local bird species and larvae. This information, combined with the experiment itself, will provide students with a scaled-down model of what is currently taking place across the world around them.

[5] The Wellcome Trust. "I'm a worm, get me out of here." National Centre for Biotechnology Education. 2009. Web <http://www.survivalrivals.org/i-am-a-worm-get-me-out-of-here/about>. Accessed 26 Feb. 2011.

[6] Fitzpatrick, Benjamin M. "Frequency-dependent selection by wild birds promotes polymorphism in model salamanders." BMC Ecology, 9:12. 2009.

[7] University of Minnesota Extension. "Interactions with Milkweed." University of Minnesota, MonarchLab, 2008. <http://www.monarchlab.org/lab/research/topics/Milkweed/Default.aspx>. Accessed 10 Aug. 2011.

[8] Speed, M.P. "Te-731. 7 April 2000sting Müllerian mimicry: an experiment with wild birds." *Environmental and Biological Studies.* Proceedings of the Royal Society B: Biological Sciences, 267(1444): 725.

MATERIALS

- Plastic gloves
- Safety goggles
- Flags / golf tees / some way to mark off designated feeding area in ground
- Tape measure
- 335g flour
- 135g lard
- 30g water
- 10ml yellow food coloring
- 0.5g of quinine hydrochloride
- 1g mustard
- Balances / weight boats
- Containers for students to collect samples
- Camera (optional)
- Eat This, Not That worksheet (page 58)
- Writing utensils

ACTIVITY PREP

1. Preparation of larvae: (it is advised that safety goggles and gloves be worn for this portion)
    a. Combine flour, lard, and water together and knead thoroughly to create dough.
    b. Measure 500g of the prepared dough and knead in the food coloring, quinine hydrochloride, and mustard. This will be used to create your bitter tasting larvae, which will be referred to as "Larvae A".
    c. Measure another 500g of the prepared dough. This will be used to create your normal tasting larvae which will be referred to as "Larvae B".
    d. Roll out all dough into cylindrical pieces that are approximately 2.5cm in length and 1cm in diameter.
    e. Depending on the desired duration and replication of this experiment, more larvae may need to be prepared. Store prepared larvae in air tight, refrigerated containers.

PROCEDURE

1. Discuss the background information on the "Larvae Information" sheet with students. After discussing how some larvae are unpalatable due to the poisonous plants they have eaten, present the prepared larvae (or have students make the larvae at this time). Explain that the two different colors represent toxicity levels. Larvae A (orange) represent larvae that eat toxic plants and thus are bitter tasting. Larvae B (non-dyed) represent larvae that consume host plants with low levels of toxicity.
2. Take 10 prepared larvae A and weigh them. Record this weight in first row on the attached data table. Repeat this process with larvae B.
3. Locate an area outside that is relatively free from human disturbance and biological debris. Measure and mark off an area 3m x 3m.
4. Within this area randomly distribute the 20 aforementioned larvae (10 A and 10 B).
    Note: If you feel it necessary a sign may be placed by testing area asking others to not interfere with the experiment and providing them with contact information in case information on toxic larvae is needed.
5. Decide on an appropriate amount of time by which to leave the larvae in the testing location. While there is no set amount of time needed to validate the results, it is advised that it be no less than 10 minutes and no more than 1 day (in an effort to give birds adequate time to survey or consume desired larvae and prevent them from drying out, thus becoming uneatable).

PROCEDURE continued...

6. At the conclusion of set time, collect larvae, sort them into type A & B, and weigh each group separately. Record your results in your data table.
   a. Safety note: Many birds are known to spread disease. Because of this, it is highly advised that students wear proper safety gloves while collecting larvae.
7. Ask students to also make observations of the larvae testing site at this time (e.g. some larvae were moved but not eaten, note weather conditions, etc.)
8. Repeat this distribution and collection process several times (while there is no set number of replicas required, it is likely that more replicas will result in more desirable results). Make sure that, in each replica, the 20 larvae are made available for the same amount of time.
9. Discuss results and complete questions on attached data table / worksheet page.

EDUCATOR NOTE:

• In an effort to model natural selection over time you may choose to allow larvae to 'reproduce' after each generation. This can easily be done by altering the number of larvae placed in the testing area at the beginning of each trial. Begin with 10 of each. However, at the end of the first set (which could be referred to as a generation) count how many of each larvae type are left. Then, claim that each larvae that survived would result in two future offspring. To represent this, double the amount of larvae that you collected and distribute that number for the next generation. At the end of several generations it is likely that you will easily be able to see which type thrived and which one is heading towards possible extinction.

• Many theories exist as to the advantages and disadvantages of mimicry. These theories can be tested in this experiment if desired. In order to do so, simply introduce other types of larvae into the experiment. Some may look identical to either larvae A or B but be made from the recipe of the other larvae. You can also vary the severity of the toxicity and the number of the two types of larvae present in an effort to achieve varied results.

• Similar experiments in the past have used spaghetti instead of pastry, claiming it is easier to produce than the pastry. If interested, detailed preparation instructions can be found at: http://www.eurovolvox.org/Protocols/PDFs/BirdWorms_UK_1.1.pdf

• If weighing the larvae at the beginning and end of each trial proves problematic (either due to lack of equipment or time) the data table may easily be altered and students may just count the number of larvae, instead of weighing them. If this is the case it is advised that you have a plan for how to count 'partially eaten' larvae and account for variations in the size of the larvae when discussing sources of error.

