TGR EDU:
EXPLORE

MIDDLE SCHOOL

MAGNETIC MIGRATION

Mindset
Method
Mastery

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Discovery EDUCATION

MAGNETIC MIGRATION

LESSON OVERVIEW

Through a series of hands-on activities, students will work together to investigate the claim: Animals use Earth's magnetic field to navigate. Students will collect evidence to support or refute this claim by breaking the claim statement into several key elements. First, students will rotate through stations that build their understanding of magnetic forces and properties. Next, they will apply this new understanding as they explore Earth's magnetic field by building a compass and considering how magnetic fields extend through space. Students will then divide into research teams and focus on if/how magnetism affects the migration of birds, sea turtles and sharks. Each research team will focus on a specific animal and will be responsible for sharing their findings with the class. Finally, students will consider all of the data they have collected in order to revisit the original claim and form a conclusion backed by evidence. As an extension, students will create a model of a device that uses magnetoreception for wildlife conservation.

The accompanying presentation was created with PowerPoint so that it can be used in a variety of classrooms. If you are using a laptop with an LCD projector, simply progress through the PowerPoint by clicking to advance. All of the interactive aspects of the presentation are set to occur on click. This includes images, text boxes, answers and links to outside videos, which will appear in your web browser. If you are using an interactive whiteboard, tap on each slide with your finger or stylus to activate the interactive aspects of the presentation. It does not matter where you tap, but you can make it appear as if you are making certain things happen by tapping them. In the notes for each slide, there will be information on how to proceed.

THIS LESSON FOCUSES ON:

ENGINEERING DESIGN PROCESS	21ST CENTURY SKILLS
○ **Defining the Problem**	○ **Collaboration**
○ **Designing Solutions**	○ **Communication**
○ Creating or Prototyping	○ **Critical Thinking**
○ Refine or Improve	○ Creativity
○ **Communicating Results**	

SUGGESTED TIME

3 class sessions (45 minutes each) + 1 optional extension

GRADE LEVELS

6–8

CONTENT AREAS

- Forces and Interactions
- Physical Science
- Natural Selection, Life Science

ESSENTIAL QUESTIONS

1. What are the properties of magnets?
2. How can magnets influence movement?
3. What is Earth's magnetic field?
4. Do animals use Earth's magnetic field to navigate?
5. How could magnetism be used to protect animals in their natural habitats? *

*Covered in the Extension Lesson

MAGNETIC MIGRATION

HAVE YOU EVER WONDERED...

Why do animals migrate?

Animals have a variety of reasons for migration. The majority of animals migrate to either find food or better living conditions. Some animals, like salmon, migrate in order to breed. Other animals, like bats, migrate in order to find a place to hibernate.

Do all animals migrate?

While all animals do not migrate, many animals certainly do. For instance, about 40% of the world's birds migrate.[1] Certain species of reptiles, fish, insects, mammals and amphibians migrate as well. While some animals only travel short distances to find what they're looking for, other animals travel vast lengths. Humpback whales, leatherback turtles and great white sharks are among the animals that swim the farthest. On land, caribou travel the farthest: an average of 2,982 miles each year.[2]

How is migration tracked and studied?

Migration is studied in a few main ways. In the past (and still to a certain extent today), animal migration is tracked using leg bands, collars, dyes and even radar. The most recent development to accurately track animal migration is through the use of satellite transmitters, which can track the position of animals over thousands of miles.[3]

MAKE CONNECTIONS!

This section captures how this activity connects to different parts of our lives and frames the reason for learning.

HOW DOES THIS CONNECT TO STUDENTS?	HOW DOES THIS CONNECT TO CAREERS?	HOW DOES THIS CONNECT TO OUR WORLD?
No matter our age, we have a responsibility to take care of our planet. Climate change is beginning to affect many aspects of life on Earth, including animal migration as animals seek more ideal living conditions in different areas. It's therefore the responsibility of all generations to take care of the Earth through strategies like conserving energy, recycling, using green transportation methods and eating less meat in order to leave the smallest footprint possible.	**Zoologists** study animal species and are involved in a range of animal-related work, including conducting research, analyzing data, educating the public, ensuring animal welfare and leading conservation efforts. **Geographic Information Specialists** analyze data such as satellite images that they obtain from geographic information systems. From this data, they may create maps of geographic areas, analyze it for scientific purposes and/or track wildlife. **Electrical Engineers** design, develop and test electronic equipment such as radar and navigation systems. It's important for them to understand how magnetism and electromagnetic forces work and use that to design everything from trains and medical equipment, to the Mars rover and GPS!	Earth's magnetic poles have switched repeatedly over hundreds of millions of years. Each time reversing Earth's magnetic field. Living things rely on the magnetic field that surrounds Earth. It protects us from ultraviolet radiation, helps us tell direction and animals use it as a natural compass. As the planet warms and animals adapt, their behavior around the world is changing. For this reason, they grow increasingly important to track. Birds, for instance, are laying eggs earlier and migrating sooner. Animals in general are shifting slowly towards the poles in search of cooler weather.[4] While some moves may be seen as positive (a new breed of fish in Europe for example), shifts also have the potential to cause larger problems and it is important that people around the world keep an eye on migratory patterns.

MATERIALS

To ease the flow of the lesson, it will be helpful to set up these materials at the various stations before the beginning of each class. Station materials are also listed on each station's student capture sheet so students can help you prepare, too!

