

# Lessons 22–25

# Saving Monarch Butterflies

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## Prepare

Throughout this module, students have built an understanding of how organisms have characteristics that help them survive over time in changing environments. In Lessons 22 through 25, students use their understanding of butterfly needs for survival and the engineering design process to design a solution to help monarchs survive in a changing environment. During this engineering challenge, students identify criteria and constraints for their design solution, develop a detailed design of their solution, and draft a letter to a community leader that outlines the specific components of their solution to explain why it will be successful. After students have drafted and shared their final diagrams and letters, they evaluate their solutions based on peer feedback.

### Student Learning

#### Knowledge Statement

Humans can change an environment to make it more suitable for an organism.

#### Objective

- Lessons 22–25: Apply the engineering design process to help monarchs survive in a changing environment.

### Application of Concepts

#### Task

Engineering Challenge

#### Phenomenon Question

How can we help monarchs survive in a changing environment?

## Texas Essential Knowledge and Skills Addressed

- 3.2A **Plan and implement descriptive investigations, including asking and answering questions, making inferences, and selecting and using equipment or technology needed, to solve a specific problem in the natural world.** (Addressed)
- 3.2C **Construct maps, graphic organizers, simple tables, charts, and bar graphs using tools and current technology to organize, examine, and evaluate measured data.** (Addressed)
- 3.2D **Analyze and interpret patterns in data to construct reasonable explanations based on evidence from investigations.** (Addressed)
- 3.2F **Communicate valid conclusions supported by data in writing, by drawing pictures, and through verbal discussion.** (Addressed)
- 3.3A **Analyze, evaluate, and critique scientific explanations by using evidence, logical reasoning, and experimental and observational testing.** (Addressed)
- 3.3B **Represent the natural world using models such as volcanoes or the Sun, Earth, and Moon system and identify their limitations, including size, properties, and materials.** (Addressed)
- 3.3C **Connect grade-level appropriate science concepts with the history of science, science careers, and contributions of scientists.** (Addressed)
- 3.4 **Collect, record, and analyze information using tools, including cameras, computers, hand lenses, metric rulers, Celsius thermometers, wind vanes, rain gauges, pan balances, graduated cylinders, beakers, spring scales, hot plates, meter sticks, magnets, collecting nets, notebooks, and Sun, Earth, and Moon system models; timing devices; and materials to support observation of habitats of organisms such as terrariums and aquariums.** (Addressed)
- 3.9A **Observe and describe the physical characteristics of environments and how they support populations and communities of plants and animals within an ecosystem.** (Addressed)
- 3.9B **Identify and describe the flow of energy in a food chain and predict how changes in a food chain affect the ecosystem such as removal of frogs from a pond or bees from a field.** (Addressed)
- 3.9C **Describe environmental changes such as floods and droughts where some organisms thrive and others perish or move to new locations.** (Addressed)
- 3.10A **Explore how structures and functions of plants and animals allow them to survive in a particular environment.** (Addressed)

## English Language Proficiency Standards Addressed

- 1C Use strategic learning techniques such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary.
- 2I Demonstrate listening comprehension of increasingly complex spoken English by following directions, retelling or summarizing spoken messages, responding to questions and requests, collaborating with peers, and taking notes commensurate with content and grade-level needs.
- 4F Use visual and contextual support and support from peers and teachers to read grade-appropriate content area text, enhance and confirm understanding, and develop vocabulary, grasp of language structures, and background knowledge needed to comprehend increasingly challenging language.