• If desired, aspects of Ornithology can be implemented into this lesson (examples of such include discussing which colors of larvae are more likely to be seen, the diet of local birds, and the best location for the testing to take place).

• In an effort to add to discussion it may be desirable to take pictures of the feeding area before and after each trial or even set up a motion-sensor camera to track responses and activity of birds.

• The following website includes videos and interactive games that closely resemble the experiment: http://www.survivalrivals.org/i-am-a-worm-get-me-out-of-here/about

Eat This, Not That Worksheet

RESEARCHER:

Date	Time	Mass of Larvae A (g)	% of Original	Mass of Larvae B (g)	% of Original	Other Observations

FURTHERING YOUR UNDERSTANDING

1. Using the information in the table above construct a graph that represents your findings. Make sure to label your x and y axis, provide a title, and key if necessary.

INVESTIGATIVE QUESTIONS

1. What trends, if any, did you observe with the bitter tasting larvae (larvae A)?

2. What trends, if any, did you observe with the 'normal' tasting larvae (larvae B)?

3. Do you think your results would have been the same had there been more larvae A than larvae B? What if there were more larvae B than larvae A?

4. How does this experiment represent the process of mimicry in the wild? Specifically, think about the Monarch and the Viceroy butterfly. Which butterfly could be compared with larvae A and which one is more like larvae B?

5. If this experiment was carried on for a month, what would you hypothesize the results to be at the end of that month?

6. What sources of error should be considered when discussing your result?

Larva Information

- The word larva refers to the growth stage of all insects with complete metamorphosis. Caterpillar refers only to a butterfly or moth in this stage. Either word is correct, but most scientists say larva.
- 'Larva' is singular and 'larvae' is plural.
- The caterpillars of most species will only eat the leaves of one or two species of plant, and thus will die if they find themselves on the wrong type of tree, bush, etc. Because of this, butterflies invest a large amount of time testing and tasting foliage before laying eggs.
- The eggs of butterflies and moths are great sources of protein, and thus prone to predation by snails, slugs, many insects, and some mammals. Eggs are also very prone to many types of parasitoids.
- Some butterflies lay 1 egg per plant while others can lay as many as 500 in a cluster.
- The duration of the larval stage varies according to the nutritional value of the food. Species which eat foods with high nutritional value (flowers, fruits) grow quickly, going from egg to pupa in less than a month. Species which feed on leaves take longer, up to 2 months, because leaves are harder to digest, and often contain toxins which need to be processed. Still others feed on grasses, bamboos, and palms and mature so slowly that larvae are forced to hibernate at the end of summer and resume feeding in spring.
- Most caterpillars have found ways to avoid being poisoned. One method they use is to bite through leaf veins, stems or petioles, to allow the toxic juices to bleed out before eating a leaf. Another method is to avoid eating the veins, and to just nibble at the edges of leaves where the toxicity is minimal.
- Many larvae have developed an immunity to the poisons of their host plants and store them in their bodies, or convert them into even more toxic substances which they use as a defense against predators. These larvae often display their toxicity via bold stripes or other forms of coloration.
- Not all caterpillars feed exclusively on vegetation. Some species have strong cannibalistic tendencies and will eat any other larva that they encounter. One species, the Maculinea arion, produce pheromones similar to a species of ant. Ants will carry them back to their underground nests where they can feed on ant grubs.
- Caterpillars only have two functions during their lives: eat and survive. They have large powerful jaws, a huge gut, legs to enable it to move around its food-plant, and highly elastic skin that stretches to accommodate the huge amount of food consumed.
- All butterfly caterpillars have six true legs located on the first 3 (thoracic) segments, which are used primarily for holding and manipulating the leaves on which they feed. On the abdominal segments they have 4 pairs of false legs called "prolegs" - effectively suckers that enable them to cling to stems or leaves, and to walk. There are also a pair of gripping "anal claspers" at the tail end of the body, which are used to secure the caterpillar while the prolegs are doing the walking.
- Caterpillars molt several times during their life. This process leaves them vulnerable to attack. The time between each molt is referred to as an 'instar' and most butterflies and moths have around 5 instars (Monarchs have 5).
- In some species the caterpillar's body is naked, but other species may have thick coats of hair-like "setae". These make it more difficult for an avian or reptilian predator to swallow a larva, and have the added bonus of cushioning the caterpillar in the event of a fall.

Larva Information continued...

- Larvae from temperate regions of the world are fairly safe to handle, but in the tropics there are many species which can inflict painful stings.
- Many larvae use bright patterns and colors to warn enemies that they are distasteful or poisonous. Others are armed with rows of extraordinary multi-branched spikes and horns which are enough to deter many birds from attacking,
- Spikes, hairs and other armature are most pronounced in young larvae which feed communally, so it seems likely that one of their functions may be to protect the individual (and the species) against cannibalism. This theory would also explain why the armature of these species reduces as they grow larger, as they tend to feed solitarily in the later instars.
- The caterpillars of some species (including Swallowtails) are equipped with an orange-colored organ behind the head. This "osmaterium" produces foul-smelling pheromones that deter predators from attacking.
- The fact that most caterpillars and other larvae have soft bodies make them extremely vulnerable to predation and parasitism.
- Many species use camouflage - "passive defense" to escape detection, and are thus often colored green to match the leaves on which they rest. Others are disguised as flowers, feathers or bird droppings.
- Generally speaking, larvae which feed as solitary individuals tend to be palatable to predators, and rely on cryptic colors, patterns and textures to avoid detection. On the other hand larvae which feed gregariously are more likely to be unpalatable or toxic to predators, and often advertise their toxicity with bold patterns and warning coloration.
- It is not possible to determine the sex of a caterpillar from its external appearance.
- For a day or two prior to pupation, the caterpillar goes through a wandering phase when it usually leaves its food-plant and may walk up to a kilometer before finding a suitable place to undertake the transformation into a pupa. During this phase it is particularly prone to predation, but the act of dispersal probably reduces overall predation of pupae by spreading them over a wider area - if they were concentrated on or around the food-plant it would be easier for birds to hone-in on them and wipe out the whole brood.