Every Day Materials

- Computer and projector
- Corresponding PowerPoint presentation
- Claim-Evidence-Reasoning student capture sheet, one per student

Day 1 Materials:

- Exit Slips, copied and cut, one per student

Station 1: Laws of Attraction

- Station 1 student capture sheet, 8 copies
- Magnets, at least 2
- Paperclips, at least 12-15
- Pennies, at least 4
- Nickels, at least 4
- Nails, at least 4
- Aluminum foil pieces, 2
- Paper fasteners, 2

Station 2: North and South

- Station 2 student capture sheet, 8 copies
- Iron filings, one 100-gram jar split in 2
- Thin sheets of transparent paper, 10
- Bar magnets with ends labeled "north" and "south", 2

Station 3: Pencil Rings

- Station 3 student capture sheet, 8 copies
- Pencils with erasers, 2
- Ring magnets, at least 8

Station 4: Water and Magnetism

- Station 4 student capture sheet, 8 copies
- Clear plastic containers filled halfway with water, 2
- Rulers, 2
- Magnet (neodymium or ceramic), 2
- Paperclips, 4

Day 2 Materials:

Build a Compass Activity

- Build a Compass student capture sheet, 8 copies
- Small flat cork piece, 8
  Note: Cut a bottle cork into half-inch pieces
- Sewing needles, 8
- Pliers, to share
- Small magnets, 8
- Wide shallow containers filled partway with water, 8
- Compasses, 8

Sea Turtle Investigation

- Sea Turtle student capture sheet, 10 copies
- Laptop or device with internet access, 2
- Small flat cork pieces, 2
  Note: Cut a bottle cork into half-inch pieces
- Wide shallow containers filled partway with water, 2
- Small piece of cardstock or poster board, 2
- Scissors, 2
- Glue, to share
- Paperclips, 2
- Strong magnets, 2

Shark Investigation

- Shark student capture sheet, 10 copies
- Laptop or device with internet access, 2
- Batteries, 2
- Alligator clip wires, 6
- Small lightbulbs, 2
- LED lights, 2
- Electrical tape
- Household light switch, 2
- Compasses, 2
- Plastic cups filled halfway with water, 2
- Copper tape, to share
- Salt, at least 6 tablespoons
- Spoons, 2

Bird Investigation

- Bird student capture sheet, 10 copies
- Bird Flyways Map student capture sheet, 2 copies
- Paper pigeon cutouts, 2 copies
- Laptop or device with internet access, 2
- Compasses, 2
- Sticky notes, 8
- Strong magnets, 8
- Tape
- Scissors, 2

Day 3 Materials:

- Lined paper

Day 4 Materials:

Materials for model device could include but are not limited to:

- Cardboard
- Magnets
- Pipe cleaners
- Paper cups
- String
- Recycled items
- Paperclips

OBJECTIVES

Students will be able to:

- **Experiment** with magnets in order to determine their key properties
- **Create** a compass to investigate Earth's magnetic field
- **Evaluate** the claim that animals use Earth's magnetic field to navigate
- **Organize** their evidence and construct a response that supports or refutes the claim

BACKGROUND INFO

Magnetoreception is the concept that animals are able to orient themselves using Earth's magnetic field, which helps them navigate as they move and migrate. Studies show that many species of animals rely on some sort of internal compass. This internal compass may help animals move as little as from one plant to the next or as much as from one corner of an ocean to another. How animals are able to sense and use Earth's magnetic field varies from animal to animal. Scientists continue to study this phenomenon and some understandings are still a work in progress. What seems to be certain is that many animals rely on Earth's magnetic field to help them navigate without a map.

This guide gives educators a resource to help students come to their own conclusions on whether animals use Earth's magnetic field to navigate. It provides slide-by-slide details to ensure educators are prepared to explain, discuss and facilitate the hands-on content in the presentation. The presentation is designed to cover three 45-minute class sessions, but it can be flexible depending on the students' needs and the time available. An additional one-class extension is provided at the end of this manuscript.

This lesson plan follows an inquiry-driven 5E instructional model: Engage, Explore, Explain, Elaborate and Evaluate. The lesson begins with a problem scenario that presents students with the following claim to investigate: Animals use Earth's magnetic field to navigate. Over the course of three class periods, students will work together to understand and test this claim, while collecting data and making conclusions on a claim-evidence-reasoning sheet. Students will begin their claim analysis by improving their understanding of magnetic forces and properties. They will then consider how Earth's magnetic field travels through space. Finally, students will divide into research teams and investigate how/if sea, land and air animals use magnetism to navigate. Each investigation will lead students to the understanding that magnetism has an effect on animal migration. Students will then ultimately consider all of the evidence they have collected to develop a conclusion and an answer to the claim. As an extension, students will expand the concept of magnetoreception to conservation as they work with their group to develop a model of a device that uses magnets to help protect wildlife.

Sources:

1. Lockhart, Jhaneel. "9 Awesome Facts about Bird Migration." Audubon Society. audubon.org/news/9-awesome-facts-about-bird-migration.

2. Davies, Ella. "Meet the animals that travel farther than any other." BBC. bbc.com/earth/story/20160719-meet-the-animals-that-travel-farther-than-any-other.

3. Viljoen G.J., Luckins A.G., Naletoski I. "Animal Migration Tracking Methods." Stable Isotopes to Trace Migratory Birds and to Identify Harmful Diseases. springer.com/chapter/10.1007/ 978-3-319-28298-5_2#citeas.

4. "Climate Change: Effects on Animals, Birdlife and Plants." Weather & Climate. climateandweather.net/global-warming/climate-change-and-animals.html.

PROCEDURE

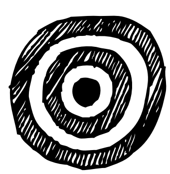
DAY 1

ENGAGE (Slides 0-2)

Overview: Students will be introduced to a problem scenario involving magnetic fields and animal migration that includes a claim they will be probed to explore further in the days ahead. Students will then consider how objects can move without direct force in order to activate their prior knowledge about magnets.