## Materials

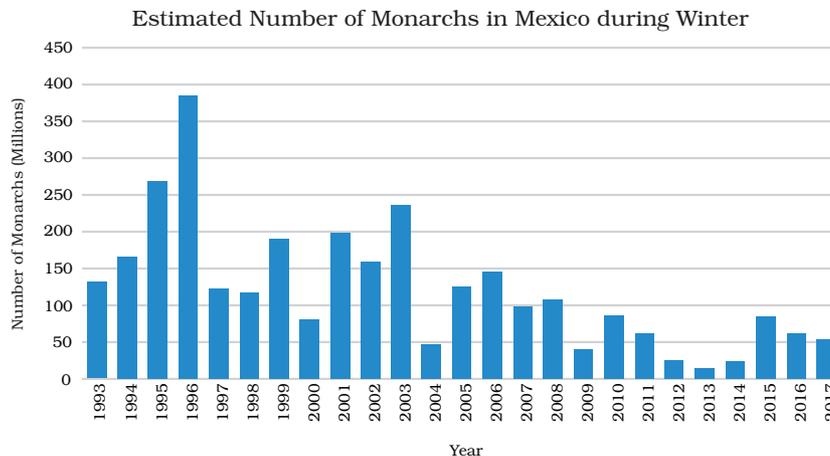
		Lesson 22	Lesson 23	Lesson 24	Lesson 25
<b>Student</b>	Science Logbook (Lesson 22 Activity Guides A and B)	●	●	●	●
	Engineering Challenge: markers, crayons, or colored pencils; rulers; paper; graph paper (optional)		●	●	●
	Science Logbook (Lesson 25 Activity Guide)				●
<b>Teacher</b>	Monarchs Graph (Lesson 22 Resource A)	●			
	Engineering Design Process (Lesson 22 Resource B)	●			
	Detailed Engineering Design Process (Lesson 22 Resource C)	●			
	Using the Journey North Website (Lesson 16 Resource C)	●			
	“Winged Mysteries” (Adams 2003) (Lesson 22 Resource D)	●			
	Monarch Butterfly Research (Lesson 23 Resource A)		●		
	Plants that Attract Monarch Butterflies (Lesson 23 Resource B)		●		
	<i>A Butterfly Is Patient</i> by Dianna Hutts Aston and Sylvia Long (2015)		●		
	Monarch Butterfly Waystation Photograph (Lesson 24 Resource)			●	
<b>Preparation</b>	Print or open web pages or identify library books for students to use to research threats to monarch butterflies (see Lesson 23 Resource A).		●		
	Print or open web pages and print plant photographs for students to research plants that attract monarch butterflies (see Lesson 23 Resource B).		●		

# Lesson 22

**Objective:** Apply the engineering design process to help monarchs survive in a changing environment.

## Launch 5 minutes

Display the graph showing the number of monarch butterflies in Mexico during winter from 1993 through 2017 (Lesson 22 Resource A). Ask students to share what they notice and wonder about the graph. 



Data adapted from the World Wildlife Fund Mexico (Rendón-Salinas et al. 2018) and Thogmartin et al. (2017). 

## Agenda

Launch (5 minutes)

Learn (35 minutes)

- Review the Engineering Design Process (15 minutes)
- Ask about an Engineering Problem (20 minutes)

Land (5 minutes)



### Teacher Note

Students may need additional support interpreting the graph. Consider pointing out a year and asking students to estimate the number of monarchs in Mexico at that time.



### Teacher Note

The World Wildlife Fund Mexico team identifies the total area (in hectares) of forest inhabited by monarch butterflies in the second half of December each year. Thogmartin et al. determined that the best estimate of the number of butterflies in that same area is obtained by assuming 21.1 million butterflies per hectare. To make the data more accessible to students, the number of monarchs was calculated by using this assumption. It is important to note that the actual number of butterflies in an area is difficult to quantify, particularly because the density of butterflies in an area may vary depending on the weather and the time of the season.

Sample student responses:

I Notice	I Wonder
<ul style="list-style-type: none"> <li>▪ Some years have more monarchs than others.</li> <li>▪ The number of monarchs is going down.</li> <li>▪ One year there could be a decrease in monarchs but then there could be an increase in monarchs the next year.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Why aren't there as many monarchs now?</li> <li>▪ What is happening to them?</li> <li>▪ Why are there more monarchs some years and fewer the next year?</li> </ul>

Explain to students that the graph shows the number of monarchs that make it to Mexico each year for the winter. Highlight responses that identify the declining number of monarchs.  Explain that this graph provides evidence for the decline of monarchs in Mexico. Since monarchs migrate back to the United States in the spring, there must also be a decrease in the number of monarchs in the United States.

Ask students to Think–Pair–Share about what may cause the number of monarchs to decrease.

Sample student responses:

- Maybe something is happening to their habitats and they no longer have a place to live.
- Maybe something is killing the monarchs and they do not have any protection from it.
- Maybe the monarchs are no longer suited for the environment where they spend winters and had to leave.
- Maybe the change in seasons is making the monarchs leave.

Tell students that they will brainstorm ways to help monarchs survive in an engineering challenge but that they will first review the engineering design process.



**Teacher Note**

Consider drawing a trend line to support students in seeing the decline in the number of monarchs over time (1C).

# Learn 35 minutes

## Review the Engineering Design Process 15 minutes

Remind students that in the last module, they read about how Margaret E. Knight used the engineering design process to design flat-bottomed brown paper bags in the book *Marvelous Mattie: How Margaret E. Knight Became an Inventor* (McCully 2006).

Have students recall the steps in the engineering design process. Ask students to work with a partner to write each stage of the process on a sticky note and then arrange the sticky notes on a personal whiteboard. 👤👤

Then re-create the engineering design process as a class. Begin by having each student pair join another student pair. Ask these new student groups to discuss and combine their ideas to develop a process on which they can all agree. After a few minutes, develop a class engineering design process. Have one group share their process for consideration as the initial class process. Ask students to agree, disagree, or suggest revisions to the class process until the entire class agrees on the process.