Monarch caterpillar

Butterfly Garden

VOCABULARY

- Host plant
- Nectar source
- Proboscis

OBJECTIVES

- Understand the importance of land-use planning as it affects people, wildlife, and the environment
- Observe butterflies in their natural environment
- Discover the correlation between butterflies and plants as it relates to attracting wildlife

BACKGROUND

Adult butterflies have mouth parts shaped into a long, coiled tube called a proboscis. Forcing blood into the tube straightens the proboscis which allows butterflies to feed on liquids. Since butterflies gather all their food from this tube, they are limited to eating nectar and standing water. Some butterflies do not have a proboscis. This is partly due to their shortened life span, with some only living a few days. Butterflies have large compound eyes that allow them to see in all directions without turning their head. Like most insects, butterflies are nearsighted and attracted to large groups of flowers rather than a single flower. Butterflies can see polarized and ultraviolet light. Polarized light tells butterflies which direction the sun is pointing and ultraviolet light guides butterflies to nectar sources. Butterflies have a well-developed sense of smell from their antennae.

Different species of butterflies have different preferences of nectar, in both color and taste. When trying to attract the greatest diversity of butterfly visitors, it is important to plant a wide variety of food plants. Select plants that bloom at different times of the season, providing a constant food source. Keep in mind that groups of the same plants are easier for butterflies to see.

It is also important to consider a butterfly-friendly site for your garden. Butterflies like sunny areas that are sheltered from high winds. These sights are most needed in the spring and fall. Be sure to provide rocks or bricks to give butterflies a place to soak up the warm sun.

Butterfly gardens are a great way to expand students' interest in nature. By providing an area with native inhabitants, students will have the opportunity to explore and observe the local environment around them. Butterfly gardens also play an important role in conserving butterfly habitats, which are diminishing due to human activities, such as urban and rural development.

Below is a list of common butterflies found in Nebraska and their host and nectar plants:

Butterfly	Host Plants	Nectar Plants
Giant Swallowtail *Papilio cresphontes*	Prickly ash, water ash, hoptree, *Rutaceae* family (Citrus)	The following nectar plants are a good start for a butterfly garden. Utilizing a combination of both annuals and perrenials will allow you to provide flowers in bloom throughout the season.
Zebra Swallotail *Eurytides marcellus*	Pawpaw and others in *Annonaceae* family	• 'Autumn Joy' sedum
Eastern Tiger Swallowtail *Papilio glaucus*	Ash, cherry, cottonwood, and tulip trees, magnolia (all *Magnoliaceae*)	• Asters
Black Swallowtail *Papilio polyxenes*	Plants in Apiaceae family including; dill, carrot, celery, fennel, Queen Anne's lace	• Bee balm
Silver Spotted Skipper *Epargyreus clarus*	Locust trees, false indigo, cassia, groundnut, rose acacia, wisteria, and other legumes	• Black-eyed Susan
Wild Indigo Duskywing *Erynnis baptisiae*	False indigo (*Baptisia*), crown vetch	• Blanket flower
Common Checkered Skipper *Pyrgus communis*	Mallow, hollyhock and others in Mallow family	• *Butterfly bush
Clouded Sulphur *Colias philodice*	Alfalfa, clover, sweet clover, vetch and other legumes	• Butterfly weed
Orange Sulphur *Colias eurytheme*	Alfalfa, clover, sweet clover, vetch and other legumes	• Clover
Cabbage White *Pieris rapae*	Radish, mustards, cabbage, broccoli, cauliflower, garlic mustard (invasive species-do not plant)	• Coneflower
Checkered White *Pontia protodice*	Wild and cultivated crucifers *(Brassicaceae)*, favors mustards (invasive garlic mustard is toxic to larvae)	• Cosmos
Pearl Crescent *Phyciodes tharos*	Asters	• Daisy Fleabane
Common Wood Nymph *Cercyonis pegala*	Grasses (*Poaceae* family)	• Dame's Rocket
Monarch *Danaus plexippus*	Milkweeds (*Asclepias* species)	• Dandelion
Viceroy *Limenitis archippus*	Willows, cottonwood, poplar, aspen	• Day Lily

For more information on Nebraska butterflies as well as host and nectar plants, visit: www.butterfliesandmoths.org

