Friend or Foe?

You can use monarchs to teach about many things! Stone Mountain Memorial Association (SMMA) uses the monarch butterfly to help students apply their knowledge in other contexts and to different disciplines. The activities relate a grade-level specific GPS to monarch life, habitat or migration. Use this lesson as a post-trip activity following your 7th Grade Exploring Wetlands field trip.

GPS correlation: S7L4. Students will examine the dependence of organisms on one another and their environments. d. Categorize relationships between organisms that are competitive or mutually beneficial.

Preparation:

Read the background information and the student worksheets. (Do not read the background information to the students.) Print the worksheets, or make an overhead or display on your Interactive white board. Make copies for each student or group of students.

Background information:

In this lesson, students will learn about the relationship that exists between the monarch *(Danaus plexippus)* and two other organisms, milkweed plants (Asclepiadaceae) and the protozoan, *Ophryocystis elektroscirrha.* They will then categorize these relationships as competitive or mutually beneficial.

Go to http://www.monarchlab.umn.edu/Lab/Research/Topics/Milkweed/Default.aspx to read about interactions with milkweed. This website contains excellent research references about the relationship between monarchs and milkweed focusing on the following questions:

1. How do chemicals in milkweed benefit monarchs?
2. How do different milkweeds and monarchs vary in the type and concentration of cardenolides that they contain?
3. How do milkweed defenses affect monarch larvae?

What is OE?
http://www.monarchparasites.org/
"*Ophryocystis elektroscirrha* (OE) is an obligate, protozoan parasite that infects monarch and queen butterflies. OE is considered an obligate parasite because it must live within a host to grow and multiply. Monarch and queen butterflies are the only known hosts of OE. Between infections, OE survives as spores that are resistant to extreme environmental conditions. OE was first discovered infecting monarch and queen butterflies in Florida in the late 1960s. It has since been found in all other monarch populations worldwide, indicating that this parasite has coevolved with monarchs."

"Adults that are heavily infected with OE either fail to eclose (emerge) fully or fall to the ground, leading to severe wing deformities and relatively rapid death. Mildly infected adults are often smaller, weigh less and have shorter forewing lengths than healthy monarchs. This parasite also damages the cuticle, or outside layer of the abdomen, causing the butterfly to dry out and lose weight faster than normal. This is especially a problem if there is a shortage of nectar or water. Studies have shown that monarchs infected with OE cannot fly as far or as long as healthy butterflies. Since infected males are weak, they are less likely to mate and produce offspring than uninfected males. Infection does not appear to harm the ability of females to reproduce. While these may all be symptoms of OE infection, many infected monarchs look healthy. They emerge normally and are not deformed. The only way to really know if a monarch is infected is to check for spores."

Activity:

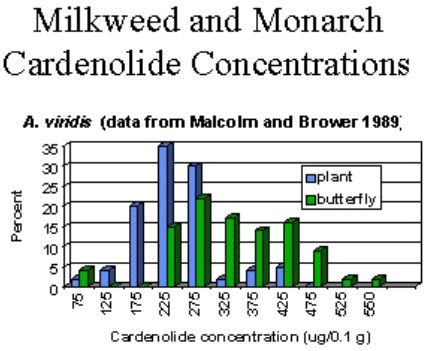
Hand out worksheets. Emphasize the focus of the lesson. Have students read the information on their worksheets and answer the essential question.

Essential Question:
After reading about the relationships between the monarch and two other organisms, how would you categorize these relationships?

Relationship 1: Monarch and Milkweed

Female monarch butterflies *(Danaus plexippus)* lay their eggs on their host plant which is in the family Asclepiadaceae (milkweeds). The larvae that emerge are herbivores, feeding on the leaves, flowers and stems of the milkweed plant.

Figure 1



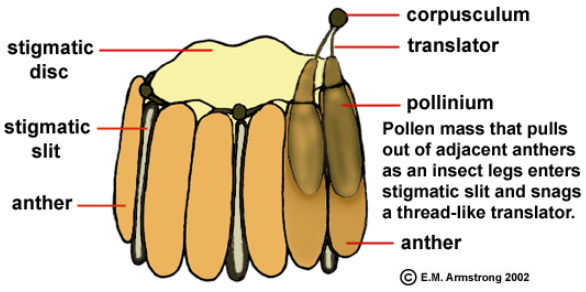
Frequency distribution of cardenolide concentrations in *A. viridis* (collected in Louisiana) and monarch butterflies fed this species. Data from Malcolm and Brower 1989. NOTE: Plant is first bar in pair. No plant bar shown above 425.

These caterpillars actually sequester the cardenolides, or cardiac glycosides, from the milkweed sap and plant material, and use them as a defense against vertebrate predators. Cardiac glycosides are toxic to vertebrates.

Adult monarchs do not eat milkweed; they simply nectar from the flowers. This graph shows, however, that they are able to store the cardenolides that they ingested as larvae also making them bitter tasting and toxic to most vertebrates.

There is no documented evidence that the milkweed plant actually benefits from this herbivory although new growth is normally stimulated.