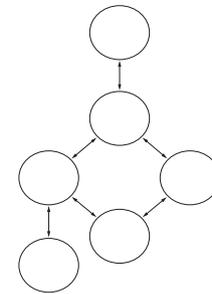
📄 When the class has come to an agreement on a process, display the provided engineering design process (Lesson 22 Resource B), and have students compare it with the process the class developed. Discuss the similarities and differences as a class.

- ▶ In this engineering design process, why are the arrows pointing in two directions?
  - The arrows show that you can go back and forth between steps.
  - Sometimes you must go back to an earlier step when something doesn't work.
  - Sometimes someone else's idea makes you rethink your design. You would change your design and go back to the previous step.



### Differentiation

Visual learners may benefit from seeing an outline of the engineering design process as they generate the list of steps. Consider creating a visual on the board that looks like the one below (1C).



### Teacher Note

As students engage in this activity, they should share similarities and differences between their own process and the class process. If students share differences, have them explain how they would modify the class process and why (1C).

With the engineering design process displayed, agree that the arrows should encourage students to go back to earlier stages if needed. Then draw arrows from each step to the others, showing that the engineering design process is like a web that allows engineers to rethink and revisit any stage from any point in the process. 📖 Explain that while engineers may take a different path to solving and sharing their solution each time they use the engineering design process and may have to repeat steps until they are satisfied with their solution, a starting point (a problem) and an ending point (a solution or device) are always part of the process.

After the class discussion, have students look at the engineering design process in their Science Logbooks (Lesson 22 Activity Guide A) and recall what they learned about the Ask and Imagine stages of the engineering design process.

Sample student responses:

- We learned that we have to research and brainstorm solutions in the Imagine stage.
- In the Ask stage, we talked about how we would know we solved the problem.
- We talked about what materials we could use.

Explain that students will learn more about the engineering design process in this lesson set by focusing on the Plan and Share stages. 📖



### Check for Understanding

Use student responses to ensure that students understand the nature of the engineering design process.

#### Evidence

Look for evidence that all students understand the steps and the purpose of the engineering design process.

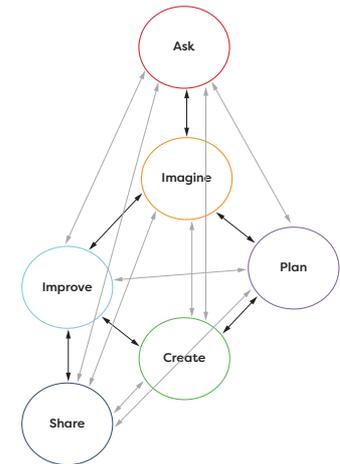
#### Next Steps

Support students as needed with their understanding of the engineering design process. If a student is struggling with any of the steps, revisit *Marvelous Mattie: How Margaret E. Knight Became an Inventor* and use the engineering design process visual (Lesson 22 Resource C) to discuss how Margaret E. Knight used the design process.



### Teacher Note

The engineering design process visual should look like the one below after arrows are drawn between each step. The visual is typically simplified to make it easier to read (1C).



### Teacher Note

In this engineering challenge, students will generate a detailed design and write a letter to share their solution. They will not create or test their solutions (2I).

► **How can we use the engineering design process to solve a problem?**

- *The engineering design process can outline the steps we need to solve a problem.*
- *It helps us organize our thoughts and ideas when we need to make a solution to a problem.*
- *We can use each step of the engineering design process to figure out if our solution will work or not.*

While discussing students' responses, emphasize the importance of planning, persistence, and teamwork involved in finding the solution to a problem.

Ask students to review the Phenomenon Question **How can we help monarchs survive in a changing environment?** Tell students that in upcoming lessons, they will work to develop a solution to help monarchs survive and, ultimately, to increase the number of monarchs. Explain that in this engineering challenge, they will write a letter to a community leader explaining a detailed plan for their solution.

## Ask about an Engineering Problem 20 minutes

Display the graph from the Launch again (Lesson 22 Resource A). Have students think back to the Launch and brainstorm a list of questions they still have about the problem.

*Sample student responses:*

- *What changed in the environment to make the numbers go down?*
- *What caused the change?*
- *Are there certain materials we can use?*
- *What do butterflies need to survive?*

Remind students that an important part of the Ask stage is to define the problem. Tell students they will begin by uncovering more about the declining number of monarch butterflies.

Revisit the monarch butterfly fall migration. Display the previous year's fall migration map on the Journey North website (<http://phdsci.link/1226>) (Annenberg Learner 1997–2019).  Play through the data on the map, and then have students revisit their flipbook monarch migration maps from Lesson 16, focusing on the second half of the flipbook (months August to December). Consider displaying a few other years' fall migration maps on Journey North to further support the migration pattern.



