Science, Magnets & You

Creating a smarter "U" through science.

Teacher Guidebook

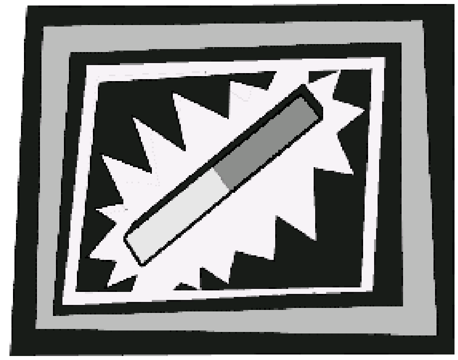
National High Magnetic Field Laboratory
Center for Integrating Research & Learning

Contents

Creating a smarter "U" through science.

Activity 1

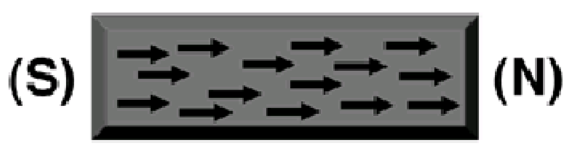
WHAT IS A MAGNET?



Most people understand magnets at the level of observable phenomena. That is, they are aware that magnets are attractred to certain metals and that they are attracted to one another; or that they repel one another depending on the orientation of the poles or ends of the magnets. This activity is designed to go one step beyond these observations by helping your students articulate why these things occur as well as to formulate new questions and answers about magnets.

Working in learning groups encourages students to communicate what they are thinking to others. Students should be in groups of 2-4 students. This activity encourages students to explain their ideas to another person, to combine their ideas with other students to design an experiment and models the way that scientists communicate their results to others. This activity is a good place to start, but these learning strategies can be used at any time in combination with other activities in *Science, Magnets and You*. It may be repeated as students become more sophisticated in their thinking about magnets and magnetic fields.

BACKGROUND INFORMATION



Materials exhibit certain characteristics because of the way in which the atoms that make up the material are aligned. In order for a material to be magnetic there must be moving electrons. Materials with magnetic qualities have domains each of which are made of billions of atoms. The way in which these domains are configured determines the magnetic ability of the material. For instance, if the domains are mostly aligned (the atoms are all pointing in the same direction), the material will exhibit strong magnetic characteristics.

Each magnet has a north and a south pole end, the regions on the magnet where the force caused by the magnet is the greatest. Like poles repel and opposite poles attract. Scientists have attempted to isolate one of the poles but have been unsuccessful. If a magnet is cut in half, both pieces of this magnet will now have a north and a south pole. No matter how small, each piece will still have a north and south pole. The smallest magnet is the electron orbiting the nucleus of an atom.

Magnets have different strengths that are dependent on several factors: the material from which the magnet is made, how the magnet is made, and how the magnet is treated. Some materials like lodestone (which contains iron) are found naturally in the earth and have magnetic properties because when formed, all of the tiny “magnets” (atoms) lined up (north poles facing in the same direction).

WHAT WILL STUDENTS DO?

1. Students can prepare a K-W-L chart. This chart enables students to identify things they know about a topic (K), record what they want to know (W) and, finally, what they have learned (L) all in one place. It is an excellent tool to help students direct their learning. After students have completed their K-W-L chart, then they can proceed with step 2 in the activity.

2. Set up groups of 2-4 students. Each group should have their Science Notebooks and their K-W-L charts available.

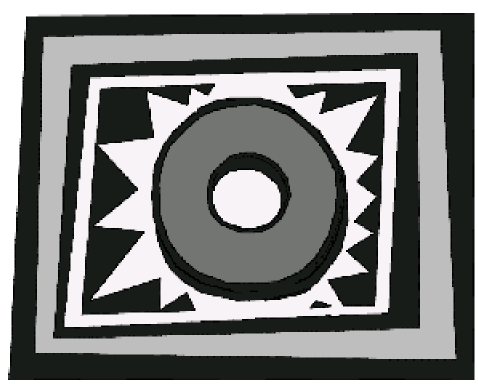
3. Individually students draw what they think a magnet looks like and share their drawings with others in the group, discussing similarities and differences, and proposing possible reasons for these differences.

4. From the discussion in Step 3, individuals in the groups will add to their K-W-L charts what they know about magnets or what they have learned from discussing the topic with their group members. Lists expand to include what students would like to find out. [For example, students will state that they know that magnets stick to the refrigerator because that is how the shopping list is kept at home or the answers could be as sophisticated as knowing that magnetic characteristics of videotapes are what enables us to watch and listen to rented movies.]

5. Groups should attempt an explanation of why the similarities and differences in the drawings exist, then share it with another group. Any refinement of the explanation for these similarities and differences should be done here. This explanation plus information from the lists created in Step 4 will become the group's theory about magnetism and include the information that they would like to test. This should be shared with other groups or representatives of other groups. During this process students will be writing in their Science Notebooks, modeling what scientists do when they work in laboratories.

6. Using books, encyclopedias, and the internet, students should research how early scientists first discovered about magnets and magnetism. Students create a useful research tool if they record in their Science Notebooks the names of the sources that provide them with the most information.

7. Have groups brainstorm ways to investigate some of the properties of magnets. Then produce a plan of action that would explain to other students and the teacher what they would like to investigate and the materials they will need to conduct their experiment. This plan will be used to complete Activity 2: What Objects Do Magnets Attract? You will want to approve the plan before students are allowed to move on.



FOR YOUR PLANBOOK:

Materials:
Drawing paper, crayons, and Science Notebooks

National Science Education Content Standards: A, B, G

Florida Sunshine State Standards:

Science
Grades K-2
SC.C.2.1.1, SC.H.1.1.1 - SC.H.1.1.5

Grades 3-5
SC.C.2.2.1, SC.H.1.2.1 - SC.H.1.2.4

Language Arts
Grades K-2
L.A.2.1.5, LA.C.3.1.2

Grades 3-5
LA.A.2.2.5, LA.A.2.2.8, LA.C.3.2.3

Assessment:

Check student Science Notebooks for entries, neatness, and attention to detail. The Science Notebook should reflect an attempt to answer the question, "What is a magnet?" and will include drawings, lists, and working notes.

Have students write an explanation of magnets and magnetism in their Science Notebook in response to Step 6 of the activity. Since this is the first step of a process leading to an explanation that includes information about the properties of magnets and strength and properties of magnetic fields, any explanation is acceptable. Further refinement can be done later.

Each group will have created a plan of action for Activity 2, "What Objects Do Magnets Attract?" This plan of action should be approved by the teacher and will include: (1) the group's hypothesis (2) how the group will test the hypothesis (3) what materials they will need; and (4) how the group will present their plan and findings to the class.

Have students provide evidence that they have used different resources to research early scientists who first investigated magnets and magnetism. The information that is collected will be used later on in a research report. Evidence should be in a form that can be shared with the group.

EXTENSIONS:

Reading and Writing:

Assign or read aloud *A Sound of Thunder* by Ray Bradbury. You may want to direct students' reading to the portion about the floating walkway to help them make the connection to Maglev train technology which uses magnetic properties to propel a vehicle. One question they could address is: Would magnets/magnetic fields have already changed the environment? This could lead to a discussion on whether or not it is theoretically possible to travel back in time without affecting the future. Being able to identify science facts in fiction is a way for the students to apply newfound knowledge about magnets and magnetism. In addressing the issue of the floating walkway, students should make the connection between the "floating" and like poles repelling each other. Have students write a review of *A Sound of Thunder* that answers the question: How does the author incorporate the concept of magnetism in this story? Did knowing about magnetism enhance your enjoyment or understanding of the story?

Write a fiction story about a sports team that is affected by an invention that magnetizes some aspect of their game. (For instance, a magnetized basketball hoop and basketball.) Students will be applying their knowledge of attraction and repulsion outside the context of the science classroom.

Create a science fiction story/movie/play about using a giant magnet to change the course of a meteorite heading toward your hometown. Students will need to answer the following questions. Is this really possible? How would you generate a strong enough magnetic field? In analyzing these issues, students will apply knowledge of magnetism in a different context.

Geography/History:

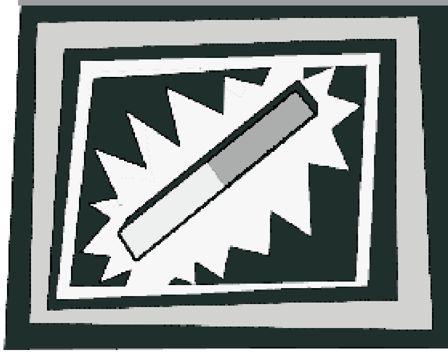
Design an experiment using foreign coins that would enhance your knowledge of Europe, Asia, Africa, or Australia. Using magnetic properties to determine the material(s) used to produce the coins reveals information about possible natural resources and abundance of certain metals.

Art:

Submit a proposal for creating "magnetic art" for your classroom or school that will educate other students about the properties of magnetism. The proposal requires students to describe magnetism, explain how it relates to making art, and apply their knowledge to a product that serves a practical purpose. Encourage students to follow through on the plan.

Research:

Write a research report or create a poster, media presentation, or web page to be presented to the class on one of the early scientists investigating magnetism. Presentations will exhibit students' application of basic principles of magnetism and their understanding that science is affected by history.



WHAT IS A MAGNET?

This activity is a chance for you to think and to share with others in a group what you know about magnets and magnetism. Scientists talk about what they know, and share ideas to solve problems. In this activity you will be talking to one another and sharing what you have experienced to answer the question, "What is a magnet?" The Plan of Action that you create at the end of this activity will be used in Activity 2 to investigate which objects are attracted by a magnet.

Materials:

- ❑ Drawing paper
- ❑ Crayons
- ❑ Science Notebook

1. Prepare a K-W-L chart in your Science Notebook. In this chart you will record what you know about magnets in the (K) column, what you want to know in the (W) column, and what you have learned in the (L) column.

2. In your Science Notebook, draw your idea of a magnet. You may include what it looks like, what it does, etc. This will be shared with the whole group when you are finished. List the similarities and differences you discovered in your Science Notebook.

3. Make a list of what the group knows about magnets and magnetism and include it in your Science Notebook. Once you have finished the list, compare it to another group's list. Notice how they are alike and how they are different. If there are things on the other group's list that you would like to include on yours, add them now.

4. In your group come up with a question about magnets and magnetism that you would like to test. If you can't think of anything, use the W column in each of your KWL charts as a list of possible things to test. This will be your *Plan of Action*.

Activity 1: What is a Magnet?

In your Science Notebook, write down the following things (these four steps will be your *Plan of Action*). Make sure your teacher has approved your *Plan of Action*.

1. What is the question that you want to study?

2. What materials will you need to do your test?

3. How are you going to do the test?

4. How will you present your results to the class?

Hans Christian Oersted
1777-1851

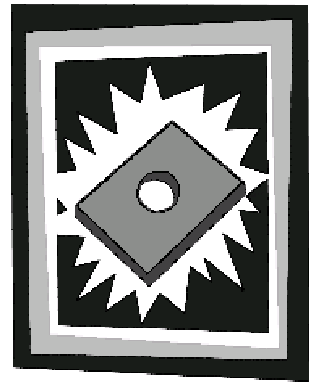
Going further:
How did early investigators test their ideas about magnetism? Use books, web sites, and other print resources to find out about scientists who first noticed magnetism. The following is a list of some scientists you might want to learn more about:

Luigi Galvani
William Gilbert
Hans Christian Oersted
Giovanni Aldini
Michael Faraday

Prepare your information in a form that will allow you to share it with the rest of the class. You may want to share your information in the form of a poster, a video, a skit, or a demonstration of an experiment that one of these scientists did.

Activity 2

WHAT OBJECTS DO MAGNETS ATTRACT?

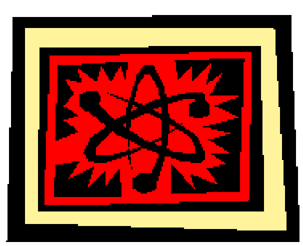


As an extension of "What Is A Magnet?" or standing alone, this activity is intended to allow students to explore magnetic qualities of various materials. Maintaining groups provides continuity and a forum through which students can test ideas. Articulating theories about magnetism before testing them can save time and will help students make sense of what they are trying to accomplish.

Creating a data table and then using this data to answer a question or solve a problem is a skill that is used frequently in the science classroom. Keeping the data table in a Science Notebook enables the student to use this data again and again if necessary. It becomes a valuable resource for many of the activities in the *Science, Magnets and You*. Whether the students have come up with their own action plan or whether you provide the parameters within which they will work, a data table is recommended. Students will then be asked to classify the data and use the information in a writing assignment.

Students might choose other ways to present data based upon personal learning styles. It is important to the understanding of complex concepts such as magnetism that the information collected makes sense to the students. Creative ways to demonstrate mastery could be through the use of graphic organizers, concept maps, lists, graphs, or computer-generated representations of the data.

BACKGROUND INFORMATION



All matter is made of atoms. Atoms can be broken down into three smaller particles: protons, neutrons, and electrons. It is one of these smaller particles, the electron, that is very important to magnetism, since only it is able to move around in magnetic materials. The movement of protons is so slight that they are of little consequence to the discussion of magnetism. In most materials, electrons occur in pairs that spin in opposite directions. However, some materials have unpaired electrons. Unpaired electrons can move freely through some metals, and they arrange themselves so that they spin in the same direction, causing the metals to become attracted to a magnet. The alignment can occur in natural or manmade materials. (See also Background Information in Activity 1: What Is A Magnet?)

WHAT WILL STUDENTS DO?

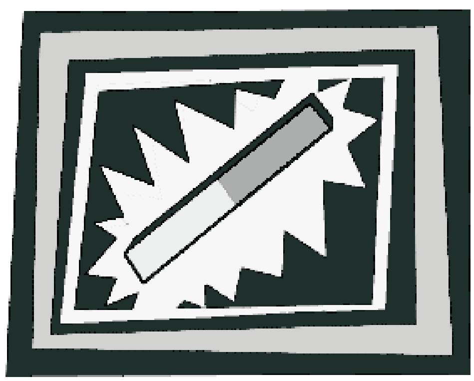
1. Groups of 2-4 students discuss the task, which is to answer the question, "What objects in and around this room are attracted to a magnet?" Instruct the groups that they will be responsible for recording observations, confirming the data they collect and then presenting it to the class.

2. If the groups have completed Activity 1: "What Is A Magnet?" they will use the plan already designed and approved by you to test their theory or theories about magnetism.

3. Have students bring from home or search their pockets and the classroom for at least 15 items they would like to test. Students will predict which of these items will be attracted to a magnet and record their results on a data table, or other method of data collection that has been approved by the teacher.

4. When all information has been collected, groups will design a method of presenting the results to the whole class.

5. Groups should be encouraged to use technology other than paper and pencil to present their findings (for example, a computer, overhead projector, and instant photographs). At this point, students could role-play, write song lyrics, or design other ways of presenting their findings.



FOR YOUR PLANBOOK:

Materials:

- ❑ Magnets
- ❑ Classroom objects
- ❑ Student instructions
- ❑ Science Notebooks
- ❑ A variety of objects such as paper clips, aluminum foil, wooden dowels, metal rods, coins glass, etc., for those students who are unable to bring them to class.

National Science Education Content Standards: A, B, G

Florida Sunshine State Standards:

<u>Science</u>
Grades K-2
SC.C.2.1.1, SC.H.1.1.1 - SC.H.1.1.5, SC.H.3.1.1

Grades 3-5
SC.C.2.2.1, SC.C.2.2.2, SC.H.1.2.1 - SC.H.1.2.5, SC.H.3.2.2

<u>Language Arts</u>
Grades K-2
LA.A.2.1.3, LA.A.2.1.5, LA.B.2.1.1, LA.B.2.1.4, LA.C.1.1.1, LAC.1.1.3

Grades 3-5
LA.A.2.2.5, LA.A2.2.8, LA.B.1.2.1, LA.B.2.2.3, LA.C.1.2.1, LA.C.1.2.3

Homework:
Create three interview questions to probe someone's understanding about magnets and magnetism. Some sample questions might be: What is a magnet? Why are some materials magnetic while others are not? Where would you find magnetic fields? Are there magnetic fields in nature? Conduct at least two interviews with adults (high school age or above) to share with your group.