Butterfly	Host Plants	Nectar Plants
Regal Fritillary *Speyeria idalia*	Violets, prefer Birdsfoot violet (Viola pedata) and Prairie violet (V. pedatifida)	• Gayfeather
Great Spangled Fritillary *Speyeria cybele*	Violets	• Goldenrod
Mourning Cloak *Nymphalis antiopa*	Willows, elm, cottonwood, aspen, birch, hackberry & other broadleaf trees	• Joe-pye weed
Common Buckeye *Junonia coenia*	plants from families: *Scrophulariaceae, Plantaginaceae, Verbenaceae, Acanthaceae*	• Lantana
Question Mark *Polygonia interrogationis*	Elm, stinging and false nettles, hackberry	• Lavender
Eastern Comma *Polygonia comma*	Elm, nettles, hops (Humulus lupulus)	• Liatris
Painted Lady *Vanessa cardui*	Thistle, mallow, others	• Lilac
Eastern Tailed-blue *Cupido comyntas*	Vetch, clover, many other legumes	• Marigold
Summer Azure *Celastrina neglecta*	New Jersey Tea, false sunflower, dogwood. Larvae often tended by ants.	• Mist flower
Gray Hairstreak *Strymon melinus*	Wide variety, most commonly mallows, legumes, and sometimes corn	• Nasturtium
Coral Hairstreak *Satyrium titus*	Woody plants in the Rosaceae family, including black cherry and American plum	• Pentas
Bronze Copper *Lycaena hyllus*	Wide variety of docks and smartweeds (*Polygonaceae*)	• Petunia
Cercropia Hyalophora cercropia	Apple, ash, boxelder, cherry, lilac, poplar, sassafras, willow, and others	• Phlox
Imperial *Eacles imperialis*	Basswood, birch, cedar, elm, maple, oak, pine, sassafras, sycamore, walnut, and others	• Tickseed sunflower
Polyphemus *Antheraea polyphemus*	Many shrubs and trees including; apple, birch, ash, dogwood, elm, maple, oak, rose, willow	• Verbena
Io *Automeris io*	Aspen, birch, blackberry, cherry, clover, elm, hackberry, hibiscus, oak, poplar, sassafras, willow, wisteria, grasses (including corn) and others	• Yarrow • Zinnia
Luna *Actias luna*	Many trees, favorites include birch, walnut, hickory	*Be sure to include a few butterfly bushes in your garden. A few large plants will attract lots of butterflies!

MATERIALS

- Water source
- Watering can
- Shovel
- Garden Scoop
- Cultivator
- Gloves
- Nature journal
- Writing utensil
- Butterflies & Moths of Nebraska Field Guide (download at www.omahazoo.com/conservation)

PROCEDURE

1. With your class, use the chart located in the background to decide which butterflies you would like to attract. Then choose the correlating plants you would like to include in your garden. It is important to research what these plants look like, how tall they grow, and the conditions in which they thrive.
2. Once you have decided on the plants needed, consider printing small pictures from the internet of each one. Use these pictures to help design your butterfly garden on paper before planting. Remember that groups of the same plant are easier for butterflies to see.
3. Purchase the plants and flowers needed. Check with your local greenhouse to find out which plants are annuals or perennials. You may want to plant the annuals in the front and perennials in the back since you will have to replace the annuals each year. Consider growing plants from seed, purchasing discounted plants in the fall, applying for a schoolyard grant, or checking your local area for a plant rescue center to save on costs.
4. Locate an area for your butterfly garden that is sunny and sheltered from high winds. Plant your butterfly garden. Be sure to identify plants with labels. Adding rain barrels to collect rainwater is an easy way to conserve water and save money. Instructions for making your own rain barrels can be found by searching the internet or contacting your local county extension office.
5. With your class, plan trips to your garden to observe and journal. In summer and fall have students look for all stages of the life cycle. *Where do they think they might find caterpillars versus adults? Would they be on the same plant?* Have students take photos to document what type of butterflies are attracted to the garden. Use the Butterfly Garden data sheet to record observations. Use the Butterflies of Nebraska Field Guide to identify common Nebraska species.
6. In the classroom compare and contrast student observations. *Is your butterfly garden successfully attracting butterflies? How do you know? Is there a preferred caterpillar or butterfly food source? When were the first and last butterflies observed in the garden?* Make a class graph combining data from each student.

AT THE ZOO

Extend your studies by visiting the butterfly garden at Omaha's Henry Doorly Zoo. The garden circles the Butterfly & Insect Pavilion and is a great location to observe all stages of the life cycle.

EDUCATOR NOTE:

You can add a number of butterfly accessories to your garden. Students could create butterfly houses with small slots, ideal for keeping birds out while providing shelter from the wind. Butterfly houses are available for purchase on-line. In addition, instructions for building your own house are readily available on the internet. Also consider providing additional nectar sources to supplement your flowers.

BUTTERFLY GARDEN OBSERVATIONS

Date: __________________ Name: ________________________

Time: __________________

Weather conditions: Sunny Cloudy Raining Windy Calm Other ___________________

Temperature: ________________

Species: _______________________

Life Cycle Stage: _________________ If caterpillar, estimate size: _____________________

Observed on (type of plant): ______________________________

==

Date: __________________ Name: ________________________

Time: __________________

Weather conditions: Sunny Cloudy Raining Windy Calm Other ___________________

Temperature: ________________

Species: _______________________

Life Cycle Stage: _________________ If caterpillar, estimate size: _____________________

Observed on (type of plant): ______________________________

==

Date: __________________ Name: ________________________

Time: __________________

Weather conditions: Sunny Cloudy Raining Windy Calm Other ___________________

Temperature: ________________

Species: _______________________

Life Cycle Stage: _________________ If caterpillar, estimate size: _____________________

Observed on (type of plant): ______________________________

Butterfly Monitoring
BECOMING A CITIZEN SCIENTIST

VOCABULARY
- Citizen Science
- Lepidopterist
- Protocol
- Transect

OBJECTIVES
- Learn how to collect data in the field by monitoring butterflies
- Analyze and draw conclusions from collected data

BACKGROUND
Nationwide, butterfly counts have become extremely popular for families, schools, and hobbyists alike. Not only do they provide a wonderful learning experience, but they also allow individuals to participate in Citizen Science where the data collected is used by researchers. By participating, Citizen Scientists are able to provide researchers with valuable data on butterfly populations and ranges. Are the populations increasing or decreasing? What might be the cause? Are butterfly ranges shifting? These are questions scientists are asking and studying on a regular basis.