Slide 1

1. Once all students are seated, instruct them to close their eyes. Tell them that they are jumping ahead 15 years into the future and the topic of today's discussion— magnets—will have the potential to make a big impact on their career!
   - Project and present the following scenario:
     - You are now working for an animal conservation group. Your organization relies on grants and donations to fund your work and you have an opportunity to work with an engineering/technology company that is exploring how animals may use Earth's magnetic field. If you can prove that animals use Earth's magnetic field to navigate, then you will be considered for a substantial grant! If you can't, there are other grants you can pursue…but your organization has never seen a grant this big so you want to make sure to investigate it as thoroughly as possible.
2. Click once to highlight the claim portion of this problem scenario: Animals use Earth's magnetic field to navigate.
3. Acknowledge that there are likely parts of this claim about which the students are unsure and that's okay. Over the course of the next several class periods, they will work together to break down this claim in order to eventually support or refute it.



Slide 2

1. Ask students: How are these images examples of a direct force? (Point to the images on the screen for reinforcement). Now ask students if they have ever seen something move without direct force?
2. Click on the video link on the slide to show this video and tell students to keep the question you just posed in mind.
3. When the video is complete, lead the class's discussion towards the idea that magnets create movement without a visible force and that this idea is directly related to the claim statement: Animals use Earth's magnetic field to navigate.
4. Click the slide once more, and direct student pairs to brainstorm what they already know about magnets before they dive in and learn more.

EXPLORE (Slides 3-7)

Overview: Students will receive a Claim-Evidence-Reasoning student capture sheet, on which they will record data as they work their way through the claim. Students will begin to investigate the claim by rotating through four stations designed to help them more thoroughly understand magnets and the concept of a magnetic field. The class will then reconvene as a group to review the information and data points that they gathered from their station work. Before the class period ends, students will individually complete an exit sheet that asks them to explain the characteristics of a magnetic field.

Slide 3

1. Direct students' attention towards the claim statement on the slide and ask: What do we need to make sure we understand first before we can move forward?
2. Click the slide once and lead students to: The first step in investigating the claim will be to understand what exactly a magnetic field is. Explain that in order to do this, student groups will be rotating through four stations.
3. Click the slide a second time and provide a brief overview of the following stations to students:
    - Station 1: Laws of Attraction – Students will explore which metals are attracted to magnets by making a hypothesis about several materials and then testing their predictions.
    - Station 2: North and South – Students will experiment with iron filings and transparent paper to see what they can learn about magnetic fields.
    - Station 3: Pencil Rings – Students will use a pencil and ring magnets to experiment with magnetic properties.
    - Station 4: Water & Magnetism – Students will experiment to see if magnets maintain similar properties in water.
4. Pass out one Claim-Evidence-Reasoning sheet to each student. Review the directions and explain that the goal of this sheet is to collect data and record their thoughts over the next few days, so they can ultimately establish whether the claim is true once their data collection is complete.

Slide 4

1. Divide the class into eight small groups. Assign two groups to start at each station. Each group should work independently of one another.
2. Review the reminders on the slide and reiterate that student groups need to work together to complete the step-by-step instructions. Steps will ask groups to predict, sketch, record or discuss and they must complete each step as a group before moving on.
3. Explain that students will be able to refer to the stopwatch on the slide to see how much time they have left at each station. (The stopwatch is set to 7 minutes, but feel free to modify the timing.)
4. Tap the stopwatch to begin the countdown.
5. When the stopwatch gets to zero, instruct students to clean up and move to the next station.

Slide 5

1. Debrief time! Once every group has rotated through all four stations, bring the class back together to share their initial findings.
2. Use the blank squares on the board to record information as the students and/or you share. Students should take similar notes on their Claim-Evidence-Reasoning sheet if they are missing information.
3. As you discuss each station, make sure the groups have arrived at the following:
   - Station 1: Laws of Attraction
     - Magnetic metals include iron (nails), steel (paperclips and nails) and nickel. (Note: The nickel coin likely didn't have enough nickel in it to be magnetic, but some international coins do!)
     - Iron has the strongest magnetic reaction.
     - Nonmagnetic metals include brass (paper fasteners), aluminum (foil), zinc (pennies) and copper (not represented).
     - Paperclips become temporarily magnetized because the magnetic force is transferred through the metal paperclips.
   - Station 2: North and South
     - Magnets attract iron. When you put iron filings around the magnet, they make the shape of a magnetic field.
     - Every magnet has two poles: North and South.
     - Opposite poles attract: When you place North and South near each other, the iron filings move to show this.
     - Same poles repel: When you place North/North or South/South together, the iron filings move away from each other.
   - Station 3: Pencil Rings
     - The ring magnets will either attach to each other (attract) or appear to float (repel).
     - Like the Earth, all magnets have a north and south pole.
   - Station 4: Water and Magnetism
     - Paperclips are attracted to magnets, because they are made mostly of iron.
     - The magnet attracted the paperclip similarly when it was under water and on a dry surface.
     - Therefore, magnets have a similar force in and out of water.

Slide 6

1. Remind students that the goal of today's investigation was to understand magnetic fields.
2. Distribute an Exit Slip student capture sheet to each student. Students should independently record an answer to: What is a magnetic field? (Be sure to explain how an item can move without direct force!)
3. Students should turn in their work when they finish.

DAY 2

EXPLAIN (Slides 7-11)

Overview: Students will apply what they have learned about magnetic fields in order to explain how a compass works. After completing an activity that will help them explain this concept, they will be able to further explain what the claim means when it mentions "Earth's magnetic field."

Slide 7

1. Begin class with a think/pair/share, reviewing the lessons learned from Day 1: What is a magnetic field?
2. Based on the exit slips that you reviewed from Day 1 and the students' current discussion, make sure students understand the following:

Note: Click to reveal each bullet separately.

- Every magnet has a North and South pole.
- Like poles repel and unlike poles attract, which is what pushes and pulls objects to move without a direct force.
- A magnetic field is the invisible area of force around a magnet. It exerts its magnetic force on other magnetic objects that come within the field.