Homework Assessment:
Use homework interview questions to discuss misconceptions about magnets/magnetism; general public's knowledge of the subject; what the implications are; what information is lacking; etc. Classroom discussions could be tape recorded and replayed for further clarification after more magnetism activities are completed. In this way students can correct any misconceptions that they might have had at the start of the series of activities.

Assessment:

Data collection record includes a table that is easily readable without detailed instructions indicating that students investigated 15 objects after predicting whether or not they will be attracted to a magnet. Tables should indicate that no nonmetals were attracted to a magnet and only some metals (not all) were attracted to a magnet.

Presentation to the class should be creative, well thought out, use technology other than paper/pencil, include a conclusion as to which materials are attracted to the magnet and why, and should indicate participation by all group members.

Science Notebooks include preparation of the data table as well as interpretation of results and the one paragraph assignment to list characteristics of magnets and draw conclusions from the investigation. There should be some indication that students have improved in their ability to predict which objects are not attracted to a magnet.

Computer-generated table or graph saved on disk becomes a part of the general Science Notebook demonstrating use of technology.

Written product (a list or paragraphs) that demonstrates how groups have classified objects that are attracted to a magnet requires that the groups have found a way to organize and articulate their assumptions.

EXTENSIONS:

Magnets and Inventions:

Create an invention that uses magnetism. Describe the purpose of the invention, who would be most likely to use it, how it works, and the purpose of using magnetism as part of the invention.

Design a trash separator that uses magnetism to help a recycling depository be more efficient. A video on trash separation could be included in this extension. This can be taken as far as is practical for the class. Discussion, debate, research, or activities on recycling and other environmental concerns would be appropriate at this point.

Art and Magnetism:

Use the results from the interview questions homework to create posters to be displayed around the school. Students need to make sure that there is included in this display a way to educate others as to what magnetism is and how it is used in everyday life.

Students can use their wand magnets and magnetic marbles to produce a painting. Use the wand magnets, tempera paint, white paper, and the magnetic marbles to produce artwork. Students place their wand magnet beneath the desk where white paper is placed. Have students place a couple of dots of tempera paint on the white paper. Place a magnetic marble in the center of the drop of paint and using the wand magnet below the desk, move the marble around producing designs. This can be repeated several times with paints of different colors. An alternative to placing the wand magnet beneath the desk would be to take a cardboard box, cut the front edge off of it so that the student's hand can hold the wand magnet beneath the cardboard box. Attach the paper with masking tape to the top of the cardboard box, and continue with the procedures as stated above.

Research and Writing:

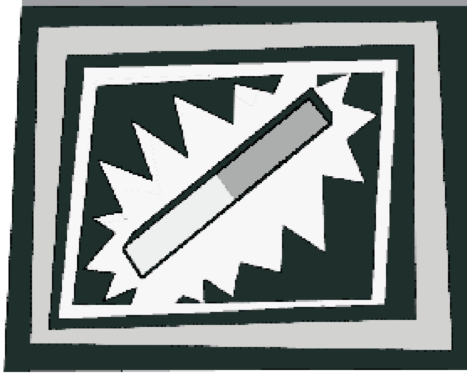
Research the origin of the word "magnet" using books, web sites, or other print media. Students will attempt to answer in writing, "What's in a name? Does it matter what we call it?" This might lead to discussion of other word origins; for instance in Earth Science, the layer between the crust and the mantle known as the Moho; the names of the different temperature scales; in Life Science, Latin names of animals and plants; in chemistry, the naming of elements.

Reading and Writing:

Read aloud *The Secret Life of Dilly McBean* about a boy with magnetic hands. The class could discuss how the novel relates to what they are studying in class. There could be written summaries, drawings, or role-playing activities when the book is finished. This is an excellent way to introduce the connection between literature and science, especially discussing that the story itself is enhanced by the knowledge of scientific concepts and facts.

Investigate various young adult authors. Students will find it surprising that many of these highly successful authors did not set out to write books and, in fact, may have begun their adult careers in science. For instance, Elaine Konigsberg was a science major at Carnegie Mellon before writing *The Mixed Up Files of Mrs. Basil E. Frankweiler* and has won the Newbery Award for her latest book about a middle school brain bowl team.

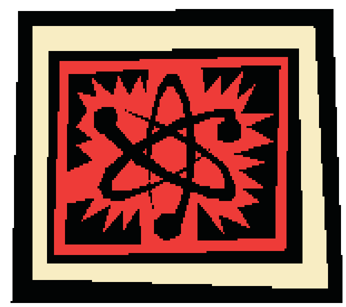
Notes:



WHAT OBJECTS DO MAGNETS ATTRACT?

All matter is made of atoms. Atoms can be broken down into three smaller particles: protons, neutrons, and electrons. It is one of these smaller particles, the electron, that is very important to magnetism. Magnetism is a force that can attract or repel objects. This attraction or repulsion is caused by the arrangement of electrons in a material. An object is said to have magnetic properties if a magnet affects it.

In most materials, electrons occur in pairs that spin in opposite directions. However, some materials have unpaired electrons. Unpaired electrons can move freely through some metals, and they arrange themselves so that they spin in the same direction, causing the metals to become attracted to a magnet.



Use the plan that you developed in Activity 1: What is a Magnet? or one suggested by your teacher to test objects and record information. You will be investigating objects in and around your classroom. This activity will help you answer the question, "What objects are attracted to a magnet?" Not only will you answer it, but also you will present your answer to the class so that you can check your results against those of the rest of the students. You will be modeling what scientists do in real-world situations. As they work, scientists post their data, or e-mail other scientists to get feedback before they go further.

Materials:

- ❑ Magnets
- ❑ Science Notebook
- ❑ 15 Different objects either from your pockets or around the classroom

Activity 2: What Objects Do Magnets Attract?

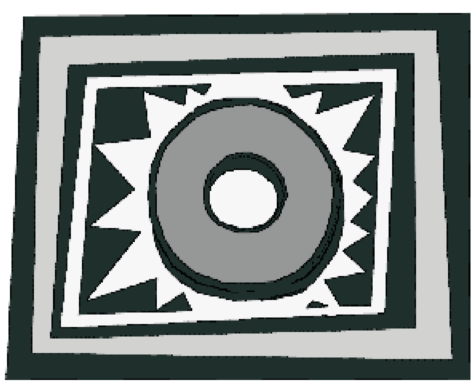
1. Investigate at least 15 different objects to see whether or not your magnet attracts these objects. (You may get these items from your pocket or from some things that your teacher provides for you).

2. Design a data table that contains three columns. One column will be where you write the name of the object you are testing. In the second column write down a prediction as to whether the material will be attracted to a magnet. In the third column record your actual results.

3. Once you have finished investigating your samples, look at the data table in your Science Notebook and notice those objects that were attracted to a magnet and those that were not. Share your results with another group. Recheck those items where there is disagreement. It is common for scientists to perform experiments more than one time, and to discuss their findings with each other.

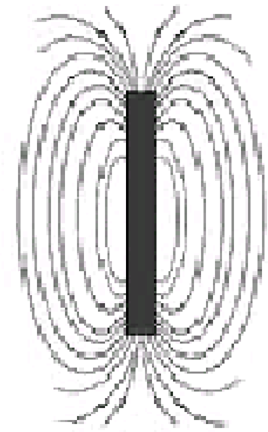
4. With others in your group, look at items that were attracted to a magnet, and make a list of how they are alike. For example, were all of them shiny? If they were, it is a characteristic. Write two to three sentences in your Science Notebook that explains some of the common characteristics of magnetic materials.

5. With the whole group, create a brief presentation of your results. Have your teacher approve your plan before you present to the whole class.



Activity 3a

EXPLORING MAGNETIC FIELDS



There are three activities directly related to magnetic fields. In Activity 3a, students make a magnetic field viewer and use this instrument to observe the field lines produced by four different types of magnets. In Activity 3b, students look at magnetic field lines by observing the effect that they have on compasses. In Activity 3c, students use permanent bar magnets and a compass to draw magnetic field lines.

The observations and drawings that the students produce, as well as the questions they will be asked to address, are designed to be exploratory and to help students formulate and clarify their ideas about magnetic fields. Conceptualizing magnetic fields not only as "real," but also as forces that can be manipulated, prepares students for dealing with the idea of magnetic fields so large that they cannot be seen.

Before students complete this activity, it would be interesting to have them go back to their first exploration about magnetism and review what they wrote in their Science Notebooks. This would be a good time for reflective writing in their Science Notebooks. How have their ideas about magnetism changed? How would they draw a magnet now? Would the drawing be different or would it be the same?

BACKGROUND INFORMATION

Some discussion of magnetic field lines is appropriate at this point. The magnet generates a magnetic field that extends to the area around the magnet. The magnetic field is visible by using iron filings to illustrate the shape of the field, the field lines, and that the fields are strongest near the poles. The field lines spread out from the North pole and circle back around to the South pole.

Magnets can be shielded so that magnetic fields go around the object blocking the field. Magnetic fields can also pass through materials. This phenomenon can easily be demonstrated by placing two magnets on either side of a piece of paper or a student's hand. A magnet can also be placed on the underside of the desk and a paper clip or other magnet can be placed on top of the desk. The degree to which this is observable depends upon the strength of the magnet, the material between an object and the magnet, or the distance between the magnet and the object. This will be observed in Activity 4: Comparing the Strength of Magnets.

The unit of measure of a magnetic field is gauss or tesla. A refrigerator magnet typically equals .025 tesla; the Earth's magnetic field, 3×10^{-5} tesla. The nucleus of a hydrogen atom equals 14 tesla. Ten thousand gauss equals 1 tesla, which is 33,333 times as strong as the Earth's magnetic field.

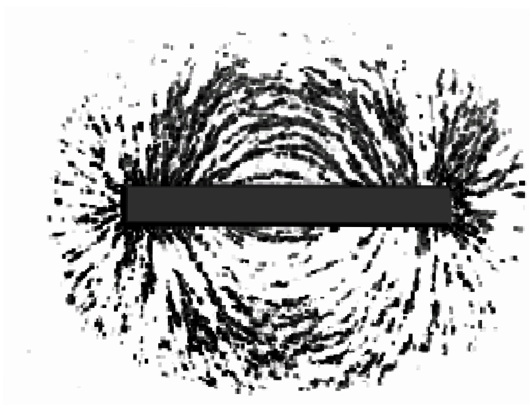
WHAT WILL STUDENTS DO?

Students will place four different type magnets on the magnetic field viewer to determine if the shape of the magnet has any relationship to the pattern of the magnetic field.

We have come a long way from the conception of a horseshoe shaped magnet (which was probably what most of the students drew in "What Is A Magnet?"). Your students have discovered that magnets take many shapes and sizes; what they have yet to discover is how these shapes affect the magnetic fields.

Throughout this activity there are a number of questions that students will address in their Science Notebooks. Encourage students to support their answers with diagrams. Questions which may be considered during this activity include:

1. Which magnets created the strongest magnetic field?
2. How do you know it was the strongest?
3. Which magnets created the weakest magnetic field?



MAKING THE MAGNETIC FIELD VIEWERS

You can make magnetic field viewers in advance or allow your students to make them depending on their abilities. Giving your students the opportunity to make the viewers will reinforce their skills in measurement, cooperative learning, and following instructions.

Materials:

- ❑ 15g (1 teaspoon) of iron filings
- ❑ 1 plastic box
- ❑ 1 plastic sheet to place on top of the box
- ❑ Clear tape

1. Measure the iron filings. It is important to measure because too many iron filings prevent you from seeing the magnetic fields as well.
2. Pour the iron filings into the plastic box.
3. Place the plastic sheet on top of the box and tape the edges to seal the magnetic field viewer.

FOR YOUR PLANBOOK:

Materials:
- ❑ Magnetic field viewers
- ❑ Wand magnets
- ❑ Bar magnets
- ❑ Round magnets
- ❑ Square magnets
- ❑ Masking tape
- ❑ Science Notebook

National Science Education Content Standards: A, D, E, F, G

Florida Sunshine State Standards Benchmarks:

Science
Grades K-2
SC.A.1.1.1, SC.H.1.1.1 - SC.H.1.1.5, SC.H.3.1.1

Grades 3-5
SC.A.1.2.1, SC.C.2.2.3, SC.H.1.2.1 - SC.H.1.2.5, SC.H.3.2.2, SC.H.3.2.4

Language Arts
Grades K-2
LA.A.1.1.4, LA.A.2.1.3, LA.A.2.1.5, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

Grades 3-5
LA.A.1.2.4, LA.A.2.2.5, LA.A.2.2.8, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.3, LA.C.1.2.3, LA.C.1.2.5, LA.C.3.2.2, LA.C.3.2.3

Mathematics
Grades K-2
MA.A.1.1.2, MA.A.4.1.1, MA.B.1.1.1, MA.B.1.1.2, MA.B.2.1.1, MA.B.3.1.1, MA.B.4.1.2, MA.E.1.1.1, MA.E.2.1.2

Grades 3-5
MA.A.1.2.3, MA.A.4.2.1, MA.B.1.2.1, MA.B.1.2.2, MA.B.2.2.1, MA.B.3.2.1, MA.B.4.2.1, MA.B.4.2.2, MA.E.1.2.1, MA.E.1.2.3, MA.E.2.2.2

Homework:

Have students design their own homework assignment relative to magnetism:

- Students may produce a wordsearch or crossword puzzle using vocabulary words.
- Students produce art based on the patterns of magnetic fields or a collage of things in nature and things human-made that are affected by magnetism.
- Students write a research paper on a scientist or a scientific discovery.
- Students could also be encouraged to write a creative story with magnetism as a theme.

Homework Assessment:

Integrating magnetism and another theme result positive evaluation. For example, if students definitions in a crossword that indicate they not onl know what the word means but know how the word is commonly used, that would demonstrate successful mastery of the words. A research paper on a scientist or scientific discovery that includes a piece on how far science has come since that discovery or because of that discovery demonstrates that the student understands how scientific work leads to more questions and m experimentation.

Assessment:

Check Science Notebooks for answers to activity questions. Answers should reflect that the shape of a magnet determines the pattern of field lines. Students at this point will predict the shape of the field based on the shape of the magnet to successfully complete the assignment.

Drawings should mirror written answers to in-text questions. To successfully complete this assignment, students will demonstrate their knowledge of the names of types of magnets by labeling the drawing; show that they know that a bar magnet, for example, creates a certain pattern every time; and distinguish between each type of magnet.

Student paragraphs will summarize the activity and must include some information about field lines, their length and density, and that the magnetic field exists within the field lines and on the lines themselves.

In sharing paragraphs, students demonstrate to you that they can articulate an explanation of magnetic fields and magnetic field lines. This particular manner of assessment requires no grading. If you wish to assign a grade, it would be appropriate to look at the paragraphs as clarification of each student's theory. For example, "If a magnet is round, then the shape of the magnetic field will. . ." or "Bar magnets will always cause iron filings to appear in the shape of . . ."

EXTENSIONS

Reading and Writing:

If you have chosen to read *The Secret Life of Dilly McBean* as recommended in "What Objects Do Magnets Attract?" students could draw what they think the magnetic field lines would look like emanating from Dilly's hands. Successful completion of this assignment will further extend students' thinking on the shape of magnetic fields being related to the shape of the magnet. The north and south poles would have to be indicated on the drawing as the basis for the field lines.

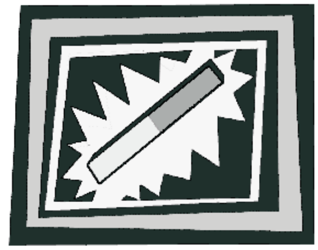
Using reflective writing activities to guide students' conceptualization of the "big ideas" can help both the teacher and the student. From a teacher's standpoint reading students' journals, Science Notebooks or reactions to statements helps identify misconceptions that students continue to hold even after activities are completed. Conversely, it is a tool a teacher can use to evaluate where the students are in relation to the teacher's expectations as well as to each other. Weekly reflections that clarify what the group accomplished identify what was important to the individual and state questions yet to be answered could be looked at on a weekly or biweekly basis. Or, depending upon the level of the class, it might never be looked at. A truly reflective piece of writing is of use only to the person writing it.