As Citizen Scientists, it is extremely important to follow a scientific protocol to ensure that data collected is accurate. A scientific protocol is the procedure or set of guidelines that are used to ensure that data is collected properly. When performing butterfly counts, it is common procedure to use transects. Transects are footpaths set up in preparation for the count, where butterflies are observed. They are a certain length and width, and should include several different habitats to ensure that as many butterfly species as possible are observed. There are several benefits to using transects. First, the same transect can be monitored multiple times, providing information on any changes that may be taking place. Secondly, they help ensure accuracy when identifying butterflies.

MATERIALS
- Survey flags or other marker
- Measuring tape
- Butterfly Count Form (1 per group, page 69 & 70)
- Nebraska Butterfly Identification Guide (available at www.omahazoo.com/conservation)
- Clip boards
- Pencils
- Digital camera (optional)
- Close focus binoculars (optional)

BEFORE YOU BEGIN
The information below is important to read before you begin monitoring butterflies. This will ensure the best results and experiences in the field.

Weather – It is best to survey on a calm, sunny day with temperatures over 70° F. For best results, do not survey if there is any precipitation.

When to Survey – For best results, survey between 10 a.m. and 4 p.m. from June to August. The surveys should last for a minimum of 30 minutes and a maximum of 2 hours. In addition, it is best to survey the same transects between 5 and 10 times throughout the season.

Butterfly Collection – This lesson does not include collecting butterflies. If you choose to net butterflies to get a closer look, please immediately release them to the location where they were found. If butterflies are collected, they should not be counted on the form.

Identifying Butterflies – It is strongly recommended to become familiar with common butterflies in Nebraska before monitoring to be as accurate as possible and create a more meaningful experience.

PROCEDURE

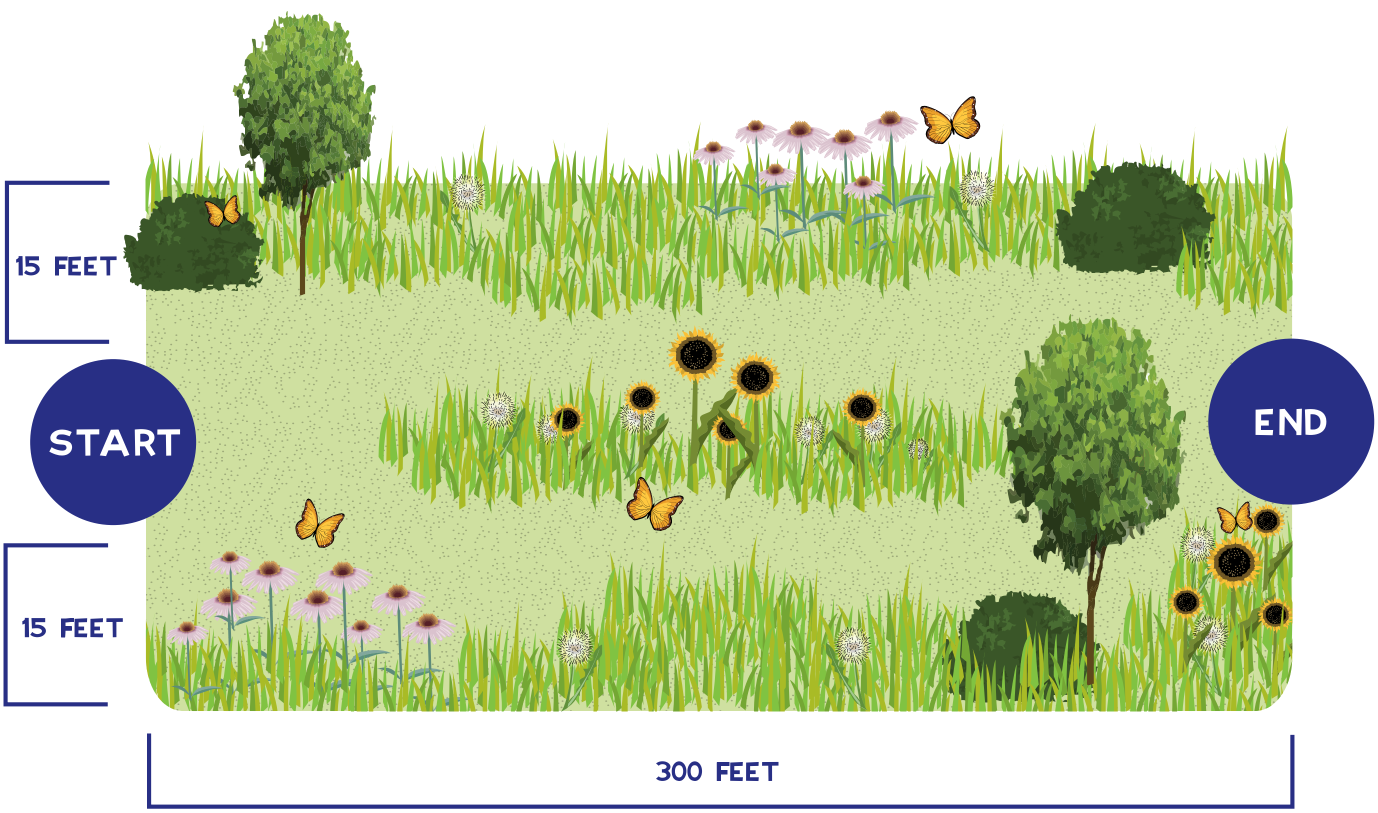
1. Choose a site

Choosing a site to conduct your butterfly count is one of the most important steps. A variety of locations are suitable, from garden areas to open fields. When choosing your location, it is important to keep in mind the amount of space that you will need. This depends on the number of students. Butterfly counts should be conducted in pairs and each group will need one transect.