Slide 8

1. Display the claim again: Animals use Earth's magnetic field to navigate.
2. Click once to check off "magnetic field" based on the exploration from yesterday.
3. Click again to circle "Earth's magnetic field".
4. Explain that today students will expand their knowledge of magnetic fields to include the Earth's magnetic field.

Slide 9

1. Direct students' attention to the compass image on the slide and ask for student input on what it is and what it is used for.
2. Explain that students will be creating their own compasses to better understand the claim.
3. Pass out one Build a Compass student capture sheet to each group and show students where the needed materials can be found.
4. Allow time for student groups to construct their own compass and answer the questions on the student capture sheet.

Slide 10

1. Debrief time! Bring students back together to review their results.
2. Encourage students to take notes on their Claim-Evidence-Reasoning sheet if they are missing information. Make sure the groups have arrived at the following:

Note: Click to reveal each bullet separately.

- The magnetized needle moved because it was affected by Earth's magnetic field.
- The needle aligned itself with Earth's magnetic field, so one end was pointing North and one end was pointing South.
- When a magnet is brought near the compass, its magnetic force causes the needle to deflect (change directions).

Slide 11

1. Click once to display an image of Earth's magnetic field.
2. Ask students to discuss the image and explain what it is portraying.
3. Guide students to the realization that the Earth's magnetic field is very similar to that of a bar magnet: It has two poles and also exerts weak magnetic forces. This is why this image looks so similar to the iron filings with which they experimented!

ELABORATE (Slides 12-14)

Overview: Now that students have an understanding of Earth's magnetic field, they will use this knowledge to investigate the overall claim provided in the problem scenario. Students will be divided into groups to examine whether Earth's magnetic field affects the migratory patterns of a land, air or sea animal. Students will work together to complete this investigation and will then present their findings to the class.

Slide 12

1. Bring students' attention to the claim statement once more. Ask: What do we need to investigate now? Arrive at the answer of: If animals use Earth's magnetic field to navigate. Click once to underline 'animals.'
2. Tell students that you just learned from an inside source that competition for the grant is fierce, so you need to up your ante. You believe the best way to win this grant is to investigate if animals on land, air and sea use Earth's magnetic field to navigate!
3. Click to reveal the animal images on the slide, and explain that, as their "manager", you will be dividing the class into research groups focused on one animal: either birds, sea turtles or sharks. Each group will complete an investigation that helps them get to the bottom of the claim. They will then present their findings to the class and decide as an "organization" if they can pursue the grant.
4. Divide the class into groups of 3-4 students. Two different groups will investigate one animal. Give each group a copy of the student capture sheet that aligns with their animal: the Sea Turtle student capture sheet, the Shark student capture sheet or the Bird student capture sheet.
5. Instruct student groups to read the directions on top of their student capture sheet before they get started and then follow the step-by-step instructions as they go through the investigation. At least one student should act as a notetaker for questions that ask for answers to be recorded.
6. As student groups complete their investigations, rotate throughout the classroom and ensure students are making progress towards developing the following key understandings:
    - Sea Turtle Group: Sea turtles do use Earth's magnetic field. Turtles as young as hatchlings are able to sense Earth's magnetic field and use it as a navigational tool when they migrate long distances in the ocean.
    - Shark Group: Sharks' salt water habitat allows them to be more sensitive to electric fields and currents. As a result, they are also able to sense magnetic fields and therefore use Earth's magnetic field to navigate.
    - Bird Group: The conclusions of this group will be a little less defined. Students should arrive at the understanding that bird migration has something to do with magnetism but it's still difficult to say exactly how. Make sure this group understands that this particular study is still in progress.

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DAY 3

Slide 13

1. Begin class by allowing student groups a little time to reconvene and finish any station work (if needed).
2. Then click once to review the criteria for group presentations:
   - Criteria for Presentations:
     - 1-2 minutes in length
     - Must answer the following:
       - Does the sea turtle/shark/bird use Earth's magnetic field to navigate?
       - What evidence do you have to support or refute the claim?
       - How does this evidence refute or support the claim?
       - If the animal does use Earth's magnetic field to help navigate, why do you think it has developed this ability? How does this adaptation help the species survive and thrive?
     - Allow groups time to prepare and answer questions as needed.
3. Encourage students to use their Claim-Evidence-Reasoning student capture sheet, as well as any notes they took at their station to help them develop their presentation.

Slide 14

1. Once student groups are prepared, it's time to present their findings!
2. Groups who are presenting should stand near the presentation backdrop.
3. Students who are listening should take notes in the space provided for that animal on their Claim-Evidence-Reasoning student capture sheet.

EVALUATE (Slide 15)

Overview: Each student will be asked to write at least a couple paragraphs responding to the original claim, proving or disproving its validity and offering specific evidence to support their opinion. Through this writing, you will be able to evaluate each student's independent understanding of the claim.

Slide 15

1. Following the presentations, pass out lined paper and instruct students to independently use their notes from the past several days to write two to three paragraphs responding to the claim and providing their own conclusion. Encourage students to include as much evidence and reasoning as possible within their response.
2. At the very end of class, click once to make the writing assignment disappear. Then hold an "organization-wide" vote that asks every student to indicate whether they believe there is enough evidence that animals ***do*** use Earth's magnetic field to navigate to apply for the grant!

DAY 4

OPTIONAL EXTENSION (Slides 16-18)

Slide 16

1. Share with your students that the engineering/technology company has announced that your organization made it to the final round!
2. Go on to explain that the company is now asking all applicants to complete one more step: Propose how magnetism could be used to conserve and protect wildlife.
3. Ask students to discuss: Why is it important to protect animals in our ecosystems?

Slide 17

1. Divide students into new teams of 3-4 students. Every group should have at least one member who focused on sharks during the last group work activity. (These students will be able to share relevant background knowledge.)
2. Click once to review the groups' task. Explain that they are being challenged to build a model of a device that could use magnetism to protect wildlife. Encourage them to think closely about how they may be able to use magnets to prevent animals from entering areas where they are likely to be harmed.
3. Explain that each group may select a location of their choice: beach, open ocean, construction site, deforestation area, fishery, etc.
4. Review the model materials that students will have available to them and then allow groups to get started.