Research:

Using the Center for Integrating Research and Learning (http://k12.magnet.fsu.edu) homepage at the National High Magnetic Field Laboratory in Tallahassee, students could begin research on what high magnetic fields are and how they are used in research. How much further you wishe to go with this information depends upon the level of sophistication of the group as well as the time available to devote to this subject. Some practical applications of high magnetic fields will be dealt with in later activities, but it would be beneficial to begin a dialogue about what high magnetic fields are used for at this point.

Research the work of Pieter Zeeman as it relates to the study of astronomy. His work solidified the relationship between light, magnetism and the existence of magnetic fields in space. The discoveries that have been made since Zeeman's initial work in 1896 can be related to the Big Bang Theory, stars, galaxies, and planets. This assignment provides yet another link between magnetism and other scientific disciplines.

Bottle Magnetic Field Viewers:
Alternative field viewers can be made with small bottles. Small clear containers or other jars will do. Add mineral oil to the bottles to within 2.5 cm of the top of the container. Sprinkle 7 grams (approximately 1/2 teaspoon) of iron filings into the oil. Cap tightly, or glue the top to the container. Students can use wand magnets, one placed on either side of the jar, to see the iron filings line up along the magnetic field between the two magnets.

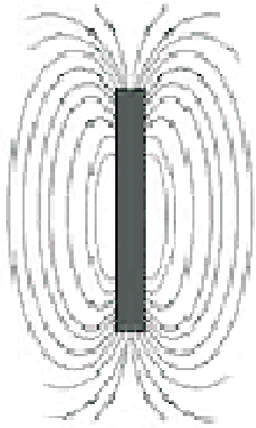


COMPARING MAGNETIC STRENGTHS OF MAGNETS USING BOTTLE MAGNETIC FIELD VIEWERS

Bottle magnetic field viewers can be used to compare the strength of the magnetic fields of different types of magnets found in the *Science, Magnets & You* package.

Materials:
- ❑ 1 bottle magnetic field viewer
- ❑ 2 wand magnets
- ❑ 2 bar magnets
- ❑ 2 ring magnets
- ❑ 2 square magnets

1. The bottle viewer should be shaken well so that the iron particles are moving and can be attracted to when magnets are placed on either side of the bottle.
2. Students stand the bottle magnetic field viewer on a piece of paper. The position of the bottle on the paper should be marked so that if it moves during the activity, students can return it to its original position.
3. Once the bottle is placed on the paper and marked, students place wand magnets on opposite sides of the bottle viewer. Students will be able to see the iron filings either line up along the magnetic field between the magnets, or see the filings remain suspended in the center of the viewer. Encourage students to “create” a magnetic field.
4. The students then gradually move the wand magnets away and make a mark on the paper when the iron filings are no longer attracted to the magnets.
5. Students measure the distance between the two magnets and record that distance in centimeters. Students repeat the experiment using 2 bar magnets, 2 ring magnets and 2 square magnets. Record all trials in a data table. The distances measured can be considered as comparative measures of magnetic strength.
6. Students record results in their Science Notebooks and compare the average strength of each type of magnet with at least 2 other students.



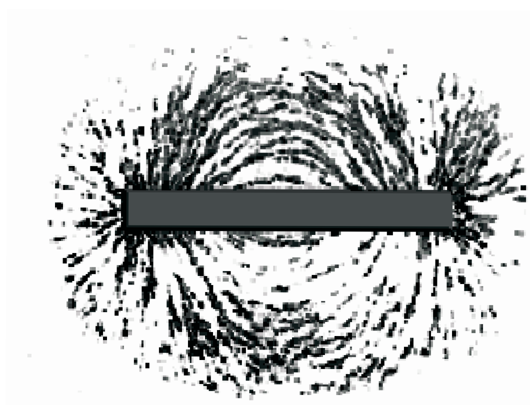
EXPLORING MAGNETIC FIELDS

A magnet produces a magnetic field which can be found around the magnet. The magnetic field can be seen if you use iron filings to see the shape of the field, the field lines, and the fact that different regions on the magnet may have different strengths. Field lines spread out from the North pole and circle back around to the South pole. Using your magnetic field viewer and differently shaped magnets, you will be observing these things.

Magnetic fields can be shielded so those magnetic fields go around the object blocking the field. Magnetic fields can also pass through materials, which can be easily demonstrated by placing two magnets on either side of a piece of paper or your hand. You can also see that magnetic fields can pass through materials by placing a magnet on the underside of the desk and a paper clip or other magnet on the top.

Materials:

- ❑ Magnetic field viewer
- ❑ Wand magnet
- ❑ Bar magnet
- ❑ Square magnet
- ❑ Round magnet
- ❑ Drawing paper
- ❑ Science Notebook
- ❑ Ruler



Activity 3a: Exploring Magnetic Fields

1. Place the magnetic field viewer over your bar magnet so that the magnet is in the middle. Tap the viewer until you get a clear view of the magnetic field.

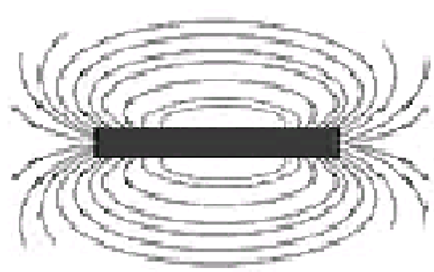
2. Draw and label what you see and answer the following questions in your Science Notebook:

   - ❑ How far does the field extend out from the magnet?
   - ❑ How far apart are the field lines?
   - ❑ Are they the same distance apart everywhere in the field?
   - ❑ If not, where are they closer together?
   - ❑ Do the field lines run in the same direction? If not, what pattern do they form?
   - ❑ Are all the field lines the same length?

3. Repeat Step 2 for each of the remaining three magnets, make drawings and answer the same questions found in step 2 in your Science Notebook.

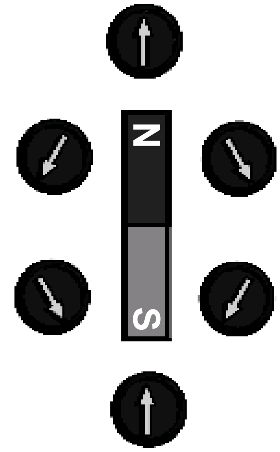
4. When you have finished this activity, write several paragraphs telling what you have learned. Make sure to include information about the distance between field lines.

5. Share your paragraph with another student. If your drawings and answers to questions are different from one another, re-test the magnets.



Activity 3b

VISUALIZING MAGNETIC FIELD LINES



Students will be looking at magnetic field lines in this activity by observing the relationship between field lines and compasses. The other activities that deal with this subject are Activity 3a: Exploring Magnetic Fields and Activity 3c: Drawing Magnetic Field Lines.

This is another activity designed to help students visualize a magnetic field. It could be used before Activity 8: Making a Map Using a Compass but can stand alone and be used at any time. This is the type of activity that can be revisited from time to time, and extensions from any of these three activities would be appropriate.

BACKGROUND INFORMATION

A magnet generates a magnetic field, which extends to the area around the magnet. The magnetic field is visible by using iron filings to illustrate the shape of the field, the field lines, and the fact that the fields are strongest near the poles.

Continuous lines of force that emerge from north-seeking magnetic poles and enter south-seeking magnetic poles may represent magnetic fields. The density of the lines indicates the magnitude of the magnetic field. At the poles of a magnet, for example, where the magnetic field is strong, the field lines are crowded together, or are more dense. Farther away, where the magnetic field is weak; they fan out, becoming less dense. Equally spaced parallel straight lines represent a uniform magnetic field. The direction of the field lines is the direction in which the north-seeking pole of a small magnet points. The field lines are continuous, forming closed loops. For a bar magnet, they emerge from the north-seeking pole, fan out and around, enter the magnet at the south-seeking pole, and continue through the magnet to the north pole, where they again emerge.

Magnetic fields can be shielded so that they go around the object blocking the field. Magnetic fields can also pass through materials; this can be easily demonstrated by placing two magnets on either side of a piece of paper or a student’s hand. It may also be demonstrated by placing a magnet on the underside of a desk and a paper clip or another magnet on top of the desk. The degree to which this is observable depends upon the strength of the magnet, the material between an object and the magnet, or the distance between the magnet and the object. This will be observed in Activity 4: Comparing the Strength of Magnets.

WHAT WILL STUDENTS DO?

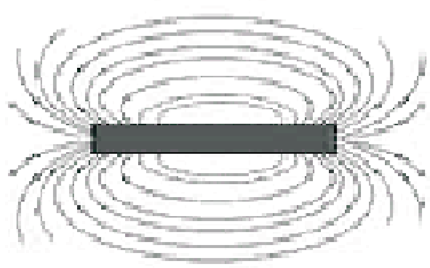
1. Have students predict in their Science Notebooks how they think compasses will respond to the magnetic field produced by a bar magnet.

2. Students will place a bar magnet on the desk with the north pole pointing away from them. They will place 6 compasses randomly around the magnet.

3. Placing the magnetic field viewer (prepared in Activity 3a) on top of the magnet and compasses, students begin gently tapping the side of the magnetic field viewer to get a clear picture of the magnetic field.

4. Have students draw what they see in this activity. Compass needles will point in the direction of the nearest field line and student drawings should reflect this. Some students may have difficulty recognizing this. If, after a few trials, they still do not see the connection, it may be helpful to suggest that the students arrange all of the compasses in an arc along one side of the magnet.

5. Encourage students to move the compasses around as many times as they wish; also encourage them to use more than one magnet (2 bar magnets pushed together).



FOR YOUR PLANBOOK:

Materials:

- ❑ Compasses
- ❑ Bar magnets
- ❑ Magnetic field viewers
- ❑ Science Notebooks

National Science Education Content Standards: A, B, E, F, G

Florida Sunshine State Standards Benchmarks:

<u>Science</u>
Grades K-2
SC.C.1.1.2, SC.H.1.1.1 - SC.H.1.1.5, SC.H.3.1.1

Grades 3-5
SC.C.1.2.1, SC.C.2.2.2, SCH.1.2.1-SC.H.1.2.4, SC.H.3.2.1, SC.H.3.2.2, SC.H.3.2.4

<u>Language Arts</u>
Grades K-2
LA.A.1.1.4, LA.A.2.1.3, LA.A.2.1.5, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2, LA.D.2.1.4

Grades 3-5
LA.A.1.2.4, LA.A.2.2.8, LA.B.1.2.1, LA.B.2.2.1, LA.C.1.2.3, LA.C.3.2.2, LA.C.3.2.5, LA.C.3.3.2

Homework:
ALLOW STUDENTS ABOUT A WEEK TO COMPLETE THIS ASSIGNMENT. THIS WILL ENSURE THAT EVERYONE HAS AN OPPORTUNITY TO GET A NEWSPAPER. Students find a newspaper article that describes an instrument used to look at or understand something else. For example, a microscope, telescope, binoculars, eyeglasses, camera, contact lenses, computer, magnifying glass, watch, television, mirror, etc. Make sure students know that they will read, summarize and report on their choice of instrument.

Homework Assessment:
If students bring in an article that they have summarized, they will have met the requirements of this assignment. When presenting the summary, if students make some analogy to the magnetic field viewer, or any other model that is used to understand magnetic fields, they will have articulated the relationship that you are looking for. Students should realize at this point that technology does not always mean computers but can be anything that enhances what a person does.

Assessment:
Science Notebooks will contain answers to the questions asked this activity. Answers should reflect an understanding that magnetic fields affect a compass, and without a magnetic field, a compass would be useless. Answers to questions will explain why magnetic fields vary in intensity.

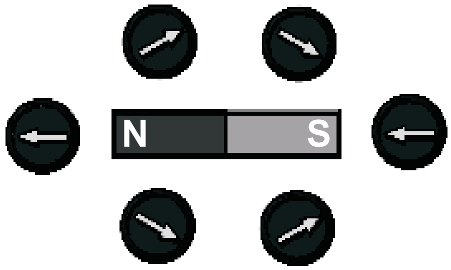
Drawings should indicate that compass needles line up along magnetic field lines. An explanation with the drawing will predict that adding another magnet will change the field lines, and compasses will still line up with those lines. Combining a drawing with a verbal explanation requires that students identify the basic concepts demonstrated by the activity.

EXTENSIONS

- Conduct a class discussion about health concerns of people living near high power lines. Some people believe that the magnetic fields created by these high power electrical lines are harmful. Recent research done by the medical community indicates that this is not true. A worldwide web search or print media search could turn up many articles on this subject.

  Students could be divided into two groups of 4 members each and the rest of the students would serve as the audience at a town meeting called by concerned citizens. At the end of the debate, the audience decides whether or not to pay to evacuate citizens that live in the affected area. This activity integrates current issues regarding a real-world concern, and the knowledge that students have about magnetic fields. They will be modeling a process that is widely used by communities to discuss issues of concern. *The New York Times Book of Science Literacy* (ISBN 0-06-097455-9) has a short article on this subject.

- A search of worldwide web sites about magnetism will reveal a large number of products for sale that claim to have medical benefits. Have students research these let each group choose one and then report back to the class. Becoming educated, responsible consumers is important, especially when students realize that they control a large percentage of dollars spent on consumer goods.



VISUALIZING MAGNETIC FIELD LINES

A magnet generates a magnetic field that extends around the magnet. The magnetic field viewer that was used in Activity 3a helps us see the shape of the field, the field lines, and that the fields are strongest near the poles of the magnet. The field lines spread out from the north pole and circle back around to the south pole. In this activity you will be observing how these field lines affect a compass needle.

Materials:

- ❑ 6 compasses
- ❑ 1 bar magnet
- ❑ 1 magnetic field viewer
- ❑ Science Notebooks

BE CAREFUL NOT TO WORK TOO CLOSE TO ANOTHER GROUP'S MAGNET.

1. You and two other students will work together to do this activity.

2. You will be placing a number of compasses around a bar magnet. Before doing this, discuss with your partners what you think will happen when compasses are placed around the bar magnet. Draw a picture of this in your Science Notebooks.

3. Place the magnet on your desk with the north pole pointing away from you. Place the compasses around the magnet.

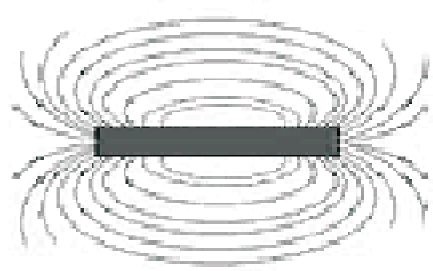
4. Put the magnetic field viewer on top of the magnet and compasses and tap the sides or top of the viewer in order to get the best view of the magnetic field lines.

5. Observe how the compasses act when placed around the magnet and record and draw what you see in your Science Notebooks.

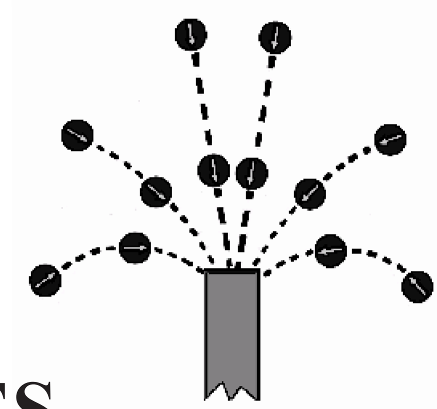
6. Remove the magnetic field viewer and rearrange the compasses. You are going to repeat steps 5-7. Make sure that you record your observations in your Science Notebook and make a new drawing.

7. Answer the following questions in your Science Notebook:

- ❑ What do you think is happening?
- ❑ Does this agree with the prediction that you and your partners made in step 2?
- ❑ Now write 2-3 sentences about how a bar magnet affects a compass.



Activity 3c



DRAWING MAGNETIC FIELD LINES

In this activity your students will be using a navigational compass and studying magnetic field lines produced by a permanent bar magnet. One of the advantages of doing this activity is that it can be used as a model of Earth's magnetic field. Some textbooks describe our magnetic field by comparing the Earth to a "big bar magnet." The connections that you make with this activity will depend upon how far you wish to go with it.

The use of a compass by students in this activity illustrates that instruments may be used in a variety of ways and not always for the purpose for which they were intended. Perhaps you can introduce this activity by brainstorming common items that we use in a variety of ways; for example, using a knife as a screwdriver.