2. Set up the transects

Students should work in pairs to conduct a butterfly count. One student will be the monitor and the other will be the recorder. You will need one transect per group.

1. Mark the beginning of each transect with a flag.
2. Measure 300 feet from the beginning flag and place a second flag at the ending point.
3. Form an outer boundary by placing a couple flags on both sides of the transect line, creating a total width of 30 feet.
4. Transects can be set up consecutively by placing a flag every 300 feet or set up transects separately.



PROCEDURE continued...

3. Begin counting!
    - Students may have difficulty identifying some butterflies. This is okay; they should still record the butterfly on their data sheet as unidentified. If they know the family that the butterfly belongs to, they can record the family name. Students should never guess if they are unable to identify the butterfly.
    - Monitors should avoid counting the same butterfly more than twice.
    - To help students become comfortable with counting butterflies along a transect, show them how wide 15 feet is on each side of the walking line. Point out bushes or trees that are 15 feet from the transect to help them gauge distance. Have students go through a practice walk before they actually begin the count.
    - Avoid counting any butterflies seen outside the boundaries.

4. Record results from the count
    - Back in the classroom; upload the pictures and data collected onto Omaha's Henry Doorly Zoo Butterfly Database. Here, researchers and other participants will be able to compare and analyze data. To join the database, follow the steps below.
        1. Create a free Google Account by going to www.google.com/accounts if you do not have one already.
        2. Once you have created your Google account, go to http://biofinity.unl.edu/HDZ/butterfly and log in.
        3. You will be taken to another screen where you will need to click "Join an existinglab." Look for Omaha's Henry Doorly Zoo Butterfly Database and click on "Join this lab" next to it.
        4. Once you have submitted your request to join the lab, you will have to be approved by Omaha's Zoo staff to proceed.
        5. To enter new data go to http://biofinity.unl.edu/HDZ/butterfly/create.
        6. Once on the database, you will be able to fill out a new "event" for each transect count. After you have submitted data for a new transect count, the database will give the option to upload a butterfly pictures.

AT THE ZOO

Extend your studies by visiting the Butterfly Garden at Omaha's Henry Doorly Zoo. The garden circles the Berniece Grewcock Butterfly and Insect Pavilion and is a great location to monitor butterflies.

Butterfly Count Form

Monitor: ______________________________ Recorder: ____

School/Organization/Family:____

Teacher/Adult Name: ____________________ Teacher/Adult e-mail:______________________________

Date (month, day, year): _________________________ County: _____________ State: ______

Collection Location Name (or nearest town): ____

Latitude: ____________________________ Longitude: __________________________ (optional)

Habitat Type: ______________________________ Temperature (F°): ____________________________

Sky (circle one): Clear Mostly Clear Mostly Cloudy Overcast Fog

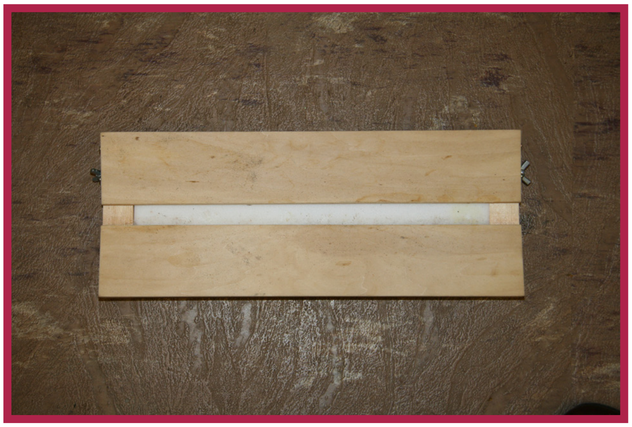
Wind (circle one): Calm Slight Wind Moderate Wind Windy

Start Time: __________________ a.m. or p.m. Stop Time: __________________ a.m. or p.m.

Butterfly	Count (# of Butterflies)	Total (All Transects)
Swallowtails		
Eastern Tiger		
Giant		
Zebra		
Spicebush		
Black		
Pipevine		
Unknown *(describe)*:		
Additional:		
Whites & Sulphurs		
Cabbage White		
Orange Sulphur		
Clouded Sulphur		
Unknown *(describe)*:		
Additional:		
Gossamer Wings		
Eastern Tailed-Blue		
Gray Hairstreak		
Spring/Summer Azure		
Unknown *(describe)*:		
Additional:		
Brush-foots		
Regal Fritillary		
Red Admiral		
Monarch		
Hackberry Emperor		
Painted Lady		
Great Spangled Fritillary		
Unknown *(describe)*:		
Additional:		
Skippers		
Tawny-Edged		
Common Checkered		
Common Sootywing		
Wild Indigo Duskwing		
Least Skipper		
Unknown *(describe)*:		
Additional:		

How to Spread a Butterfly

Creating specimens for long-term use in the classroom



ITEMS YOU WILL NEED:

- A pinning board - The best spreading boards are covered in balsa wood and have an adjustable groove. You can also use a piece of flat styrofoam with a slot cut out to accommodate a butterfly body.
- Plastic container with lid
- Wire mesh
- Insect pins - sizes 00 and 2
- Wax strips or pieces of paper
- Forceps
- Wax envelopes – These can be used to store your butterfly specimen. Butterfly specimens can be kept in a freezer indefinitely until ready to be spread.
- Syringe with a small needle
- Display case (Riker mounts are good for classroom use)

This technique is meant to be used with non-living specimens. Keep in mind, the average life span of a butterfly is two weeks, with some species living only a few days as adults. Please read through this document thoroughly before beginning.