Slide 18

1. If time allows once the models are complete, encourage students to participate in a gallery walk to view their peers' work and ask questions.
2. During this time, you may pretend to be a representative from the engineering/technology company, asking questions specifically related to magnetism.
3. At the end of class, you can decide and announce (on behalf of the engineering/technology company) if your class has won the grant!

NEXT GENERATION SCIENCE STANDARDS

PHYSICAL SCIENCE

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking Questions and Defining Problems Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. **Engaging in Argument from Evidence** Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Planning and Carrying Out Investigations** Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.	**PS2.B: Types of Interactions** Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, a magnet, or a ball, respectively).	**Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems.

LIFE SCIENCE

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing Explanations and Designing Solutions Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.	**LS4.B Natural Selection** Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	**Cause and Effect** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

ELA COMMON CORE STATE STANDARDS

Writing
CCSS.ELA-LITERACY.CCRA.W.1
Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

Speaking and Listening
CCSS.ELA-LITERACY.CCRA.SL.4
Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

CLAIM – EVIDENCE – REASONING STUDENT CAPTURE SHEET

Claim: Animals use Earth's magnetic field to navigate.

Evidence: In this column, take note of observations and data that may support the claim.	**Reasoning**: In this column, explain how the evidence that you recorded could support the claim.
Station 1: Laws of Attraction	
Station 2: North and South	
Station 3: Pencil Rings	
Station 4: Water and Magnetism	
Build a Compass Activity	
Animal Investigation: **Sea Turtle Hatchlings**	
Animal Investigation: **Sharks**	
Animal Investigation: **Birds**	

STATION 1 STUDENT CAPTURE SHEET
LAWS OF ATTRACTION

Materials needed at station:

- 2 Magnets
- Paperclips (made of steel)
- Pennies (made of mostly of zinc)
- Nickels (75% copper; 25% nickel)
- Nails (steel)
- Foil (aluminum)
- Paper fasteners (brass)

Step 1

Predict and discuss: Which (items) will be attracted to the magnet? Which items will not be attracted to the magnet? Why?

Step 2

Test your hypothesis and record your results below:

Material	Was it magnetic? What did you observe?
Paperclip	
Penny	
Nickel	
Nail	
Foil	
Paper Fastener	

Step 3

Put aside all of the materials except for the magnet and a few paperclips. Experiment to see what happens when you put the paperclips near the magnet in different formations.

Discuss: What happens? Why do you think this occurs?

Step 4

Fill out the Station 1 Row on your Claim-Evidence-Reasoning Sheet. Record what you observed and do your best to consider how this may be related to the claim.

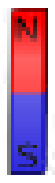
STATION 2 STUDENT CAPTURE SHEET
NORTH AND SOUTH

Materials needed at station:

- Iron filings
- Transparent paper, 10 sheets
- Bar magnets with ends pre-labeled North and South, 4

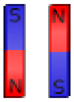
Step 1

Place one bar magnet on the table, so its North end is pointing up like in the image below. Place one piece of paper on top of this magnet. Then lightly sprinkle the iron filings uniformly over the paper and give the paper a few gentle taps to help the filings re-align. Draw a sketch of what the iron filings look like around the magnet below.



Step 2

Carefully put the iron filings back in their container. Place a second magnet under the piece of paper so the magnets look like the ones below. Again, sprinkle the iron filings onto the paper and then give the paper a couple gentle taps. Draw a sketch of the iron filings around the magnets below:



Step 4

Carefully put the iron filings back in the cup one last time. Rearrange the magnets again so they look like the ones below. Sprinkle the iron filings, give the paper a couple taps and then draw a sketch of the iron filings around the magnets:

Step 5

Look back at your group's sketches. Discuss: What observations can you make about iron filings? Why do you think the iron filings arranged themselves these ways?

Step 6

Fill out the Station 2 Row on your Claim-Evidence-Reasoning Sheet. Do your best to consider how your observations at this station may be related to the claim.

STATION 3 STUDENT CAPTURE SHEET
PENCIL RINGS

Materials needed at station:

- Pencil with eraser, 2
- Several ring magnets

Step 1

Put the eraser end of the pencil on a table, so the pencil is standing up (with your help).
Then place the ring magnets around the pencil. What happens?
Draw a sketch of what you see below. Then discuss what you think is happening.

Step 2

Now flip at least one of the ring magnets over. What happens when you do this? Draw a sketch of what you see below. Then discuss: Do the magnets attract each other or repel each other? Is this similar or different from what happened in Step 1?

Step 3

Discuss: Can you make a connection between this information and your observations of the ring magnets?

Step 4

Fill out the Station 3 Row on your Claim-Evidence-Reasoning Sheet. Do your best to consider how the observations you made may be related to the claim.

STATION 4 STUDENT CAPTURE SHEET
WATER AND MAGNETISM

Materials needed at station:

- Clear plastic containers filled with water, 2
- Rulers, 2
- Magnets (neodymium or ceramic), 2
- Paperclips, 4

Step 1

Discuss: Do you think magnets exert the same force under water as they do in the air? Why or why not?

Step 2

Place the ruler on the table. On top of the ruler, place the water container so the ruler runs underneath the long side of the water container. When you look down into the water, you should be able to see the 1-inch mark on the ruler. If you can't, move the ruler.

Step 3

Place a paperclip underwater on top of the ruler's 1-inch mark. Then hold a magnet underwater at the opposite end of the container. Very slowly, move the magnet closer and closer to the paperclip. Stop moving the magnet once the paperclip attaches to the magnet. How far away did the magnet have to be from the paperclip for this to happen? Record the distance below.