This activity is best done individually or in pairs. The use of 3 or 4 members in a group would be too large for students to get the full benefit from drawing the magnetic field lines.

This activity is more prescriptive than some of the others in that all students must follow the same directions in order to draw the magnetic field lines. They will be answering the question, "Can I draw the lines of magnetic force by using only a compass? Will that be an accurate representation of magnetic field lines?" There may be other questions that students will answer based upon their own preconceptions of magnetic field lines.

BACKGROUND INFORMATION

The magnet generates a magnetic field that extends into the area around the magnet. Iron filings show the shape, strength, and extent of the magnetic field. The field lines spread out from the north pole and circle back around to the south pole.

Magnetic fields can be shielded so that magnetic fields go around an object blocking the field. Magnetic fields can also pass through materials which can be easily demonstrated by placing two magnets on either side of a piece of paper or a student's hand; or a magnet on the underside of the desk and a paper clip or other magnet on the top. The degree to which this is observable depends upon the strength of the magnet, the material between an object and the magnet, or the distance between the magnet and the object.

The unit of measure of a magnetic field is gauss or tesla. A refrigerator magnet typically equals .025 tesla; the Earth's magnetic field, 3×10^{-5} tesla. The nucleus of a hydrogen atom equals 14 tesla. Ten thousand gauss equals 1 tesla, which is 33,333 times as strong as the Earth's magnetic field.

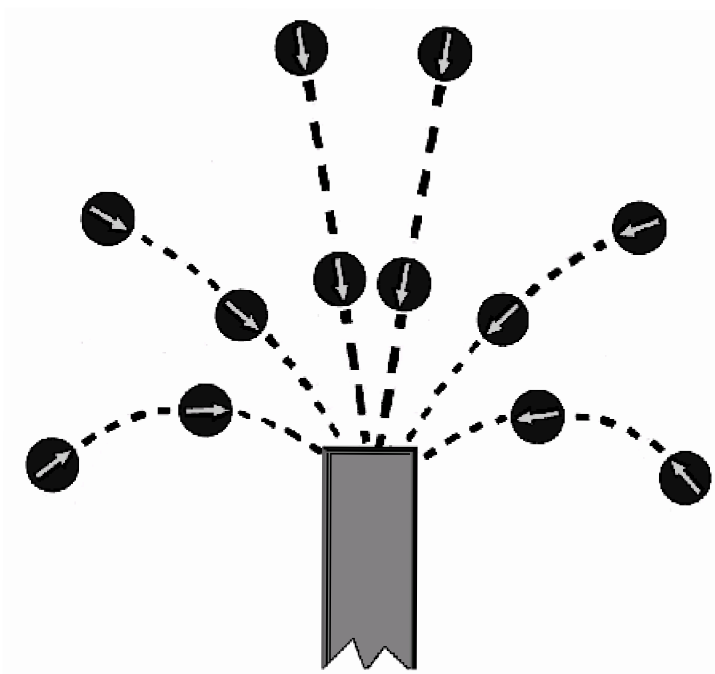
WHAT WILL STUDENTS DO?

1. Students place the bar magnet in the middle of a large piece of paper. They will be moving a compass around the magnet, so depending upon the level of your students, you may want students to tape the magnet to the paper.

2. Place the compass at one end of the magnet and make a dot at both ends of the arrow.

3. Then put the compass down again so that the point of the arrow is over the dot where the tail of the arrow was. Students will keep moving the compass in this manner until they reach the other end of the magnet, or until they lose the magnetic field.

4. By connecting the points marked on the paper students will be drawing the magnetic field lines.



FOR YOUR PLANBOOK:

Materials:

- ❑ Bar magnets
- ❑ Large drawing paper (18” x 24”)
- ❑ Compasses (enough of each for students to complete this activity individually or in pairs)

National Science Education Content Standards: A, B, D

Florida Sunshine State Standards Benchmarks:

Science
Grades K-2
SC.C.2.1.1, SC.H.1.1.1 - SC.H.1.1.3, SC.H.1.1.5

Grades 3-5
SC.C.2.2.2, SC.C.2.2.4, SC.H.1.2.1 - SC.H.1.2.4, SC.H.3.2.2

Language Arts
Grades K-2
LA.A.1.1.4, LA.A.2.1.3, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

Grades 3-5
LA.A.1.2.4, LA.A.2.2.5, LA.A.2.2.8, LA.B.1.2.1, LA.B.2.2.1, LA.C.1.2.3, LA.C.3.2.2, LA.C.3.2.5

Homework:
This assignment is intended for use after the activity has been completed. Present the following scenario: In view of what you have learned about magnetic field lines, imagine that you are a farmer and the power company in your area will be putting high voltage power lines on your property. You object because you believe that the electromagnetic fields surrounding these lines might affect the health of your livestock as well as your family. Can you visit another site of high voltage power lines and figure out how far the electromagnetic fields extend? Devise a plan that you will use to figure this out and that you could use as evidence to support your opinion.

Homework Assessment:
Student plans should include some way of measuring the field lines. If students attempt to do this using a compass, although this would be unreliable at best, it is a natural extension of the activity and should be accepted as their attempt to find a relationship between the classroom and the outside world; between real life problem solving and classroom theorizing. If students propose writing a letter of inquiry to the power company and/or calling to get already published information, this should be acceptable as well. Any attempt at measuring how far the field lines extend is a successful completion of the assignment.

Assessment:

Science Notebooks will contain a drawing of magnetic fields. By completing this diagram, students will have modeled magnetic field lines in a way that is transferable to other applications. Students will then be able to predict field lines for differently shaped magnets.

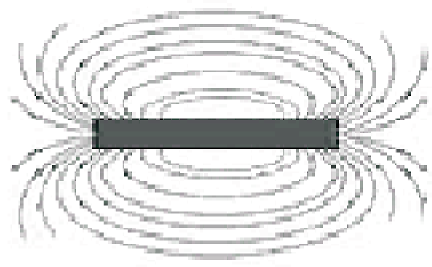
Often science and nature are the inspiration for artwork (see Extension). Have students develop an art project that incorporates magnetic field lines. This could be a collage, a 3-dimensional model, a drawing, a sketch, sculpture, poster, or any artwork that they can defend as having something to do with magnetism. By doing this assignment, students become aware that science, technology, art, and culture are interwoven.

By walking around the room looking at what the students are accomplishing and talking with them, you can determine whether the students are identifying the relationship between the magnetic field lines and their affect on a compass. By doing so, students will be demonstrating that they recognize the relationship between evidence (the drawing of the lines) and explanation (why does the compass allow you to do this?).

EXTENSION

Magnetism and Art:

Science and nature have been the inspiration for artwork for centuries. Have groups of students (or, if you wish, pairs or individuals) find one example of science influencing art. Encourage them to use various resources, for example, the worldwide web, print media, videos, films, music (audiotapes or scores of shows, operas, etc.), museums and poster shops. Students will realize that science is not something done in isolation but that it influences the culture in which it is an enterprise. Have students compare what they have found.



DRAWING MAGNETIC FIELD LINES

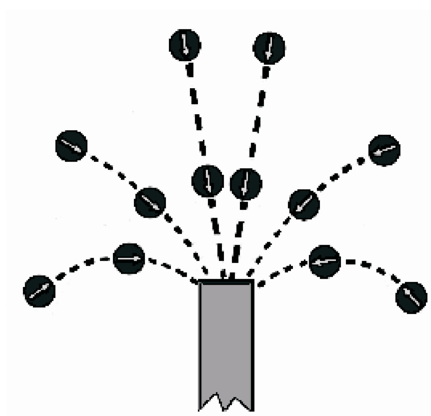
You will be using a compass to draw magnetic field lines of a small bar magnet in order to look at their direction and strength. This will be a good model for supporting what you already know about magnets. The magnet makes a magnetic field that extends to the area around the magnet. The field lines spread out from the north pole and circle back around to the south pole.

Materials:

- ❑ Bar magnet
- ❑ Large piece of paper
- ❑ Directional compass

1. Place the bar magnet in the middle of the paper. Trace the outline of the magnet. That way if it gets bumped or moved you can put it back in exactly the same place. If you do not complete this activity today, you will know where to start tomorrow.

2. Place the compass at the end of the magnet (near the edge) and make a dot where the compass arrow points (see picture).



3. Move the compass so that the bottom of the arrow is at the dot and make a new mark where the tip of the arrow is pointing. Keep doing this until you reach the other end of the magnet.

4. Connect the dots as you move around the magnet.

5. Go back and begin again placing the compass about 5 mm along the edge of the magnet. Repeat the steps connecting the dots as you go along.

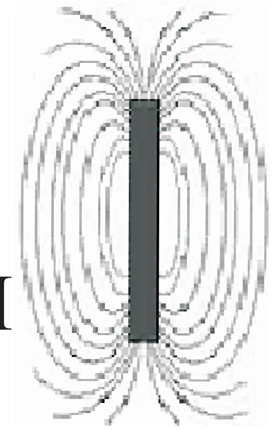
6. Repeat the process until you have drawn as many lines as you can for both ends of the magnet. You will now have a representation of magnetic field lines.

7. In your Science Notebook, answer the following:

   - ❑ Where have you seen this pattern before?
   - ❑ Write several sentences about magnetic fields.
   - ❑ List two new things that you know about magnetic fields.

Activity 4

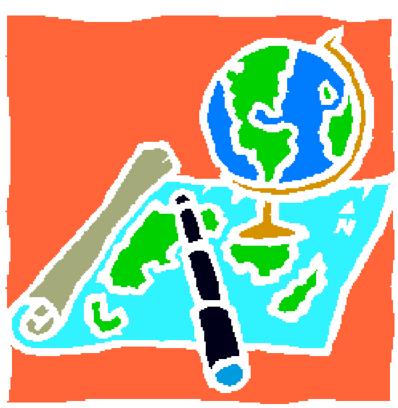
COMPARING THE STRENGTH OF MAGNETS



Students at this point should understand that by observing the size and shape of a magnet, they can predict the shape of a magnetic field. In experimenting with various magnets and objects that are attracted to them, students will also have found that the strength of magnetic fields varies from one type of magnet to another. This activity is best when used in conjunction with Activity 3a: Exploring Magnetic Fields, but it could be used on its own. Using the magnetic marbles exposes students to another magnet shape. Students will be comparing the field strength of several different types of magnets, wand magnets, square magnets, ring magnets and bar

Up to this point the activities have been structured to provide basic information on magnetism and magnetic fields. Now it is time for students to extend their thinking to phenomena that are not easily observable. Science requires the use of models to help scientists, teachers, and students form theories about objects or phenomena that are too large to see, or too abstract to understand. Putting these into a concrete form that can be manipulated hels us use what we already know to help us answer questions.

It is important for students to know that modeling is a real world strategy; for example, models of hurricanes and tornadoes help scientists determine how these storms are formed. The use of models also helps scientists understand the reasons why these storms form sometimes and not others even though conditions seem to be the same. Other models that could be used to help students answer the question, "Why do we use models in science?" are maps and globes, solar system models that represent planet sizes and distances from the sun, and cross-sectional models that allow us to "look" inside of things.



BACKGROUND INFORMATION

Scientists treat magnetic fields separately from magnets and magnetism. The discovery of magnetic fields and the observation that they had properties distinct from those of magnets, by James Clerk Maxwell, was based on the work of Michael Faraday. Maxwell linked the study of magnetic fields with that of electrical fields, which became the basis for Field Theory. Field Theory states that fields could be mathematically manipulated and treated as separate entities. With this in mind, it would not be necessary to know what is causing the magnetic field in order to study its effects. This theory, however, did not explain how forces can act at great distances and, until Richard Feynman proposed quantum electrodynamics (QED) in the 1950s (for which he won the Nobel Prize), it was the predominant theory used to understand magnetic fields.

The magnetic field lines that your students produced with iron filings in the magnetic field viewer illustrate that magnetic field lines are one way of determining how strong a field is being generated. The closer lines are, the stronger the magnet is; the further away, the weaker the magnet is. There are many ways that scientists use lines to depict ideas (see Extensions) and this may be a way to incorporate other facets of science instruction.

WHAT WILL STUDENTS DO?

1. Using a ruler with a groove in the middle, students will place one of 4 different types of magnets at the 0-cm end of the "track" and a magnetic marble at the 15-cm mark.

2. Have students predict and record their predictions in their Science Notebook about which type of magnet, bar, wand, ring or square will be the strongest.

3. Students will construct a data table in their Science Notebooks. In this data table they will record 5 trials of 4 different types of magnets (wand magnet, bar magnet, ring magnet and square magnet). They will determine the average distance between the magnetic marble and where the magnetic force was felt.

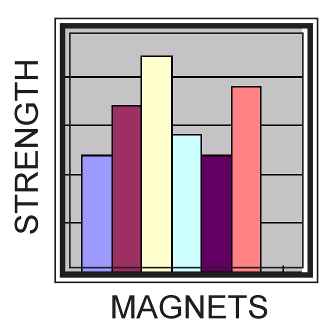
4. Slowly students will push the marble with a pencil, and stop when the marble is attracted to the magnet. They will record this distance in the data table they have created in their Science Notebooks.

5. Students will repeat this 4 more times and then determine the average distance that the force was felt between the magnet and the marble.

6. Students will repeat the experiment, but this time they will choose another magnet to test. They will do 5 trials, and then average the distances.

7. Students will continue the experiment until the strength of all 4 magnets has been tested.

8. All observations, conclusions, and answers to questions will be written in their Science Notebooks.



FOR YOUR PLANBOOK:

Materials:

- ❑ Ruler with a groove in the middle
- ❑ Magnetic marbles
- ❑ Ring magnet
- ❑ Bar magnet
- ❑ Wand magnet
- ❑ Square magnet
- ❑ Science Notebook

National Science Education Content Standards: A, B, D, E, G

Florida Sunshine State Standards:

Science
Grades K-2
SC.H.1.1.1-SC.H.1.1.3, SC.H.1.1.5, SC.H.3.1.1

Grades 3-5
SC.C.2.2.4, SC.H.1.2.1 - SC.H.1.2.4, SC.H.3.2.2., SC.H.3.2.4

Language Arts
Grades K-2
LA.A.2.1.3, LA.B.2.1.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

Grades 3-5
LA.A.2.2.5, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.3, LA.C.1.2.3

Mathematics
Grades K-2
MA.A.3.1.2, MA.B.1.1.1, MA.B.2.1.1, MA.B.2.1.1, MA.B.3.1.1, MA.B.4.1.2, MA.E.1.1.1, MA.E.3.1.2

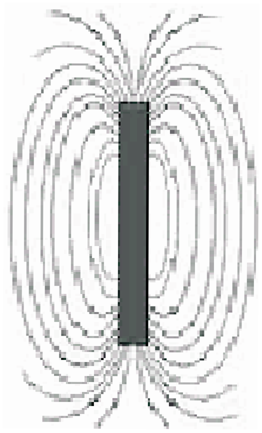
Grades 3-5
MA.A.3.2.2, MA.B.1.2.2, MA.B.2.2.1, MA.B.3.2.1, MA.B.4.2.2, MA.E.1.2.1, MA.E.3.2.1

Assessment:
Check Science Notebooks for evidence of stu conversations that include statements about whether not magnets have different strengths. If students' comments reflect the fact that magnets have different strengths, and are actively making predictions about the strength of magnets, then this is where your students should be in terms of understanding about the strength of magnets.

EXTENSIONS:

Richard Feynman is an interesting biographical study for students. His influence transcended science and his many and varied interests demonstrate for students that scientists are not one-dimensional characters in a lab coat working with test tubes in a sterile environment. Students could create a timeline of Feynman's accomplishments; could role-play an incident from Feynman's life; or could create a poster after researching his life on the worldwide web or in print media. "Last Journey of a Genius" is an excellent video to show older students. There are several biographies, three autobiographical works currently in print, and CDs of some of his Cal Tech lectures available.

Connected lines are used to display of scientific information. Isobars (lines that connect areas of equal barometric pressure), isotherms (lines that connect areas of equal temperature), contour lines (that connect areas of equal elevation), and magnetic field lines are examples. How close or far apart these lines are represent important information to meteorologists, map makers, geologists, and physicists. Students could investigate ways of using lines by obtaining from various sources sample maps that are then shared with the class. (The U.S. Geological Survey, local weather stations or television meteorology departments, the public library, university departments, and departments of transportation are some sources.)