The most important part of spreading butterfly wings is to soften the specimen properly in a relaxing chamber. The relaxing chamber can be a plastic container lined with a wet cloth or paper towel. Use warm water to dampen the cloth/paper towel. Cut a piece of wire mesh that fits down into the container so that the butterflies aren't sitting directly on the wet paper towels. Put a few moth balls in the container as well to prevent mold.

Lay your butterfly specimen on the wet cloth. If you have envelopes, you can leave the butterfly in the envelope during the relaxing process. Cover the specimen for 12-24 hours. The specimen is now relaxing which means it is absorbing moisture into its body, veins and wings. The trick to knowing if the butterfly is relaxed enough to spread is that it should feel very much like a live specimen with movable wings, antennae, etc. Large or stout bodied butterflies will take longer to relax.

Another way to relax a butterfly is to inject the butterfly thorax with hot water and then let it rest for a few to several hours, this is called speed relaxing. This technique also makes it easier to spread stout bodied species.

1. After the butterfly has relaxed properly, hold it by the thorax and squeeze gently or pinch thorax and wings will open slightly. If you have problems, you can gently use your fingers to spread the wings apart. The less you touch the wings the better, otherwise you are likely to get fingerprints on your specimen. While squeezing thorax to separate wings, carefully insert an insect pin through the thorax about half way. Make sure the pin is going into the thorax vertically and not at a slant.

2. Holding the pinned butterfly, place the body in the groove of a spreading board and push the pin into the groove to hold butterfly in place. After the thorax is pinned in the groove, place a strip of wax paper (or a strip of paper) over one side of the wings, close to the body, holding the wings down with the wax paper separating your fingers from the wings. This allows you to hold the wings down with your fingers without damaging the wings.

3. First you'll want to place the forewing. To do this, you'll want to use 00 insect pins. Find a large vein in the forewing of your specimen and use the pin to maneuver the wing. Try not to pierce a hole in the wing unless you have to. The 00 insect pin creates a very tiny hole. Move the wing so that the bottom of the wing creates a 90 degree angle with the body of the specimen. Once the wing is in the desired spot, put a wax strip over the wing and use pins to hold it down. Make sure not to stick the pins through the wing. The hindwing can be maneuvered in the same manner. In placing the hindwing, you will want it to go just under the lower edge of the forewing creating a "V" in between the 2 wings.

4. Once the forewing and hindwing are in place on one side you are ready to move onto the next side. Make sure when placing the wings on the other side of your specimen that the wings are even. You don't want your butterfly to look lop sided. If your specimen has antennae you can pin those as well. Antennae should form a V extending outward. Use pins to hold them in place.

5. Dry your specimen on the board for 24-48 hours. Remove all pins carefully except the pin through the thorax. Your butterfly specimen is now ready to be pinned in your display case.

Vocabulary

Abdomen – The most posterior portion of the three segments of an insect.

Antennae – Specialized, segmented, receptive, sensory organs found on the head of all insects.

Anther –The part of the flower (specifically found on the stamen) that houses pollen.

Arachnid – Any member of the class Arachnida, which have two-segmented bodies, four pairs of legs, and no antennae.

Binomial Nomenclature – The system of assigning scientific names to organisms.

Butterfly – Any member of the Lepidoptera order within the following families: swallowtails (Papilionidae), brush-footed butterflies (Nymphalidae), whites and sulphurs (Pieridae), gossamer-winged butterflies (Lycaenidae), Metalmarks (Riodinidae), and skippers (Hesperiidae). They generally have brightly colored wings and are diurnal.

Caterpillar – Larva stage of a butterfly or moth.

Chrysalis – The hard-shelled or cased-in form of some pupas, when going through metamorphosis.

Citizen Science – The practice of volunteers or other laypeople conducting scientific research.

Classification – Method used by biologists to categorize and group organisms.

Compound Eye – An eye that is made up of many, separate, visual units that allow the user to have a wider field of vision, better detect movement, and see a wide range of colors.

Cross-pollination – The transfer of pollen from the flower of one plant to another.

Dichotomous Key – A key used to identify organisms. The user goes through a series of descriptions that narrow down possible species until the organism is identified.

Distribution – The frequency and natural geographic range of where something can be found.

Diversity – The state of being different.

Family – The major subdivision of an order when classifying organisms, which usually contain several genera.

Habitat – The natural environment of an organism or the type of location where it is generally found.

Head – The most superior segment of an insect, containing the antennae and other cranial organs.

Host plant – The specific plant that the larvae of an insect may use as a food source rearing site.

Insect – Any member of class Insecta, which has six segmented legs, three body parts, and one or two pairs of wings.

Larva – The growth stage of all insects with complete metamorphosis. Caterpillar refers only to a butterfly or moth in this stage.

Lepidopterist – A person who studies butterflies and/or moths.

Life cycle – The various, developmental changes that an organism goes through from its time of conception to its point of death. Each step in the cycle is often marked by obvious, physiological changes.