Step 4

Discuss: Were you surprised by this distance? Why or why not? Does it make you reconsider your hypothesis from Step 1? Why or why not?

Step 5

Repeat this same experiment *not* underwater. To do this, carefully remove the ruler from under the water container. Place a dry paperclip on the 1-inch mark.

Dry off the magnet and place it on the 12-inch mark. Very slowly, move the magnet closer and closer to the paperclip. Stop moving the magnet once the paperclip attaches to the magnet.

How far away did the magnet have to be from the paperclip for this to happen? Record the distance below.

Step 6

Compare the distances recorded in Step 3 and Step 5. Discuss: Was your hypothesis correct? Why or why not? What conclusions can you make?

Step 7:

Fill out the Station 4 Row on your Claim-Evidence-Reasoning Sheet. Do your best to consider how the data you collected may be related to the claim.

EXIT SLIPS STUDENT CAPTURE SHEET

Exit Slip: What is a magnetic field? (Be sure to explain how an item can move without direct force!)

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BUILD A COMPASS STUDENT CAPTURE SHEET

Materials needed in each group:

- Small flat cork piece
- Sewing needle
- Pliers
- Small magnets
- Container filled partway with water
- Compass

Step 1

Rub the magnet against the sewing needle 15 times. Do not rub the magnet back and forth: Choose one direction and rub only this one way. After 15 times, your needle should be magnetized!

Step 2

Use the pliers to carefully push the needle through the side of the cork. (The needle should be inserted the long way, so less needle is showing). Push the needle through so about the same amount of needle is showing on both sides of the cork.

**Your teacher may require their assistance for this step*

Step 3

Fill the container with at least an inch of water. Place the cork and needle in the water and observe. Discuss: What does the needle do? What direction do you think it is pointing? Record your observations below:

Step 4

Now turn the container. Discuss: What does the needle do now? Turn it again. Discuss: Why do you think it moves this way?

Step 5

Use the actual compass to see if your directional hypothesis was correct. Discuss: What direction does the needle keep facing, no matter how much you turn the container?

Step 6

Place a magnet next to the water container. Observe: What happens to the cork and needle? Discuss: Why do you think this happens?

Step 7

Fill out the Make Your Own Compass row on your Claim-Evidence-Reasoning Sheet. Do your best to consider how the data you collected may be related to the claim.

SEA TURTLES STUDENT CAPTURE SHEET

Claim Statement: Animals (specifically sea turtles) use Earth's magnetic field to navigate.

Directions: For this activity, you will need your Claim-Evidence-Reasoning student capture sheet, as well as the materials listed below. Work with your group to follow the step-by-step directions and make sure each step is fully completed before you move on.

Remember that the goal of this activity is to help you better understand the claim statement. So, if at any point during the activity you believe you have information that would be relevant to the claim, make sure to record it on your Claim-Evidence-Reasoning sheet!

Materials for each group:

- Small cork piece
- Wide, shallow container of water
- Cardstock or poster board
- Scissors
- Glue
- Paperclip
- Strong magnet
- Laptop or device with internet access

Step 1

Discuss: What do you know about sea turtles? Discuss any background knowledge with your group.

Step 2

Place the cork piece into the water. From now on, pretend this is a hatchling (a baby sea turtle) and the water container is the ocean. Therefore, in front of you is a baby sea turtle in the ocean by itself, trying to find its way to food and safety.

Step 3

Use your fingers to create currents and waves to move the hatchling through the ocean without ever touching the hatchling. Once you give this a try, see if you can make the hatchling move in certain shapes through the water—such as a circle, square or triangle. Again, do this without touching the hatchling.

Step 4

Discuss: What was difficult about this activity? How do you think this is different from what happens in the ocean? How might sea turtles actually navigate themselves through the ocean?

Step 5

Draw a quick sketch of a tiny hatchling on cardstock and glue it to the cork piece that was floating in the water. On top of the hatchling, glue a paperclip. Then place the hatchling back in the water.

MAGNETIC MIGRATION

Step 6

Pick up the strong magnet and place it on the outside of the water container. Move it around the outside of the container and observe any hatchling activity.

Step 7

Discuss: Did the sea turtle move? Why do you think this happened?

Step 8

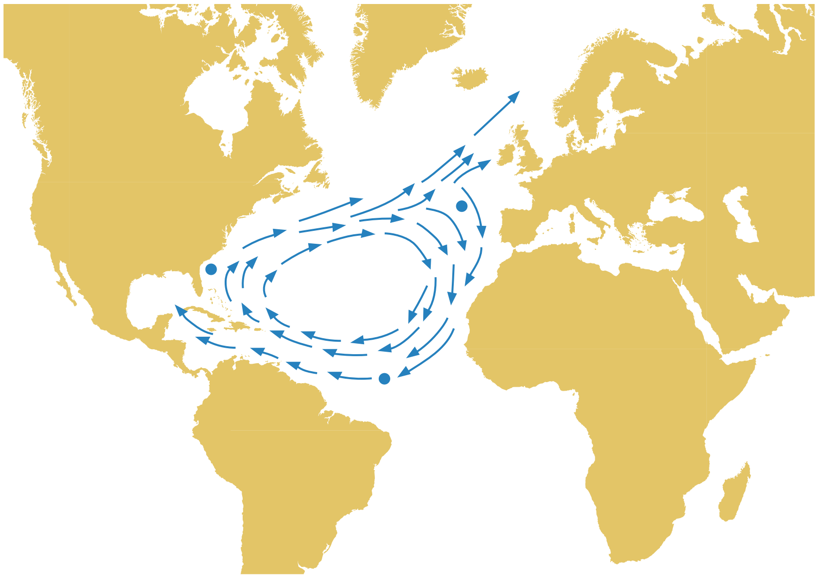
On the laptop or device at this station, watch the following video:
youtube.com/watch?v=eU4mTAaWb6k from 1:14 – 2:02.