COMPARING THE STRENGTH OF MAGNETS

In this activity you will test the magnetic field strength of different magnets.

Materials:

- ❑ Ruler with a groove in the middle
- ❑ Magnetic marbles
- ❑ Ring magnet
- ❑ Bar magnet
- ❑ Wand magnet
- ❑ Square magnet
- ❑ Science Notebook

1. In your Science Notebook make a prediction or a guess as to which type of magnet will be the strongest. Why do you think this is so?

2. Answer the following:

   - ❑ Do you think that all magnets have the same field srength?

   - ❑ What evidence do you have to support your answer?

   - ❑ Does the shape of a magnet make a difference to its field strength?

.

3. Prepare in your Science Notebook a data table that looks like the one below.

DATA TABLE: TESTING MAGNETIC FIELD STRENGTH

Type of Magnet	Trial # 1	Trial # 2	Trial # 3	Trial # 4	Trial # 5	Average

4. Place the ruler on the table with the wand magnet at the 0-cm end of the ruler. Place the front edge of the magnetic marble on the 15-cm mark of the ruler. The groove in the ruler will be the “track” that the magnetic marble will move on.

5. Slowly push the marble with the pencil point along the “track” until the magnet attracts it. Mark this distance in centimeters (cm) and record it in your data table.

6. Repeat this five times. Record your measurement of the distance for each of the five trials. Find the average distance and record it in your data table.

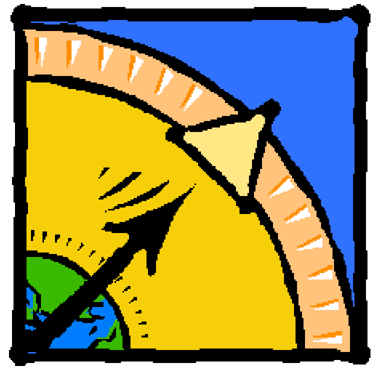
7. Test the other types of magnets just as you did the wand magnet. Record your results in your data table.

8. Answer the following questions in your Science Notebook:

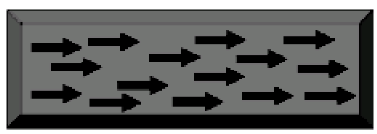
- ❑ Look at your predictions. How did they compare with your results?
- ❑ Write a paragraph explaining what you learned in the experiment.
- ❑ List the magnets in order from strongest to weakest.

Activity 5

NORTH AND SOUTH POLES



Reinforcing the idea of opposite poles attracting and like poles repelling one another, this activity requires that students use this information to figure out the pole alignment of wand magnets (the poles on these magnets are different than the others they have been using). They will identify the poles on the wand magnets, and use similar strategies to identify the poles on ring magnets and square magnets. This will be particularly useful later on in Activity 8: Build a MagLev Train Model. This activity asks students to rethink their conception of where poles are located on a magnet.



BACKGROUND INFORMATION

Materials exhibit certain characteristics because of the way in which the atoms that make up the material are aligned. In order for a material to be magnetic, there must be moving electrons. Materials with magnetic qualities have domains, which are each made up of billions of atoms. The way in which these domains are configured determines the magnetic ability of the material. For instance, if the domains are mostly aligned (the atoms are all pointing in the same direction), the material will exhibit strong magnetic characteristics.

Each magnet has a north and south pole end, the regions on the magnet where the force caused by the magnet is the greatest. Like poles repel and unlike or opposite poles attract. Scientists have attempted to isolate one of the poles but have been unsuccessful. If a magnet is cut in half, two magnets each with a north and south pole is created. No matter how small, each piece will still have a north and south pole. The smallest magnet is the electron orbiting a nucleus.

Magnets have different strengths that are dependent on several factors: the material from which the magnet is made, how the magnet is made, and how the magnet is treated. Some materials like lodestone (which contains iron) are found naturally in the earth and have magnetic properties because when formed, all of the tiny magnets lined up (north poles facing in the same direction).

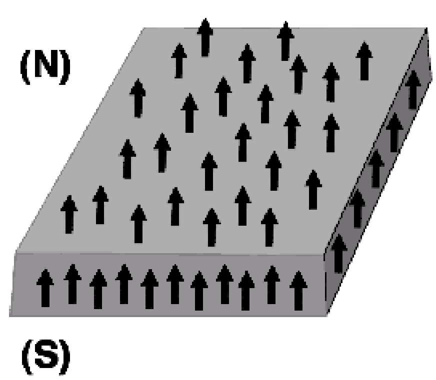
WHAT WILL STUDENTS DO?

In this activity students determine by exploration and experimentation, where the poles are on three different types of magnets. As an introductory activity, have students role play attraction and repulsion.

Attraction & Repulsion Activity

1. Have all students stand in a circle facing the center of the circle. Explain to them that if they are facing the same direction they cannot touch one another, however if they are facing in a direction opposite the person next to them, they may connect and hold hands.
2. Have every other student turn around and face away from the center. Ask students to see if any connections can be made with another student.
3. Repeat this exercise, two or three times but each time have a different pattern for selecting students to turn away from the center. (for example, 2 students facing in, 1 student out, or 3 students facing in, 2 students out, etc.) After each exercise, see if students can see any connections that can be made with other students.

1. Have students work in pairs with each student having a wand magnet. Ask them to explain in their Science Notebook what they notice about the attraction between magnets. Are the two magnets always attracted to one another?
2. Have students write in their Science Notebooks a plan for discovering where the north pole is located on the wand magnet and where the south pole is located on the magnet.
3. Students will explain the location of the poles on a variety of magnets.



FOR YOUR PLANBOOK:

Materials:

- ❑ Wand magnets
- ❑ Ring magnets
- ❑ Square magnets
- ❑ Compass
- ❑ Science Notebook

National Science Education Content Standards: A, B, G

Florida Sunshine State Standards:

Science
Grades K-2
SC.C.2.1.1, SC.H.1.1.1 - SC.H.1.1.3, SC.H.1.1.5

Grades 3-5
SC.C.2.2.4, SC.H.1.2.1-SC.H.1.2.4, SC.H.3.2.1, SC.H.3.2.2

Language Arts
Grades K-2
LA.A.2.1.3, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

Grades 3-5
LA.A.2.2.5, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.3, LA.C.1.2.3

Homework:
Have students attempt to create a game in which they use magnets.

Homework Assessment:
Game design should indicate that by using what students know about poles of the magnets they could move the game piece through the maze they have designed.

Assessment:

Student Science Notebooks should reflect their knowledge that like poles repel and opposite poles attract. Drawings of poles of wand magnets, ring magnets and square magnets demonstrate that students have recognized that poles can be located in positions other than top and bottom. Students clarify the concept of north and south poles, reinforcing what they have been studying.

Have students write a science fiction story that uses the concept either of poles being in different configurations on magnets (not always top and bottom) or of opposites attracting and like poles repelling. If they need a "story starter," you could use the Extension from Activity 1: "What Is A Magnet?": Write a fiction story about a sports team that is affected by an invention that magnetizes some aspect of their game (for instance, a magnetized basketball hoop and basketball). Or, an alien visits Earth and is examining a magnet; how would you explain it to someone with absolutely no knowledge of magnets whatsoever?

Students may design a piece of jewelry that uses magnetism in its construction. The results could be displayed by a diagram or in writing and should include materials used in making a prototype. Products will reflect student understanding of forces acting at a distance and through certain materials; design will take into consideration magnet strength, etc.

EXTENSIONS:

Reading and Writing:

Have students read *The Wind From the Sun* by Arthur C. Clarke in *Science Fiction Stories* edited by Edward Blishen, 1988 (ISBN 1-85697-889-3) Kingfisher Books, NY . Students will compare and contrast the design problems between Merton and themselves in creating either jewelry or inventions involving magnets.

Research:

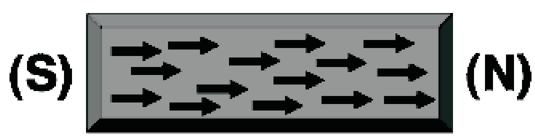
Research current technology (trash separators, MagLev trains) that use the principle of likes repelling and opposites attracting. Students will develop a way to present the results of their research to the class; a poster, written report, oral report, computer presentation, etc., would be appropriate. Encourage students to make phone calls, explore the Internet, and research current popular magazines (*Popular Science, Autoweek, Discover,* etc.) for articles. Students will articulate to their classmates how classroom science is being used in practical applications

NORTH AND SOUTH POLES

In this activity, your group will be experimenting with 3 different types of magnets: a wand magnet, a ring magnet and a square magnet. Every magnet has a north and south pole, the regions on the magnet where the force caused by the magnet is the greatest. Poles that are alike repel or push away from one another and poles that are opposite attract one another. Scientists have attempted to isolate one of the poles but have been unsuccessful. If a magnet is cut in half, two magnets each with a north and south pole is created. No matter how small, each piece will still have a north and south pole. The smallest magnet is the electron orbiting a the nucleus of an atom.

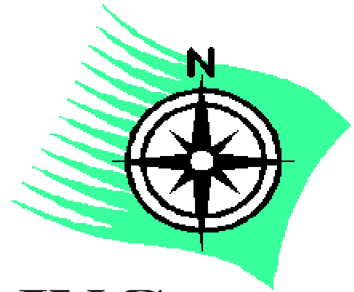
Materials:

- ❑ Wand magnets
- ❑ Ring magnets
- ❑ Square magnets
- ❑ Compass
- ❑ Science Notebook



1. Since the poles are not marked on the wand magnet, predict where you will find the poles of a wand magnet and write your prediction in your Science Notebook.
2. In your group, design an experiment that will help you find out where the poles of a wand magnet are located.
3. Make a prediction of where you think the poles of a ring magnet are located.
4. Record your predictions and draw diagrams of your ideas in your Science Notebook. Remember drawings are a good way to explain your predictions.
5. Perform a test to find out if your predictions were correct. Explain your test.
6. Make a prediction of where you think the poles of a square magnet are located. Record your prediction in your Science Notebook.

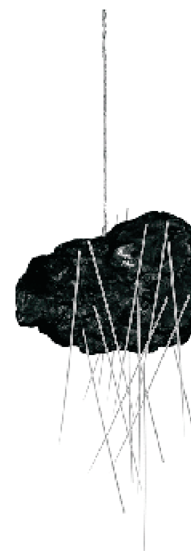
Notes:



Activity 6

UNDERSTANDING A COMPASS

Most students are aware that compasses are used to determine direction in some way. They may have had some experience if they have been involved with Scouts. However, do they know where they come from and how they are used? Do they really point north? How do magnets affect a compass? These are some of the questions that students will ask and answer by completing this activity. This activity is used in conjunction with others and compasses will be used in a practical application in Activity 8: Making a Map Using a Compass.



The invention of the compass in its present form transformed travel and exploration. Many times students believe that an invention has to be "big" to be important. It is possible that they miss the importance of "smaller" inventions on the development of culture and society. Certainly the compass is one of these that is easily overlooked by students. The intention here is to introduce compasses as measurement instruments, to begin to articulate how magnetic fields affect a compass, and to discuss compasses in relation to the development of culture.

BACKGROUND INFORMATION

Early scientists and travelers noticed the quality of a rock found in Magnesia in northern Greece. This rock became known as a lodestone and was observed to attract iron and repel other lodestones. This observation of magnetic properties led to further observation that the lodestone always pointed toward the mine in which it was found. However, it appeared all lodestones actually pointed in the same direction, not just to the area in which it was found. Using Polaris as a point of reference, it became clear that there was a definite north-south orientation to the lodestone.

Finding a way to measure and study this phenomenon produced early attempts at manufacturing compasses. Once sailors started using compasses, they realized that there was a distinction that needed to be made between magnetic north and geographic north. Manufacturing compass needles became important as did the directions that went with them enabling sailors to remagnetize the needles with a lodestone when necessary. So, sailors still carried with them the original compass, the lodestone, as well as the new technology.

For a detailed history of lodestones and the development of compasses, see *Hidden Attraction: The Mystery and History of Magnetism* by Gerrit L. Verschuur (Oxford University Press, 1993).

WHAT WILL STUDENTS DO?

1. Have students write in their Science Notebooks what they know about compasses. You could have them create a K-W-L chart.

2. Pass out compasses to each student and allow them to observe and investigate their behavior, characteristics and properties. By encouraging individual, unstructured observation, students will begin to articulate their own ideas about compasses and examine preconceived ideas about what they think a compass is and what they think it does.

3. Students will begin their work investigating how a bar magnet affects the compass. They may notice that geographic north and magnetic north are different from one another and will notice the tilt of the compass needle.

4. As students work they will write observations, draw conclusions and give explanations about what they are experiencing in their Science Notebooks.

5. Groups will share their findings with one another or with the entire class.

FOR YOUR PLANBOOK:

Materials:

- ❑ Compass for each group member
- ❑ Bar magnets
- ❑ Drawing paper
- ❑ Science Notebook

National Science Education Content Standards: A, B, E, F, G

Florida Sunshine State Standards:

<u>Science</u>
Grades K-2
SC.C.1.1.2, SC.C.2.1.1, SC.H.1.1.1 - SC.H.1.1.5

Grades 3-5
SC.C.1.2.1, S.C.C.2.2.2, SC.C.2.2.4, SC.H.1.2.1-SC.H.1.2.4, SC.H.3.2.1, SC.H.3.2.2, SC.H.3.2.4

<u>Language Arts</u>
Grades K-2
LA.A.2.1.3, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

Grades 3-5
LA.A.2.2.5, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.3, LA.C.1.2.3

Assessment:
Check Science Notebooks for preconceived ideas abo compasses. Entries in the Science Notebooks shoul demonstrate that students have moved beyond the basic idea of a compass pointing north to the fact that it is a measuring device. Beyond that, the notebooks should indicate a realization that there are misconceptions about compasses (they always point north) that the students can now explain.

Have students write a fiction story that includes a homemade compass as the device that either helps someone in the story or is the focus of the story. For example, soldiers in World War II had compasses in their buttons in case they were taken prisoner; or, a magnetized needle could be included in a package to a prisoner who would then use it to make a compass to find his way home. In order to do this effectively, students will be asking critical questions and analyzing them. Look for clear answers to well-articulated questions.

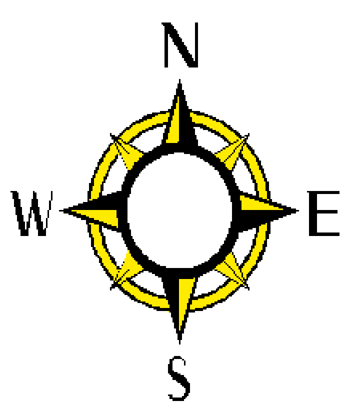
EXTENSIONS:

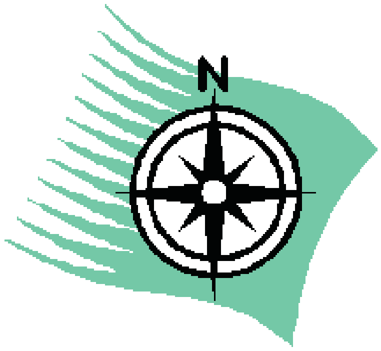
Reading and Writing:
Either read to students or have them read *How We Were Tracked By A Tripod* by John Christopher (in *Science Fiction Stories* edited by Edward Blishen). Students can create an explanation of how the Tripods are tracking the main characters. Are they using compasses? If not, could they have used compasses? How does the metal enable the Tripod to track the boys? By answering these questions (and any others either you or the students formulate), students are encouraged to find a relationship between the activity they did and a fictional adaptation of that information.

Lodestones were the basis not only for scientific advancement and the evolution of science but for myths and legends that sought to explain the magnetic phenomena. Early investigators had little science knowledge on which to explain their observations, so they resorted to using what they did know—the natural world. Early on, observers thought that lodestones all pointed toward Polaris because of a celestial connection. Have students create their own explanations with reference to natural phenomena to explain lodestones. This will prepare students for predicting outcomes and explaining results.

Gulliver's Travels by Jonathan Swift contains a section about a magnetic island that can be rotated. The island is made of lodestone and the magnetic qualities of lodestone are used as the basis for explaining how the island was moved and why. Reading this aloud and basing class discussions upon Swift's explanations for natural phenomena serves as a vehicle for students to clarify their own ideas about magnetism.