Milkweeds have a unique mechanism in which the plant relies on the Orders Lepidoptera (butterflies and moths) and Hymenoptera (bees, ants and wasps) for pollination. Monarchs, although not the major pollinators of Asclepiadaceae, are noted in several studies to contribute significantly.



Milkweed Flower (stigmatic column)

This diagram shows the translator which can be snagged by the leg of an insect that inadvertently slips down into the stigmatic slit.
As the insect flies away, the pollinium, or pollen mass, is pulled out of the anther sacs like a pair of saddlebags, and carried off to another milkweed blossom.

Relationship 1 Reading Guide:

Use this page as a guide through the scientific terminology about the relationship between monarch butterflies and the milkweed plant.

1. Is the relationship between the larva and the milkweed plant competitive or mutually beneficial?

2. Is the relationship between the adult butterfly and the milkweed plant competitive or mutually beneficial?

3. How does the monarch butterfly utilize the milkweed plant (Asclepiadaceae) during each of the following life cycle stages?
   Egg:
   Larva:
   Adult:

4. How do monarch caterpillars utilize cardenolides from milkweed?

5. Why are butterflies and moths necessary parts of the milkweed life cycle?

6. Look at the **Milkweed and Monarch Cardenolide Concentrations** frequency diagram:
   A. What changes do you notice as the concentrations increase?

   B. What does this demonstrate about the relationship between monarchs and milkweed?

7. Look at the diagram of the Milkweed Flower:
   A. What structure of the milkweed flower allows monarchs to assist milkweeds in pollination?

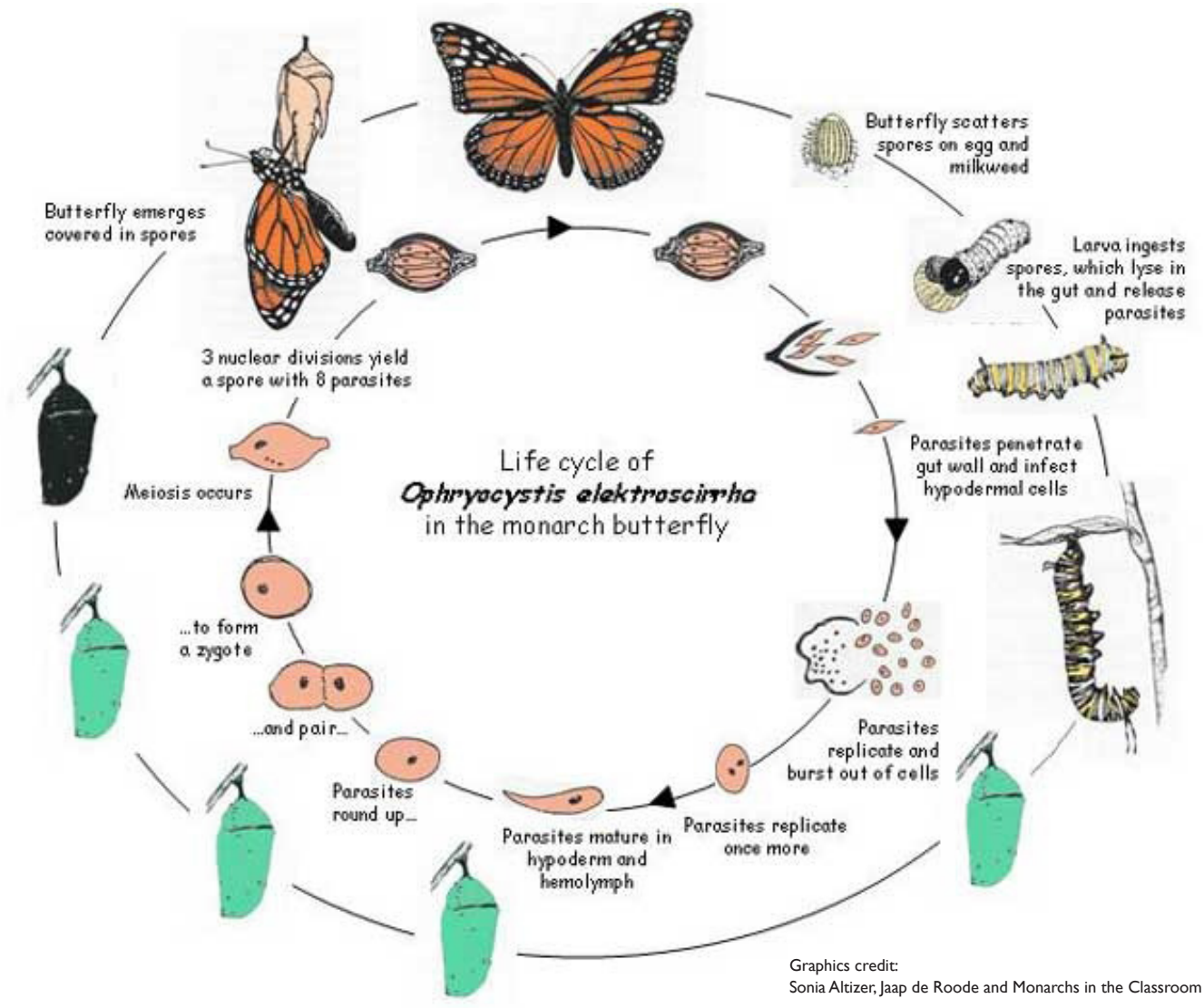
   B. Why is this structure important to milkweeds?