Step 9

Again, discuss: Why and how do you think the sea turtle moved?

Step 10

Study the map below. The arrows on the map represent the currents in the ocean. The dots represent the location and migratory route of sea turtles. After leaving the coast of Florida as a hatchling and swimming for years, the turtles eventually find their way back to a beach not far from where they were born to lay their own eggs.



Discuss: Looking at the map above, what do you notice? Considering the video, the map and the information above, how might the hatchlings' migratory route be connected to Earth's magnetic field?

Step 11

If you haven't already, go back and record your observations, evidence and reasoning on your Claim-Evidence-Reasoning sheet!

SHARKS STUDENT CAPTURE SHEET

Claim Statement: Animals (specifically sharks) use Earth's magnetic field to navigate.

Directions: For this activity, you will need your Claim-Evidence-Reasoning sheet, as well as the materials listed below. Work with your group to follow the step-by-step directions and make sure each step is fully completed before you move on.

Remember that the goal of this activity is to help you better understand the claim statement. So, if at any point during the activity, you believe you have information that would be relevant to the claim, make sure to record it on your Claim-Evidence-Reasoning sheet!

Materials for each group:

- Laptop or device with internet access
- Battery
- Alligator clip wires, 3
- Small lightbulb
- LED light
- Electrical tape
- Household light switch
- Compass
- Plastic cup, filled halfway with water
- Copper tape
- Salt, at least a couple spoonful's
- Spoon

Step 1

Create a simple circuit:

- Grab two alligator clip wires and connect one end of each wire to the base of the lightbulb using electrical tape.
- Grab one battery. Use another piece of electrical tape to connect an end of one of the free wires to the negative end of this battery.
- Then connect the remaining free wire to the positive end of the same battery.
- Once the lightbulb lights up (which is proof that your circuit works!), untape the wire from the lightbulb that is also connected to the negative end of the battery. It should stay attached to the battery but *not* to the lightbulb.
- Reattach this wire to the light switch. Then use your third alligator clip wire to connect the light switch to the lightbulb. (Use electrical tape as needed.)
- You now have a new circuit. Test your circuit by switching the light switch: If the light bulb turns on, you're all set!

Step 2

Discuss: What do you think will happen if you place the compass next to the circuit when the switch is turned off? What will happen when the switch is on?

Step 3

Give it a try! Test what happens to the compass when the switch is both off and on. Did the compass change? Why? Record your thoughts below.

Step 4

Now let's apply this to sharks! On your laptop or device, watch the Shark Cam (whoi.edu/osl/sharkcam) from about 2:00 to 2:27. Pause the video at 2:27 and discuss:

What do you think the shark is doing? Why do you think this?

What do you notice on the shark's snout area?

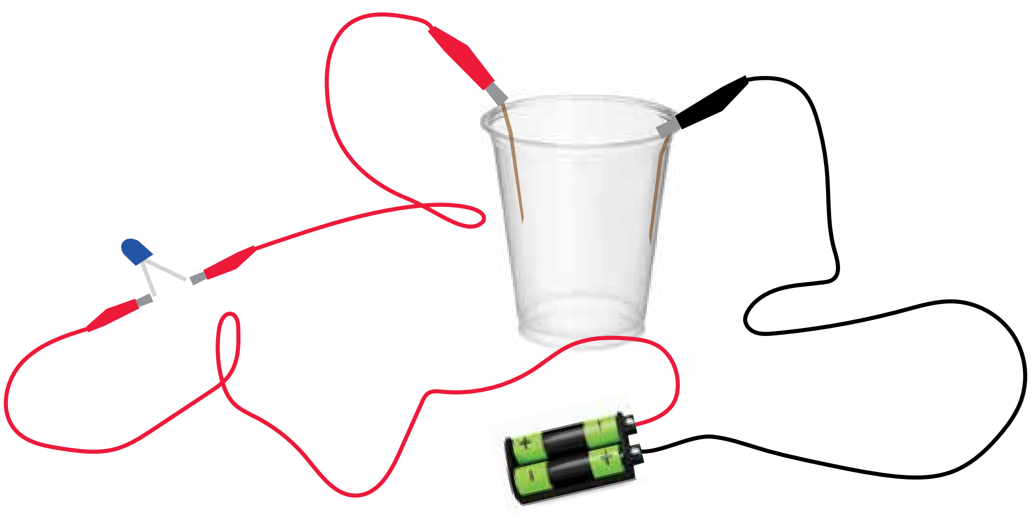
Step 5

Select a group member to read the following three sentences aloud:

The freckle-like dots on the shark's snout are electroreceptors. These electroreceptors are called ampullae of Lorenzini. Sharks use them to sense electric fields found in the water.

Step 6

Now investigate how sharks can sense electric fields in the ocean by going back to your circuit and testing what happens if part of it is put underwater! To do this, study and recreate the circuit image below:



Step 7

Fill the cup with water and mix one spoonful of salt into it. Keep adding salt and mixing until the LED light turns on. Then discuss: Why do you think this happened?

Step 8

Connect and discuss: How might this be related to sharks?

Step 9

If you haven't already, go back and record your observations, evidence and reasoning on your Claim-Evidence-Reasoning sheet!

BIRDS STUDENT CAPTURE SHEET

Claim Statement: Animals (specifically birds) use Earth's magnetic field to navigate.

Directions: For this activity, you will need your Claim-Evidence-Reasoning student capture sheet, as well as the materials listed below. Work with your group to follow the step-by-step directions and make sure each step is fully completed before you move on.

Remember that the goal of this activity is to help you better understand the claim statement. So, if at any point during the activity, you believe you have information that would be relevant to the claim, make sure to record it on your Claim-Evidence-Reasoning sheet!

Materials for each group:

- Laptop or device with internet access
- Compass
- Sticky notes
- Bird Flyways map
- Strong magnets, 4
- Tape
- Scissors

Step 1

Observe the Bird Flyways Map student capture sheet. Then discuss: What do you notice about the direction of the birds' route?