Art:
Design a bulletin board that indicates the north-south orientation of the bulletin board and presents information on compasses, their history and characteristics, influences on modern technology (for instance, navigational devices). Translating what they have learned into language that makes it clear to others is a way for students to gain a deeper understanding of the subject matter.





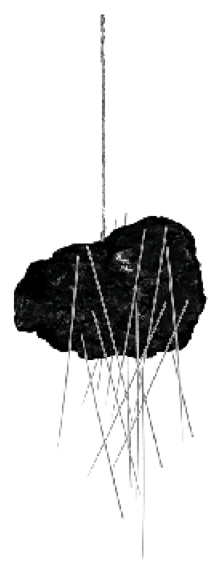
UNDERSTANDING A COMPASS

Early scientists and travelers noticed a particular quality of a rock found in Magnesia in northern Greece. This rock became known as a lodestone and was observed to attract iron and repel some rocks. The observation of these magnetic properties led to the observation that lodestone always pointed toward the mine in which it was found. However, it seemed that all lodestones actually pointed in the same direction, not just to the area in which it was found.

Lodestones were used to magnetize needles in early compasses. Once sailors started using compasses, they realized that there was a difference between magnetic north and geographic north. Manufacturing compass needles became important as did the directions that went with them. These directions helped the sailors remagnetize the needles with a lodestone when necessary.

Materials:

- ❑ Compass for each group member
- ❑ Bar magnets
- ❑ Drawing paper
- ❑ Science Notebook



Activity 6: Understanding a Compass

1. Write in your Science Notebook everything that you know about compasses. Do not worry about whether you are "right" or "wrong."

2. Place the bar magnet on your desk with the north pole pointing away from you. Place the compass on the magnet so that the north seeking end of the needle points to the north pole of the magnet. Observe what happens to the compass needle and draw a picture in your Science Notebook.

3. Discuss the following questions with your group and answer them in your Science Notebook:

   - ❑ Is the needle of the compass still pointing to the north pole?
   - ❑ Is this what you expected to happen?
   - ❑ Why do you think this happened?
   - ❑ What do you think will happen if you move the compass around the magnet?
   - ❑ Explain your answer. This will be your "hypothesis."

4. Before you test your hypothesis, make a group decision as to how you want to record your data.

   - ❑ Do you want to write your data in sentence form?
   - ❑ Do you want to draw a diagram each time you move the magnet?
   - ❑ Do you want to make a model?
   - ❑ Can you think of any other way to record your information? You will be sharing your findings with other groups, so be creative!

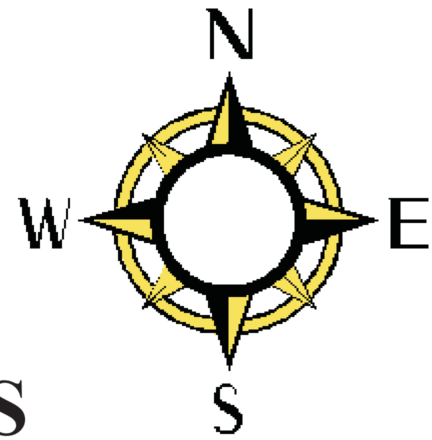
5. Test the hypothesis. Move the compass around the magnet. Since each time you move the compass you may move it a different distance, you might want to measure the distance you move the compass so that you move it the same each time.

6. Record the results of each trial in the way you and the group decided in Step 4.

7. Share your results with another group. In your Science Notebook write several sentences about what you learned from this activity.

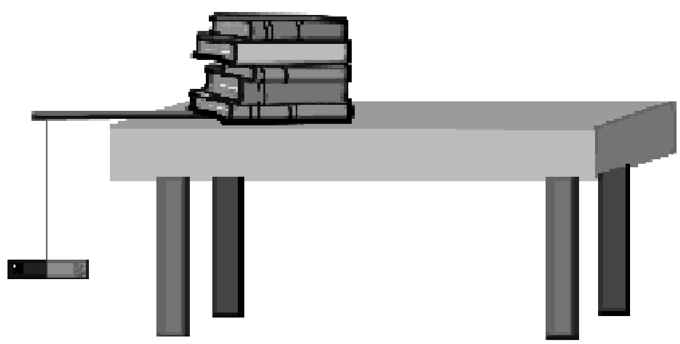
Activity 7

MAKING A COMPASS



Recreating the work of early scientists and scholars will help your students discover that the simplest solution can often be the best. Today's compasses are made in much the same way that they were imagined in the 13th century. Some innovation has been made in their manufacture such as adding degrees to the cardinal points to help determine the difference between geographic north and magnetic north, replacing the lodestone with a magnetized needle, or putting the needle on a pivot.

Because the students must make a compass without specific directions or a model from which to copy, they will have to ask themselves certain questions before trying each design. Discussing with one another the possibilities for success or failure is replicating what scientists do in the real world. Before scientists undertake a major design or implementation of a design, they anticipate points at which they might run into trouble.



BACKGROUND INFORMATION

In the 13th century, Peter Peregrinus, a crusader in Italy, attempted to write down all he knew about lodestones. As he tried to explain to himself the phenomena that he observed, he devised a compass by shaping a piece of lodestone into a circle and floating it. Not for another 300 years did sailors try to use this idea and manufacture magnetic compasses. (See *Hidden Attraction* by Gerrit L. Vershuur for a detailed history.) Early explorers took with them compass needles and lodestones (to keep the needles magnetized). Compasses as we know them, encased and easy to carry around, still did not exist.

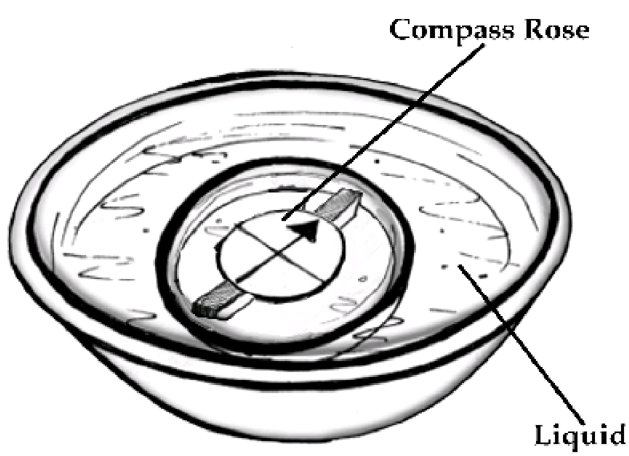
WHAT WILL STUDENTS DO?

You will be giving your students materials from which they will be asked to build a working compass. Encourage your students to bring in other supplies if they need to and if needed devote another class period to refining their original designs. Design sketches should be included in the Science Notebook since each group will give to another group their handwritten instructions to copy the design. One important lesson taken from this activity is that it is very difficult to write clear instructions for another person (see Extensions).

If students would like to research the "first compass" or early compasses for ideas on how to proceed, encourage them to do so. However, what you want to avoid are your students building a compass from instructions provided for them. The experience of trial and error and putting together different materials is important.

Students can keep the compasses they make for use in Activity 8: "Making a map using a compass," or they can use the compasses in your *Science, Magnets & You* package.

1. Inform students that they can use any and all of the materials at their disposal to create their compasses.
2. Students first discuss which of the group's plans (done for homework) they will adapt for use in this activity. This will require a good deal of discussion.
3. Each group will build their compass and test it to be sure it does what they expect it to do.
4. Students should draw a labeled diagram in their Science Notebooks with observations and comments.
5. The group writes a step-by-step instruction sheet for another group to use.
6. Groups exchange written instructions and proceed to build and test another compass.
7. In their Science Notebooks students compare and contrast the two compasses.



FOR YOUR PLANBOOK:

Materials:

You will need to assemble a variety of items. Most of these are found around the home, or are items that your students may bring in for the class to use. A letter home to parents requesting these disposable items could be sent prior to the activity. Be sure that if you use packing peanuts in this activity they are not the type that dissolve in water!

- ❑ Steel needles or pins
- ❑ A variety of magnets
- ❑ Petri dishes or small containers
- ❑ Pie plates
- ❑ Pieces of wood
- ❑ Packing peanuts
- ❑ Cardboard
- ❑ Water
- ❑ Permanent marker
- ❑ Paper
- ❑ Masking tape
- ❑ Aluminum foil
- ❑ Corks
- ❑ Jars
- ❑ Mineral oil (if possible)
- ❑ Clay
- ❑ Bottle caps
- ❑ Thread

National Science Education Content Standards: A, B, D, G

Florida Sunshine State Standards:

Science

Grades K-2

SC.C.1.1.2, SC.H.1.1.1 - SC.H.1.1.2, SC.H.1.1.5, SC.H.3.1.1

Grades 3-5

SC.C.2.2.4, SC.H.1.2.1 - SC.H.1.2.5, SC.H.3.2.1, SC.H.3.2.2, SC.H.2.3.4

Language Arts

Grades K-2

LA.A.2.1.3, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

Grades 3-5

LA.A.2.2.5, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.3, LA.C.1.2.3

Homework:

Have each student create a plan for building a compass. Tell them that they must use only materials in the classroom or that they bring in, the plan must include a labeled drawing, and step-by-step instructions. They may use any supplies from the above list (which you will place on a chalkboard or overhead).

Homework Assessment:
Look for use of commonly found materials or materials you have on hand in class. The assignment should include a list of materials, a labeled diagram, and step by step instructions. If all are included, then the student has successfully completed the assignment. Whether the plan is actually one that will work will be determined during the activity and should not be part of the homework assessment.

Assessment:
Students have built a compass that consistently indicates a north-south orientation. Look for clear, easy to understand step-by-step directions that were followed by another group of students to replicate the original model. Completion of these two steps demonstrates that students are able to state explanations for why the compass points north-south and can communicate their observations through a clearly written set of instructions.

Students successfully construct a second compass using another group's set of instructions. By doing so, students demonstrate the ability to apply what they have learned to a new set of ideas. Then they will list similarities and differences between the two compasses. Finding the relationship between the two methods requires analysis of their own ideas of how compasses work. Students will then determine which compass is the "better" of the two and explain their choice, thus predicting which compass will work best in a practical application.

Have students answer the following questions in their Science Notebooks:

- ❑ How did the group decide which model to make?
- ❑ How did they test their compass?
- ❑ What problems did they have replicating someone else's model?
- ❑ If there were no problems, why was the plan a successful one?
- ❑ What are the features of a good model drawing and set of instructions?

By answering these questions (and any others that you believe are pertinent), students articulate their beliefs about the tools they need to successfully complete an activity. This provides insight to you and to them. Students will be identifying alternate ways to be successful with a task (drawing, writing instructions, verbally communicating information).

Have students create a concept map or other visual tool to explain what a compass is, how it is made, and how it is used. A visual tool will allow students to construct their own meaning because they will be designing a personal way to organize the information. Be flexible about grading this product since it represents the student's ideas, not necessarily yours or anyone else's. But, it should contain the basic vocabulary that you believe necessary for understanding the idea of compasses as directional tools related to the Earth's magnetism. For example, if the visual tool is

one that you can interpret (or another student can interpret) without help, then it will receive the highest grade (A). If it has all the right words, but you need the student to show you how they relate, then it would get a B. If the student has clustered words without attempting any connections, then it would receive a C and if the student has put only some of the words and no connections, it would receive a D. Not completing the assignment would be the only way to fail.

EXTENSIONS:

Writing:

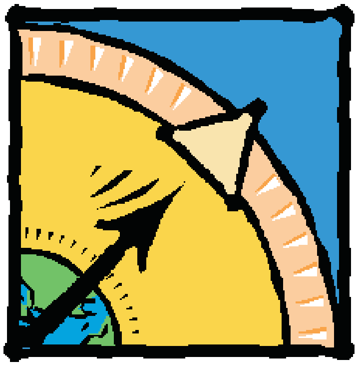
In an episode of *Star Trek: Deep Space Nine*, the chief engineer was asked to find a ship that had crashed. The planet it crashed on was surrounded by satellites that disrupted all instruments. He decided that he needed a magnet that would detect the metal in the downed ship. He created a magnet, found the ship, and all was well. What if it was not a magnet that he needed but a compass? Would this storyline work? Rewrite the story to reflect this idea. Stories should indicate some knowledge that a compass (such as the ones the students made in this activity) would not work in space as a directional device. Student stories should explain this and demonstrate that compasses work as they do because of Earth's magnetic north and south pole.

If you are unsure whether or not your students understand how to write directions, you could start with something like: Pretend you are hosting a person from another planet who is unfamiliar with what a hamburger is. Write out a description that would enable them, when they return to the home planet, to recreate the hamburger. Or, write out instructions for someone to do a chore like putting dishes in the dishwasher or setting the dinner table. This exercise will require students to describe steps and then refine their instructions by restating those steps.

Vocabulary and Art:

Instruct students to brainstorm (with another student or a parent) common phrases that include the words magnet, magnetism, or magnetic. For example, magnetic personality, animal magnetism. Students will then draw their interpretation of one of these phrases to share with the class. Drawings will reflect the meaning of the phrase as yet another way for students to demonstrate their fluency with the vocabulary of this unit.

Notes:



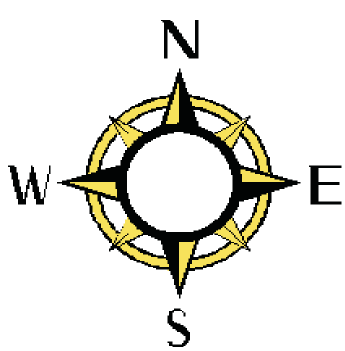
MAKING A COMPASS

In the 13th century, Peter Peregrinus, a crusader in Italy, attempted to write down all he knew about lodestones. As he tried to explain to himself the phenomena that he observed, he made a compass by shaping a piece of lodestone into a circle and floating it. Not for another 300 years did sailors try to use this idea and manufacture magnetic compasses. Early explorers took with them compass needles and lodestones (to keep the needles magnetized). Compasses as we know them, encased and easy to carry around, still did not exist.

This activity will help you to make your own compass based on what you know about magnetism. You will be using your homework design in this activity as a model from which to work. Remember to write down all observations and comments in your Science Notebook. This will help make it easier for you to remember how you made your compass.

Materials:

- ❑ Different items either provided by your teacher, or items you brought from home
- ❑ Science Notebooks



Activity 7: Making a Compass

1. In your group discuss the compass designs that you did for homework. Talk about the advantages and disadvantages of each, making a list of the most desirable features in your Science Notebook. Decide which design your group will use.

2. Build your compass. When you have finished, use your knowledge of magnetism and geography to test it. Write the results in your Science Notebook and include a labeled drawing of your compass.

3. As a group, write up a set of instructions for another group so that they can copy your model. Write directions that are clear.

4. When you have completed your written (not drawn) instructions, exchange those with another group and build and test their compass.

5. In your Science Notebook compare and contrast the two compasses, listing advantages and disadvantages of each.

6. Choose the compass that you will use for Activity 8: Making a Map Using a Compass.

Activity 8

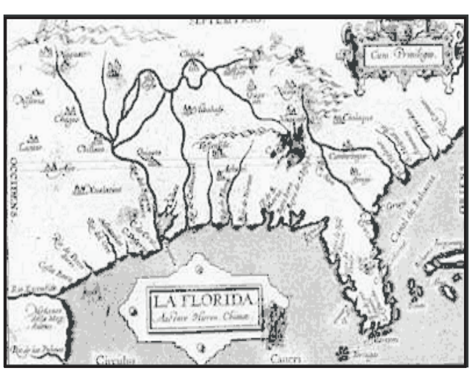
MAKING A MAP USING A COMPASS

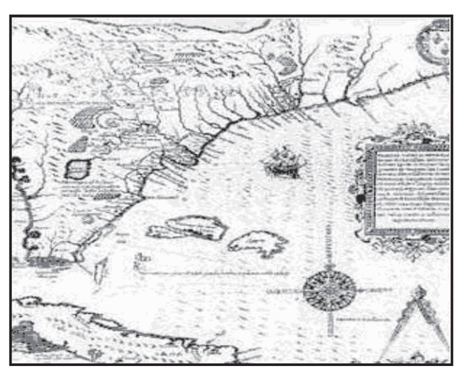
This activity is designed to allow students to use the compass they built in Activity 7 for a practical purpose. (Using compasses provided in your *Science, Magnets & You* package is equally effective.) In this case that purpose will be to make up directions, follow directions to reach a predetermined point, and to make a map. Because you are giving students a reason for having constructed their compasses in the previous activity it becomes more meaningful. Real-world orienting experience will allow students to appreciate the compass as a navigational device.