Metamorphosis – A very profound change in physical form from one stage of some organisms' life cycle to the next. Examples include: the change from caterpillar to butterfly or from tadpole to frog.

Microevolution – A change in gene frequency of a population over a period of time.

Mimicry – The similarity of one species to another, which increase the fitness and/or protection of one or both species.

Müllerian Mimicry – A form of mimicry where two species both share the same warning signals and attributes that make them unpalatable. By having this, the learning curve of the predator to not eat the species is much quicker (as is the rate of reinforcement).

Batesian Mimicry – A form of mimicry where the mimic has the same warning signals as its model, but does not have the actual attribute that makes it unpalatable to predators.

Moth - Any member of the Lepidoptera order within the following families: sphinx or hawk moths (Sphingidae), giant silkworm and royal moths (Saturniidae), tiger moths (Arctiidae), owlet and underwing moths (Noctuidae), prominent moths (Notodontidae), or geometer or inchworm moths (Geometridae). They generally have dull colored wings and are nocturnal.

Natural Selection – The overall process by which traits become more or less common in a population due to the survival and reproduction of organisms that possess those traits.

Nectar –The sugary fluid produced by some plants that helps attract pollinating insects and other animals.

Nectar source – A flowering plant that produces nectar (a sugary liquid that often attracts pollinating insects and other animals).

Pistil – The female organ of a flower, which is made-up of a stigma, style, and ovary.

Pollen – Microscopic grains produced by the male reproductive organs (anthers) of some plants that are used to carry male reproductive cells (sperm) in order to fertilize the female reproductive organs (pistils) of plants of the same species.

Pollinate – The depositing of pollen in order to allow for fertilization.

Prairie – A mostly treeless area of land, generally found along the Mississippi valley, with fertile soil and coarse grasses.

Predator – An organism that hunts for food (prey).

Prey – An organism that is hunted for food (by a predator).

Proboscis – An elongated, straw-like, flexible mouth part of some invertebrates which allows them to suck up nectar.

Protocol – The established procedure of an activity, group, or situation.

Rainforest – A tropical type of forest with various layers of vegetation, unfertile soil, high amounts of annual rainfall, and high biodiversity.

Self-pollination – The transfer of pollen from the flower of one plant to either the same flower, or another flower on that same host plant.

Stamen – The male, pollen-producing reproductive organ of a flower.

Stigma –The receptacle for pollen, found at the top of most pistils (the female reproductive organs of plants).

Style – The portion of the pistil (the female reproductive organs of plants) that transfers pollen from the stigma to the ovary.

Symmetry – The characteristic of an object with exact, mirrored-halves across an axis.

Taxonomy – Process of classifying animals into larger categories based on shared features and genetics.

Technical Writing – A formal form of communication and writing practiced on-the-job in various, scientific fields. It often includes unique jargon and lingo specific to that field.

Thorax – The middle portion of the three segments of an insect.

Transect – To cut-across or make a line or section though an object.

Warning signal – An outward sign (e.g. bright colors, foul odors, etc.) from a possible prey to its predator that signals that it would not be advantageous for the predator to it eat it.

Monarch
Danaus plexippus

Birdwing
Ornithoptera

Resources

Books

Butterflies & Skippers of Ohio field guide by the Ohio Division of Wildlife

Butterfly and Caterpillar by Barrie Watts

*Caterpillars of Eastern North Americ*a by David L. Wagner

Kaufman Field Guide to Butterflies of North America

Moths & Caterpillars of the North Woods by Jim Sogaard

Peterson First Guides: Butterflies and Moths by Paul Opler

Peterson First Guides: Caterpillars by Amy Bartlett Wright

The Butterfly Alphabet Book by Brian Cassie and Jerry Pallotta

The Butterfly Alphabet by Kjell Sandved

The Practical Entomologist by Rick Imes

The Very Hungry Caterpillar by Eric Carle

Waiting for Wings by Lois Ehlert

Useful Website

Butterflies Ranges by state: www.butterfliesandmoths.org

Monarch Butterfly Information

www.fs.fed.us/monarchbutterfly

http://monarchlab.org

www.monarchwatch.org

www.journeynorth.org

General Butterfly Conservation and Information

www.learnaboutbutterflies.com

www.xerces.org

www.fws.gov/endangered

www.butterly-conservation.org

www.omahazoo.com/conservation

www.pollinator.org

Science Education Standards

Page Name	I. Life Science					II. Unifying Concepts & Processes					III. Science As Inquiry	IV. Science In Personal & Social Perspectives		V. History & Nature of Science	
	Structure & Function	Reproduction & Heredity	Regulation & Behavior	Populations & Ecosystems	Diversity & Adaptations	Systems, Order & Organization	Evidence, Models & Explanation	Change, Constancy & Measurement	Evolution & Equilibrium	Form & Function	Science as Inquiry	Populations, Resources & Environment	Science & Technology in Society	Science as Human Endeavor	Nature of Science
Highly Classified						●	●								●
Who am I?	●				●	●				●					
One of These Things is Not Like the Other										●					
Wings-n-Things	●									●					
Come Fly with Me							●								●
Seeing Double															●
Inch by Inch								●							
Social Butterfly															
Wings of Change		●					●								
Beautiful Pollinators	●	●		●	●					●					●
The Power of the Pollinator	●	●		●							●	●			●
Smells Like Home	●			●	●				●						
Eat This, Not That			●	●	●		●		●		●				●
Butterfly Garden											●	●		●	●
Butterfly Monitoring								●			●	●			●