Step 2

Use a compass to figure out the cardinal directions, and mark the directions in your classroom with sticky notes. Then choose a group member to close their eyes. Gently spin this person around 3 or 4 times, and then ask them to figure out the cardinal directions, with their eyes still closed. Did they get it right? Discuss: Why was this difficult?

Step 3

Choose a group member to read the following paragraph from *The Economist* aloud:

For decades scientists have known that birds' ability to navigate with great accuracy over long distances, in some cases migrating from one side of the world to the other, relies on a sense that humans lack. Experiments with homing pigeons performed in the early 1970s found that attaching a magnet disrupted their ability to orientate themselves.

Source: economist.com/the-economist-explains/2013/07/17/how-do-birds-navigate

Step 4

Now let's investigate this statement!

- Grab two magnets, one paper pigeon (cut out from the bottom of the Bird Flyways Map), and the Bird Flyways Map.
- Place one magnet on Earth's North Pole and one magnet on Earth's South Pole. Secure each magnet with a piece of tape. These magnets represent Earth's magnetic field.

Step 5

Place the paper pigeon somewhere on the map. Test and discuss: Can the pigeon feel the pull of Earth's magnetic field when it is magnet-free?

Step 6

Use a piece of tape to attach a magnet to the pigeon. Use your hand to gently move the pigeon. Discuss: Can the pigeon feel the pull of Earth's magnetic field when it has a magnet attached to it?

Step 7

Place one more magnet on the pigeon. Discuss: Is the pull of Earth's magnetic field affected when another magnet is attached to the magnetized pigeon? Why or why not?

Step 8

Discuss: What conclusions can you make?

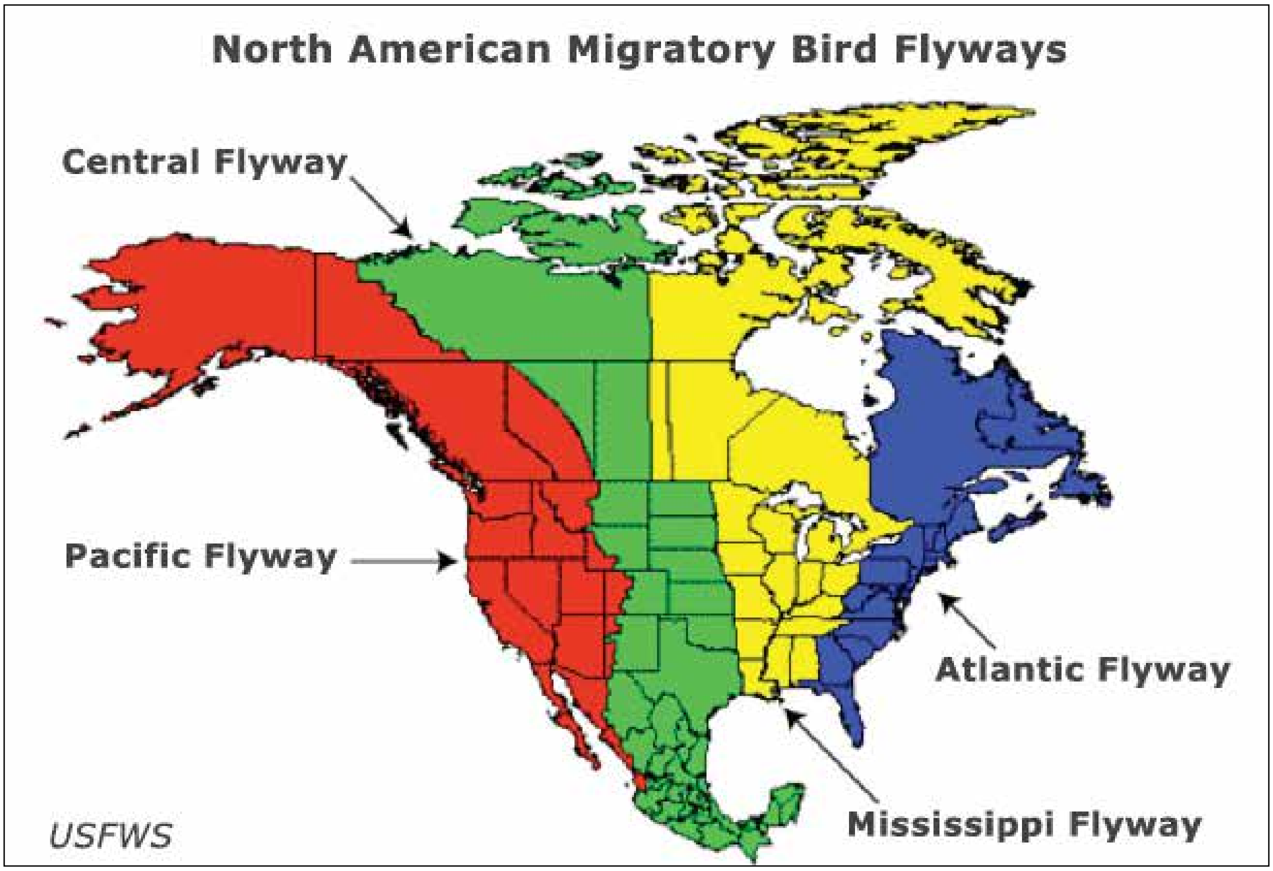
Step 9

Use the laptop/device at this station to watch this video from *Scientific American:* scientificamerican.com/video/migratory-birds-may-use-magnetic-gps. As you watch, think about how it connects to your observations.

Step 10

If you haven't already, go back and record your observations, evidence and reasoning on your Claim-Evidence-Reasoning sheet!

BIRD FLYWAYS MAP STUDENT CAPTURE SHEET



Credit: U.S. Fish and Wildlife Service