Relationship 2: Monarch and *Ophryocystis elektroscirrha* (OE)

The life cycle of the protozoan, *Ophryocystis elektroscirrha* (OE) is very closely related to the life cycle of the monarch butterfly, *Danaus plexippus*. This protozoan can only reproduce inside the insect's body. (See the diagram below.)

If a female monarch harbors OE, the dormant spores will be on the outside of her abdomen and will be scattered on the eggs and milkweed leaves during ovipositioning. When the caterpillar emerges, it will consume first the chorion, or egg shell, ingesting the spores, and then as it feeds on the milkweed leaves, more spores will be consumed.

The spores will move through the larval digestive system. Digestive chemicals will break open the spores releasing the protozoan which then moves through the intestinal wall to an underlayer of epithelial cells that secretes substances for the overlying cuticle, or exoskeleton. Here OE reproduces asexually, greatly increasing in numbers. Most damage to the butterfly occurs during their pupal stage. OE reproduces sexually inside of the chrysalis, again increasing in numbers. Approximately three days before the adult butterfly ecloses, spores will begin to form. These spores allow OE to survive outside of the monarch's body. The spores can be seen through the outside layer of the pupa. Adults harboring OE emerge covered with spores. The spores are inactive, or dormant, until they are eaten by another monarch caterpillar.



Graphics credit:
Sonia Altizer, Jaap de Roode and Monarchs in the Classroom

Relationship 2 Reading Guide:

Use this page as a guide through the scientific terminology about the relationship between monarch butterflies and the OE protozoan.

1. Is this relationship competitive or mutually beneficial?

2. How does a monarch caterpillar become infected with OE?

3. What is the role of milkweed in the reproduction of OE?

4. How does OE survive inside a monarch larva's body?

5. How does OE survive outside a monarch adult's body?

6. What would happen to the OE spores on an infected adult monarch if the infected adult did not lay any eggs?

Relationship 1 Reading Guide:

1. Is the relationship between the larva and the milkweed plant competitive or mutually beneficial?
Competitive

2. Is the relationship between the adult butterfly and the milkweed plant competitive or mutually beneficial?
Mutually beneficial

3. How does the monarch butterfly utilize the milkweed plant (Asclepiadaceae) during each of the following life cycle stages?
   Egg: The leaves provide a place for development and shelter (protection from weather)
   Larva: Leaves provide food, the plant provides shelter
   Adult: Provide a source of nectar (food); leaves provide females with a place to lay eggs

4. How do monarch caterpillars utilize cardenolides from milkweed?
As a defense mechanism. Cardenolides are toxic to vertebrates and thus provide protection to monarch caterpillars from most vertebrate predators

5. Why are butterflies and moths necessary parts of the milkweed life cycle?
They are flower pollinators. Insect pollinators are required for successful seed production

6. Look at the **Milkweed and Monarch Cardenolide Concentrations** frequency diagram:
   A. What changes do you notice as the concentrations increase?
   Concentrations in the monarch become higher than in the plant they are feeding on

   B. What does this demonstrate about the relationship between monarchs and milkweed?
   Monarchs can sequester and concentrate cardenolides from milkweed plants

7. Look at the diagram of the Milkweed Flower:
   A. What structure of the milkweed flower allows monarchs to assist milkweeds in pollination?
   The translator

   B. Why is this structure important to milkweeds?
   The translator can be snagged by the leg of an insect that inadvertently slips down into the stigmatic slit. As the insect flies away, the pollinium, or pollen mass, is pulled out of the anther sacs like a pair of saddlebags, and carried off to another milkweed blossom at which pollination (and seed production) can be accomplished.

Relationship 2 Reading Guide:

1. Is this relationship competitive or mutually beneficial?
Competitive

2. How does a monarch caterpillar become infected with OE?
It consumes OE spores when ingesting its egg shell (chorion) and milkweed leaves that have spores on them

3. What is the role of milkweed in the reproduction of OE?
It is the place where OE spores are held, waiting to infect the next monarch caterpillar

4. How does OE survive inside a monarch larva's body?
The protozoan infects, replicates and forms spores

5. How does OE survive outside a monarch adult's body?
As a spore

6. What would happen to the OE spores on an infected adult monarch if the infected adult did not lay any eggs?
An infected male could mate with a non-infected female and transfer some OE spores to the outside of her body. These spores could be deposited on the milkweed plant at oviposition.

If an infected male monarch did not mate or infected female monarch did not lay eggs, OE spores could be left on plant material at which they nectared. Contamination by contact with other monarch adults is possible.