Students will learn to be precise in their measurements so that others can follow their directions and create a map from them since they will be evaluating one another. Maps could take various forms, any of which should be acceptable if the information is usable. Sharing and discussing the maps made for homework will let you to see what students consider usable maps and allow you to maintain some control over the kinds of maps that are acceptable for this activity.

BACKGROUND INFORMATION

Compasses as navigational tools have been used since the 13th century. Sailors, campers, cartographers, and explorers use them for a variety of purposes. Although early compasses took a different form than ones we use today, the technology is the same: a magnetized needle that points north/south because of the Earth's magnetic field.





WHAT WILL STUDENTS DO?

There are several ways to complete this activity. Your students can develop their own directions for another group to follow or you can supply the directions to a certain location or several locations. This depends upon how much time you wish to devote to this experience. If you decide to make up directions ahead of time, you will want to create several sets so that all of your students are not moving in the same direction at the same time. Let other teachers around the school know that your students will be outside doing this activity.

You can require students to create their maps in groups of 2-4 students, individually, or you could give them the choice. There are two student pages included here to accommodate either option.

If you are having students create their own directions to a place of their choice, proceed as follows:

1. Instruct students to take their compasses and make up a set of directions leading to a predetermined place. For instance, "walk 3 feet west, 2 feet north, 5 feet northwest." Students can then add clues if they wish such as "walk 3 feet west, 2 feet north, you should see a sign. . . ." etc.
2. Also instruct students to map their route as they are making up the directions.
3. Students exchange directions and try to follow the new ones, also mapping their route as they follow the new set of directions. When they are finished, each group will have two sets of directions and two maps.
4. When all students are finished, the groups that exchanged sets of directions should sit down together and compare maps, noting similarities and differences and difficulties they might have had following each other's directions.
5. The Student Group Worksheet will instruct students to make notes and answer questions in their Science Notebooks.

If you are giving students directions that you have made up leading to a certain destination, proceed as follows:

1. Instruct students (in pairs or groups) to take their compasses and follow your directions mapping their route as they go.
2. When they have completed the route, have students sit in groups and compare maps, discussing similarities and differences and discussing difficulties they might have had in following the directions.
3. The Student Group Worksheet will instruct students to make notes and answer questions in their Science Notebooks.

FOR YOUR PLANBOOK:

Materials:

Students can use the compass constructed in Activity 7 to complete this activity or they can use the compasses in the *Science, Magnets & You* package, to complete the map making.

- ❑ Compasses
- ❑ Clipboards
- ❑ Paper
- ❑ Pencils
- ❑ Science Notebooks

National Science Education Content Standards: A, B, E

Florida Sunshine State Standards:

Science
Grades K-2
SC.C.2.1.1, SC.H.1.1.1 - SC.H.1.1.5, SC.H.3.1.1.1

Grades 3-5
SC.C.2.2.2, SC.H.1.2.1 - SC.H.1.2.4, SC.H.3.2.2

Language Arts
Grades K-2
LA.A.2.1.3, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

Grades 3-5
LA.A.2.2.5, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.3, LA.C.1.2.3

Social Studies
Grades K-2
SS.B.1.1.2

Grades 3-5
SS.A.6.2.2, SS.B.1.2.1

Mathematics
Grades K-2
MA.B.1.1.1-MA.B.1.1.2, MA.B.2.1.2, MA.B.4.1.2

Grades 3-5
MA.B.1.2.1-MA.B.1.2.2, MA.B.2.2.2, MA.B.4.2.2

Homework:
Have students make a map from their home to the school. Assure them that you do not intend for this to be a map to scale, but one they would give as directions to their home. Encourage those students who are worried about this assignment to use graph paper if that makes them more comfortable and remind them to use landmarks. One of the comments that was frequently made after Hurricane Andrew in Homestead, Florida, was that when all buildings, homes, and trees were flattened, it was difficult (if not impossible) for people to figure out where their homes were.

Homework Assessment:
Accept any reasonable map as successfully completing this assignment. Maps should include major landmarks, ordinal directions, and approximate distances. This exercise will get students thinking about maps and, if they share them before doing the activity, they can work out some of the difficulties before starting.

Assessment:
As part of the activity, students create a set of directions that can be followed by another group. The successful completion of the pre-set route demonstrates that the directions were usable and that the first group made the transition from the prior activities to practical usage of a compass.

Students successfully follow your directions to a predetermined location. Completion of this part of the activity demonstrates that students are able to apply the information from other activities in a practical manner.

Students create a map using the given set of directions. Doing so indicates that students can transfer one type of information into a graphic representation of that same information. The map can be to scale or not (your choice depending upon the level of students). This is a good opportunity to discuss map scales in general. Because they are working in groups, students will need to state explanations about maps, how to make maps and the use of maps before they decide what type of map to make.

EXTENSIONS:

Reading and Writing:

Read an excerpt from *Treasure Island* by Robert Louis Stevenson (or any other story that includes a treasure map) that describes the treasure map. As a class discuss the problems that are encountered when using a map of this kind. What types of changes could take place over time that would affect a treasure map? (Students will probably note that trees and plants grow, weathering or erosion might change physical features, etc.) Point out to students that each person's "pace" is different depending upon their height, how quickly or slowly they are walking, whether they are walking uphill or downhill, etc. Students will determine that maps of this sort are unreliable at best and unusable at worst.

If you are reading aloud, either about the race to the north pole or about Dilly McBean's magnetic hands, have students write about how their information on compasses as navigational tools could help them avoid a potentially dangerous or risky situation.

Early cartographers sometimes could not see what they were mapping. Have students imagine that they were asked to map a country for which they have limited information. It is across the sea, is many months' journey, has a beach that leads to mountains which then becomes plains interrupted by yet another mountain range. Eventually another sea is reached after crossing two rivers. You can make up any description you wish that could represent a real place. Ask students to create a map from your description and compare it to the actual map. Students will explain how they made their maps and the difficulties they faced. They will evaluate their own work by determining how close they came to the actual map.

Ask students to brainstorm kinds of maps. Offer a prize for the group that comes up with the most types of maps. This exercise will help students articulate different ways that maps are used including concept maps.

Research:

Develop a bulletin board showing as many different types of maps as possible. Have the students cut out maps from magazines and newspapers and bring them to school to put on the bulletin board.

Ask students to watch the evening news for three or four nights. Have them list all the maps they see on the news and what they show.

Have students brainstorm a list of jobs that may require the use of maps. Then have students list as many reasons as they can as to why they would need a map.

Have students research early maps of Florida on the worldwide web, or using print media. Because Lake Okeechobee is so large, early cartographers did not imagine that it could be a lake. This belief affected maps of Florida and thus affected exploration and settlement. Reports will bring historical mapmaking information to a local level enabling students to better visualize some problems associated with the making of maps. Students may visit the Mag Lab Alpha website for early map of Florida (http://k12.magnet.fsu.edu/maglabalpha/html/index.html).

Notes:

MAKING A MAP USING A COMPASS (A)

You will be making up a set of directions for another group to follow using a compass. At the same time, you will be mapping the route, so you must decide where you are going before you begin. You are applying what you learned from previous activities in a practical way. You will use a compass to find a particular location.

Materials:

- ❑ Compass
- ❑ Clipboard
- ❑ Paper
- ❑ Pencil
- ❑ Science Notebook

What Will I Do?

Part I:

1. With your group or partner choose a place somewhere on school grounds. Once you have decided on a place, start at the classroom door and describe that route using points on a compass. For instance, "Begin at the classroom door and go 5 meters west. Then go 2 meters north." You can put in hints if you think your route is difficult to understand, such as "Begin at the classroom door and go 5 meters west. You should see the office door." Try to make this a challenge.
2. As you are creating the directions make a map of your route and return to the classroom.
3. In your Science Notebook, write about any trouble you had either with the directions or with the map.

Part II

4. Exchange your written directions (not your map!) with another group.

5. Try to follow the new set of directions mapping the route as you go much as you did in the first part of the this activity. Remember some of the problems you had in making your map and use them to help you. When you are finished, return to the classroom.

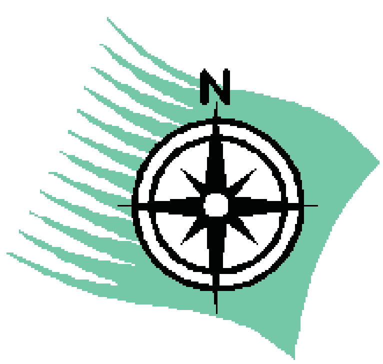
6. Sit down as a group and discuss your map fixing any points that you believe are incorrect or unclear. In your Science Notebook, write down any observations that you made about your trip.

Part III

7. When the group with whom you exchanged directions returns, compare maps and answer the following questions in your Science Notebook.

   - ❑ How do the maps compare with the original maps made by the group creating the directions?
   - ❑ Compare and contrast the maps. What suggestions do you have for people giving directions?
   - ❑ What would you do differently if you were to repeat this experience?

8. Make a list in your Science Notebooks of times that you might have to give directions to another person. Have you changed your ideas about how you would do this? What are some important elements of giving directions that you had not thought of before this activity?



MAKING A MAP USING A COMPASS (B)

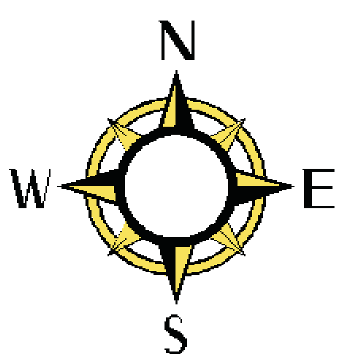
Using a compass, you will be following a set of directions that leads you to a certain place. This allows you to use your compass as a navigational device as you would for orienteering. As you find your way, you will also be mapping the route. When you reach your destination, return to the classroom. Take your compass and follow the directions, mapping your route as you go.

1. When you return to the classroom sit down with another group and discuss the directions and compare and contrast your maps.

2. Answer the following questions in your Science Notebook:

   - ❑ How do the maps compare? Are they the same or different?
   - ❑ What would you suggest to people giving directions?
   - ❑ What would you do differently if you were to repeat this experience?

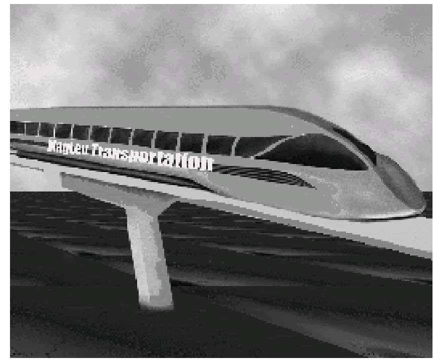
4. Make a list in your Science Notebook of times when you might have to give directions to another person. Have you changed how you would do this? What are some important things about giving directions that you had not thought of before this activity?



Notes:

Activity 9

BUILDING A MAGLEV TRAIN MODEL



In this activity and its follow-up, "MagLev Model Train Competition," students will build models of a transportation system to demonstrate how magnets can be used in a practical way. Combining content issues like magnetism with real-world applications brings another dimension to science in the classroom.

It is possible to build a simple levitating train using some of the principles that your students already know about magnetism. Although a true MagLev train is a very complex device, students should be able to build a mock-up of a simple train that levitates along a 30 cm (approximately) track just by using permanent magnets and common materials.

Scientific advances bring both problems and benefits, and informed citizens need to understand how these advances impact their lives. Today's citizens must make decisions regarding scientifically based social issues, i.e., genetic engineering, cloning, energy consumption, or environmental conservation. These decisions will affect not only society as a whole but also students' individual lives. Using real-world applications of science in classroom instruction provides opportunities for students to analyze the impact of science and technology on society and to determine their costs and benefits. Students engage in real world situations, which motivate the learning of science content.

If students come up with ideas using other materials, encourage their creativity, and make other magnets or related materials available to them if possible.

BACKGROUND INFORMATION

Fossil fuels are dwindling. They are also a source of pollution that is threatening our atmosphere. A magnetic levitation system consists of safe, quiet, nonpolluting vehicles. Worldwide there are two types of magnetic levitation trains: those that use superconducting magnets and those that use permanent magnets. Both systems can travel at very high speeds; both systems are nonpolluting.

The German system relies on attraction, the Japanese system on repulsion. In both systems propulsion is similar in that the train rides on an electromagnetic wave. The German Transrapid has no wheels; electromagnets on board are attracted to a magnetic surface on top of the track. This lifts the train about 1 cm off the ground. The Japanese train rests on a set of wheels. When it reaches 100 mph it levitates 10 cm above the rails. Both systems rely on a lateral guidance system to keep the train in the middle of the track.

Using technology similar to that used to develop Maglev trains, scientists around the world are attempting to use this technology for other purposes. In Japan, for instance, engineers are working on a motor to propel elevators to greater heights in skyscrapers. The vertical linear motor will use the concept that magnetic forces act at a distance but will be limited, of course, as to the speed and acceleration that can be used since the elevators will contain human beings. Electromagnets have traditionally been the basis for motor design. However, permanent magnets are becoming more desirable due to the fact that they can be made smaller, stronger, and are advantageous environmentally. They need no electric current, thus no fossil fuels are used.

Another use, however, for this same technology is to build electromagnetic launchers to propel vehicles beyond Earth's gravity into space. These vehicles could carry, for example, parts and supplies for a space station or a moon colony. Currently, most research that is being done in Japan and the United States is producing rail guns (also called rail launchers and coil guns).

Rather than propelling space vehicles, these electromagnetic launchers are being manufactured as modern weaponry. One such tested rail launcher is 2.23 meters long with a bore of 17.5mm X 39mm. The transition of technology from one use to another is common in science.

Other sources of information are: Richard P. Brennan (1990). *Levitating Trains and Kamikaze Genes*. New York: John Wiley & Sons; The Florida Department of Transportation, High Speed Program Office, Tallahassee, Florida; or, on the worldwide web (www.hsgt.org).

WHAT WILL STUDENTS DO?

1. Students construct a base for a MagLev train from foam board, poster board, or cardboard.

2. Using magnets, students will construct the track. As they do this, they will discover (if they did not realize this before they began) that the magnets must be aligned in a certain way for this to work. Students will also find that taping the magnets together so that like poles line up is not as easy as it first seems. It may be helpful for students to figure out which surface of each magnet represents the same pole, and mark an "X" on that surface before placing the magnets on the tape.

3. Once the tracks are in place, students need to make a "train" that will float on the rails. They discover that weight and shape is important. Students need to experiment with several variables before arriving at the best design.

4. Encourage students to decorate their models and personalize them. They could develop a team name and logo.

5. Students will demonstrate their model for you and for other groups.

FOR YOUR PLANBOOK:

Materials:

- ❑ Foam board, poster board, or cardboard
- ❑ Marker
- ❑ 20-30 square magnets
- ❑ Masking tape
- ❑ Science Notebook

National Science Education Content Standards: A, B, E, F, G

Florida Sunshine State Standards:

Science

Grades K-2

SC.B.2.1.1, SC.C.1.1.1, SC.C.2.1.1, SC.H.1.1.1 - SC.H.1.1.5, SC.H.3.1.1

Grades 3-5

SC.B.2.2.2, SC.C.1.2.1, SC.C.2.2.2, SC.C.2.2.3, SC.D.2L2L1, SC.H.1.2.1 - SC.H.1.2.5, SC.H.3.1.1 - SC.H.3.2.4

Language Arts

Grades K-2

LA.A.2.1.3, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

Grades 3-5

LA.A.2.2.5, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.3, LA.C.1.2.3

Social Studies

Grades K-2

SS.A.1.1.1, SS.A.1.1.2, SS.A.1.1.4, SS.A.2.1.2

Grades 3-5

SS.A.1.2.1, SS.A.1.2.3, SS.A.2.2.2, SS.B.2.2.3, SS.B.2.2.4, SS.D.1.2.2

Homework:

This works best if assigned before completing the activity. Allow students several days to complete the assignment. Have students interview a grandparent, great-grandparent, or other adult over 50 (the older the better). The interview will be comprised of asking two questions about changes in transportation:

1. What kinds of transportation did you use when you were elementary school age?
2. How has transportation changed since that time?