### Teacher Note

Lesson 16 Resource C includes instructions about how to navigate and use the Journey North website.

- ▶ **Where do the monarchs travel during the fall months?**
  - *The monarchs travel very far. They end up in Mexico, California, and sometimes Arizona.*
  - *The monarchs travel all the way from northern states or Canada to Mexico.*
  
- ▶ **How long does it take for most of the monarchs to migrate to the location where they spend winter?**
  - *They start traveling in August and it looks like most of them stop traveling when they get to Mexico around November.*
  - *It takes several months for them to travel because they travel so far.*
  
- ▶ **If you were on a long car trip, what would you need to survive?**
  - *I would need food.*
  - *I would need something to do. I hate long trips!*
  - *I would need water and somewhere to rest.*
  
- ▶ **What do you think the monarchs need to survive their long journey while migrating?**
  - *They need a place to eat and sleep.*
  - *I think they need to stop in safe areas to rest and get food and water.*
  - *Maybe they need to find places that protect them from storms or cold weather.*
  
- ▶ **What problems might the monarchs face during migration?** 
  - *Maybe some places along the way don't have what they need to keep going.*
  - *I remember this time of year is hurricane season. Maybe the butterflies get stuck in hurricanes.*
  - *I wonder if another animal eats butterflies.*

Explain that students will consider some of these problems and others as they continue to learn more about the engineering problem.

Read aloud an overview of several threats to monarchs in the text adapted from “Winged Mysteries” by Jacqueline Adams (2003) (Lesson 22 Resource D). While reading, ask students to raise their hand or give another nonverbal signal if they hear a threat to the monarch butterflies. Create a bulleted list, visible to all students, of the threats identified. Then lead a discussion to add other possible threats to the list, such as predators and weather.



### Teacher Note

Students may benefit from follow-up questions such as these (21):

- What kind of severe weather can butterflies encounter during their migration?
- What time of the year does their migration occur?

Sample list of threats to monarchs:

Threats to Monarchs
<ul style="list-style-type: none"> <li>▪ Deforestation (cutting down trees) in winter living areas</li> <li>▪ Development by humans</li> <li>▪ Loss of milkweed due to pesticides </li> <li>▪ Animals that eat butterflies</li> <li>▪ Weather</li> </ul>

► Which threats could humans minimize to protect the number of monarchs?

- Deforestation
- Development by humans
- Loss of milkweed

Acknowledge that threats by animals and weather are natural threats that humans cannot control. As a class, discuss why each of these environmental changes poses a problem for the monarchs, highlighting the monarch needs that are affected by each threat. Record the problems and effects discussed on a class chart.

Sample class chart:

Problem	Effect on Monarch Needs
Deforestation	Trees protect the butterflies from the rain and snow. Without the trees, they don't have that protection.
Development by humans	There isn't enough space and food for monarchs. We are removing what they need to survive from the environment.
Loss of milkweed	Less milkweed is available for butterflies to eat and to lay their eggs on, so fewer butterflies will return to Mexico.

Reiterate that there are many factors that contribute to the declining number of monarchs. Then explain that engineers and scientists typically focus on solving one part of a problem at a time. Divide the class into groups of three to four students.  Ask each group to select one of the monarch threats to focus on in the engineering challenge.



### Teacher Note

While most of the threats discussed in the text affect butterflies as they migrate south, the loss of milkweed is a threat that affects butterflies after they migrate back north. If the butterflies cannot find food or reproduce, the number of butterflies migrating south the next fall may decrease.



### Differentiation

When forming groups, consider the needs of each student, and develop groups with a variety of interests. For example, it may help to group students with varied English language ability to support students as they develop interpersonal and academic language.

# Land

5 minutes

Have students write a problem statement in their Science Logbooks (Lesson 22 Activity Guide B) for the threat their group selected. Explain that this is the problem their group will work to solve as they continue with the engineering challenge.

*Sample student responses:*

- *Too many trees are being cut down in the forest. The monarchs don't have a way to stay warm to survive winter.*
- *There is less land available for monarch butterflies to live. Humans are building more and more.*
- *People are spraying stuff that kills the milkweed that the monarchs need for food.*



## Teacher Note

Consider having student groups quickly share the problem they have chosen to solve. Record the names of each group's members and a summary of the group's chosen problem to refer to throughout the engineering challenge.

Ask students to reflect on where they are in the engineering design process and where they are headed next.

*Sample student responses:*

- *We have defined our problem, but we still need to know what the criteria and constraints are before we start the Imagine stage.*
- *We are in the Ask stage, but we're not done yet. We don't know what materials we can use. We are going to start thinking about ideas for solutions soon.*

Inform students that, in the next lesson, they will continue working in the Ask stage and begin the Imagine stage of the engineering design process.