Instruct students to note the name, date, and place of the interview as well as the age of the interviewee. Answers should be recorded in their Science Notebooks.

Homework Assessment:
Encourage students to consider all types of transp when conducting their interviews, for example, nc cars or planes, but scooters, roller skates, sk walking as a mode of transportation, horsebac riding or tractor. Interviewing is a way of gathering data from a primary source. If students come to class with answers to the two questions as well as the name, date, and place of the interview, they have successfully completed the assignment.

Assessment:
Use data gathered from the interview questions assigned for homework to conduct a class discussion. From this discussion, students generate a list of modes of transportation and then add to it how each has changed over time. Students develop an understanding of the historical place of science in society. This would be a good place to distinguish between innovation and invention.

Have students create a Venn diagram (3 concentric circles) based on the information from their interviews and follow-up discussions. One circle could represent transportation in the past; another, transportation in the future; and the third, transportation at present. The intersection of the three would be a place to list those modes of transportation that are common to all three.

Instead of the Venn diagram (above), have students create a concept map based on the same information. It serves the same purpose: students view science as a human endeavor with lasting influence upon society. A concept map is a way for students to present, in visual form, their conception of certain information. To create a concept map, students must first clarify how new knowledge is related to other ideas that they have encountered. Concept maps present interrelated knowledge rather than isolated facts.

Models created should indicate that students understand enough of the technology to know that the MagLev trains are created by permanent magnets that repel and attract. They should also understand that all magnets must be placed in a certain configuration in order for these forces to work, and that the nature of science is such that trial and error create opportunities for new development.

Check Science Notebooks for record keeping. Students realize quickly the need for accurate and detailed records. In this activity, particularly, it will be to the students' advantage to write down any problems they have and how they solve them. If Science Notebooks contain this type of information, students have been successful in their record keeping. Remind students that replication is most important in science. Others have to be able to reproduce what another scientist has done in order to validate the results.

EXTENSIONS:

Reading:

Either read or have students read a Jules Verne science fiction story. Using science fiction as a reference for science fact is a technique that is appealing to many students. When they realize that Jules Verne wrote about things in his novels that were decades away from being discovered, students gain a respect for fiction as a vehicle for understanding fact (some of the things that he imagined were submarines, space travel, television, mass transit, computers). By placing each of these novels in its historic context, students will be amazed at the foresight shown in each. In *Paris in the Twentieth Century* (1996, Random House, ISBN 0-679-44434-3), Verne talks about mass transportation (at issue in this activity and the one that follows).

Art and Writing:

Have students read "The Shot From the Moon" by Arthur C. Clarke (found in *Science Fiction Stories* chosen by Edward Blishen, Kingfisher Books, ISBN 1-85697-889-3). This science fiction story contains mention of a magnetic launcher in use on the moon. (In the 1970s, Arthur C. Clarke came up with this idea that was then heavily promoted for a short period of time.) Transporting people and goods to and from the moon if a moon colony were established is a problem that theoretically could be alleviated by using a magnetic launcher. Ask students to draw their idea of what a magnetic launcher would look like and answer the following questions in their Science Notebooks. Why would a magnetic launcher be appropriate for use on the moon? [The moon's gravity is one-sixth that of Earth; it is fuel-efficient; the moon has no atmosphere.] Drawings should portray the concept of opposites attracting and like poles repelling like poles.

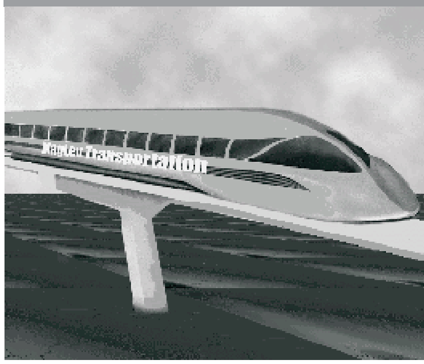
Research:

Fossil fuels are an issue that is discussed frequently on television news programs, newspapers, and magazines. By middle school, students should be able to identify the fossil fuels and the reasons why we should be conserving them. Have students research the use of fossil fuels using print media, videotapes, or worldwide websites. They will be using this information in the next activity "MagLev Model Train Competition." Each group should identify this as an area of worldwide concern.

The use of fossil fuels is an issue that is discussed frequently on television news programs, newspapers and magazines. Students should be introduced to types of fossil fuels and research some of the reasons why we should be conserving them. Have students research the use of fossil fuels using print media, videotapes or worldwide web sites. Each group of students should identify this as an area of worldwide concern.

One of the reasons that the United States has cut back on fossil fuel use is that they pollute the atmosphere. Have students research the issue and present their findings at a poster session. Students may want to invite others to share their information as scientists do in actual laboratory situations.

Notes:



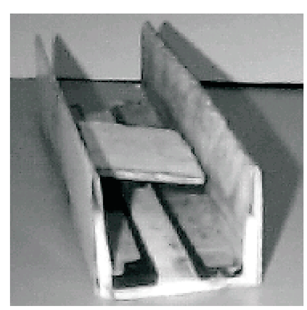
BUILDING A MAGLEV TRAIN MODEL

Fossil fuels are becoming less and less abundant. They are also a source of pollution that is threatening our atmosphere. A magnetic levitation (MagLev) train system is made of safe, quiet, nonpolluting vehicles. Worldwide there are two types of magnetic levitation trains: those that use superconducting magnets and those that use conventional magnets. Both systems can travel at very high speeds; both systems are nonpolluting. The German system relies on attraction, the Japanese system on repulsion. The German Transrapid has no wheels; electromagnets on board are attracted to a magnetic surface on top of the track. This lifts the train about 1 cm off the ground. The Japanese system rests on a set of wheels. When it reaches 100 mph it levitates 10 cm above the rails. Both systems have a way to keep the train in the middle of the track.

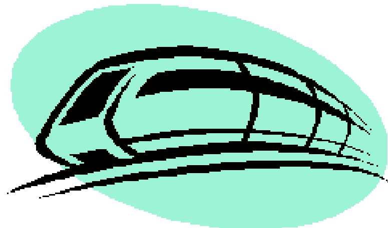
It is possible to build a simple levitating train using some of the principles you have learned about magnets. Although a true MagLev train is a very complex device, you should be able to build a model of a simple train that levitates along an approximately 30 cm long track using permanent magnets and common materials.

Materials:

- ❑ Foam board, poster board, or cardboard
- ❑ Marker
- ❑ 20-30 square magnets
- ❑ Masking tape
- ❑ Science Notebook



Activity 9: Building a MagLev Train Model



1. Using the materials you have, construct a track for your MagLev train. (If you think of additional materials you need, ask your teacher.) This is a little more difficult than it seems at first, so be patient. Keep a record of any problems you may have in your Science Notebook.

2. If you get to a point where you have questions about your design, talk with another group, or with your teacher.

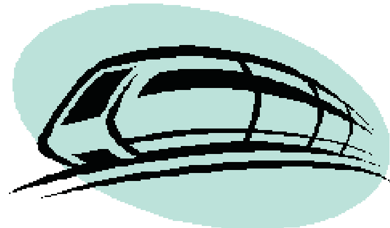
3. Once your track is in place, make a "train" that will float on the rails. Weight and shape are important; try several different designs before deciding on the final one.

4. In your Science Notebook, draw a plan of the train, listing materials and directions. Remember, other scientists will need to replicate (repeat exactly) your work.

5. Decorate your model. Design a logo based on a team name or nickname.

6. Demonstrate your model for the other groups.

Activity 10



MAGLEV MODEL TRAIN COMPETITION

For this activity, students will use models created for Activity 9. You will need to refer to the group descriptions on the student group worksheets. Students will be divided into role playing groups to decide whether MagLev transportation should be adopted in Florida. They will also be deciding which of four MagLev designs to implement should the decision be reached to have this type of system in Florida. In this activity, students will answer the question, "Should Florida, whose population has grown to almost 15 million in the year 2000, develop and build the Florida High Speed Transportation System?" by modeling the decision-making process that goes into high-stakes financial commitment to new technology.

Each group will have a predetermined role to play so this activity will have five different student pages instead of one. Divide your class into 9 groups as follows: a design group**,** 4 groups of builders, a marketing group, state legislators, the public and the Department of Transportation. Here is where you may wish to take a look at the talents of individual students to preselect the groups. It is a good opportunity for students to work with other groups. You can study each group description and determine who best suits each category.

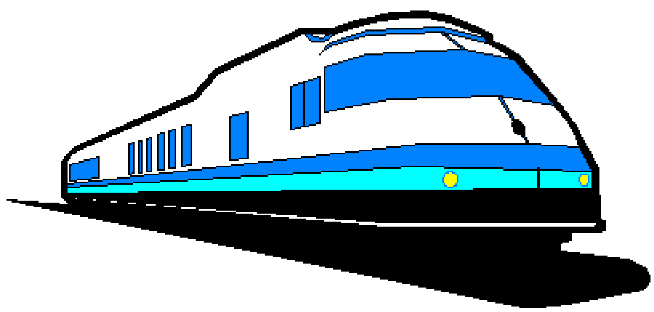
There is one student group worksheet for each role. It describes the role that students are to play, some tasks that the group will be performing, and reasons why certain steps must be done before other groups can get their work done. Be sure to set a deadline for the public presentation of the MagLev models and the town meeting.

BACKGROUND INFORMATION

Fossil fuels are dwindling. They are also a source of pollution that is threatening our atmosphere. A magnetic levitation system consists of safe, quiet, nonpolluting vehicles. Worldwide there are two types of magnetic levitation trains: those that use superconducting magnets and those that use conventional magnets. Both systems can travel at very high speeds; both systems are nonpolluting. The German system relies on attraction; the Japanese system on repulsion. In both systems propulsion is similar in that the train rides on an electromagnetic wave. The German Transrapid has no wheels; electromagnets on board are attracted to a magnetic surface on top of the track. This lifts the train about 1 cm off the ground. The Japanese system rests on a set of wheels. When it reaches 100 mph it levitates 10 cm above the rails. Both systems rely on a lateral guidance system to keep the train in the middle of the track.

The Florida Maglev Consortium, Inc. (FMLC), a public-private partnership of private high-tech companies, local governments, and the Florida Department of Transportation that proposed building a high-speed transportation system based on magnetic levitation technology. The high-speed vehicles were to run from Miami to Orlando to St. Petersburg. FMLC made the following claims: environmental impacts are minor; the system will attract business; and the system will provide safe, fast, and affordable mass transportation.

The Florida system proposes the superconducting magnet system. The vehicle itself becomes a superconducting magnet that rides in a magnetic field on a "guideway." The magnetic field shifts (controlled from a substation) and the wheelless train is propelled at great speeds along the guideway. The Florida Maglev system was intended to be inexpensive, fast, and frequent; one feature was to link the high speed train system with airlines, buses, local railway lines, and cruise ships to become part of an overall statewide transportation system.



WHAT WILL STUDENTS DO?

1. Remind students that they will need their models created for Activity 9.

2. Divide the class into 9 groups and hand out the student group worksheets for each of the following groups:

   - ❑ Design Group
   - ❑ 4 Builders Groups
   - ❑ The Public
   - ❑ Marketing Group
   - ❑ State Legislators
   - ❑ The Department of Transportation

3. Give each group a chance to look them over and then discuss the worksheets with each group individually before they begin the activity.

4. Either set up a schedule to meet with each group or walk around visiting with eachgroup on a regular basis for the duration of the Activity.

5. Once you are comfortable that groups know what to do, you serve in an advisory capacity.

6. Once the public meeting is organized by "The Public," you will need to make a poster or put on the board the question that will be answered in the meeting: Should we support a MagLev system of transportation in Florida?

FOR YOUR PLANBOOK:

Materials:

- ❑ MagLev train models from Activity 9
- ❑ Group worksheets
- ❑ Materials to make new train models (See Activity 9)
- ❑ Science Notebooks

National Science Education Content Standards: A, E, F, G

Florida Sunshine State Standards:

Science
Grades K-2
SC.B.2.1.1, SC.C.1.1.1, SC.C.2.1.1, SC.H.1.1.1 - SC.H.1.1.5, SC.H.3.1.1

Grades 3-5
SC.B.2.2.2, SC.C.1.2.1, SC.C.2.2.2, SC.C.2.2.3, SC.D.2.2.1, SC.H.1.2.1, SC.H.1.2.5, SC.H.3.1.1 - SC.H.3.2.4

Language Arts
Grades K-2
LA.A.2.1.3, LA.B.2.1.1, LA.C.1.1.1, LA.C.1.1.3, LA.C.3.1.2

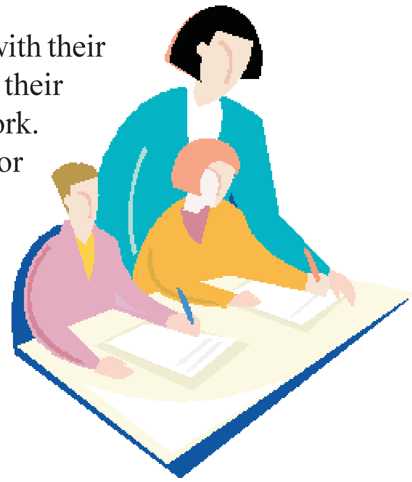
Grades 3-5
LA.A.2.2.5, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.3, LA.C.1.2.3

Social Studies
Grades K-2
SS.A.1.1.1, SS.A.1.1.2, SS.A.1.1.4, SS.A.2.1.2

Grades 3-5
SS.A.1.2.1, SS.A.1.2.3, SS.A.2.2.2, SS.B.2.2.3, SS.B.2.2.4, SS.D.1.2.2

Homework:
Assign this task before beginning the activity. Each student will consider his or her role for this activity and write a paragraph or two identifying what they think their job will be, what kinds of tasks they will have to do, and who they will be dealing with. For example, if the student is assigned the role of member of the design group, they will probably imagine that their group must prepare a materials list, approximate costs of materials, make a plan from which the builders group will work, etc.

Homework Assessment:
Not only will students be better prepared to work with their groups on this activity, but they will also organize their ideas about how people in these positions really work. Encourage students to seek out friends, relatives, or neighbors who might be in similar positions. They could call the Department of Transportation, for instance, or a design office that creates plans for others to follow. Students will be translating their classwork to real world experiences. Any description that closely approximates the job as you envision it is acceptable.

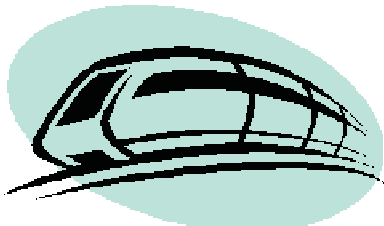


Assessment:
One way to assess whether or not your students have successfully completed this activity is to devise a checklist. For example, with each group, list characteristics of a successful group experience: all members participated, group defined their task, wrote letters of support, interacted with other groups, defended their position, participated in public debate, and so forth. If all criteria are met, then the group earns an A; if 5 out of 6 are complete, then they have earned an A-, etc. In this way, students are aware of grading criteria ahead of time and have a shared vision of how to be successful.

EXTENSIONS:

Reading:
Have students read “Buy Jupiter” by Isaac Asimov (found in *Fantastic Reading: Stories and Activities Grades 5-8*, Scott, Foresman, & Co., 1984, ISBN 0-673-15936-1) or you can read it aloud to them. Negotiating is an important skill in deciding what scientific innovations or inventions to market to the public. In the story, the Minister of Science is the one who is in charge of negotiations. Clearly, the government thought the negotiations involved a scientific discovery of some importance. Students will model the relationship between scientific invention and the real-life skills necessary to bring that invention to the public.

Research:
Students research, using the worldwide web, specifications of present magnetic levitation train systems. Then have them compare and contrast the systems.



MAGLEV MODEL TRAIN COMPETITION

DESIGN GROUP

The job of the Design Group is to choose four MagLev train model designs that will be built and presented to the general public, a marketing group, state legislators, and representatives of the Department of Transportation. This group, including you and the model builders, will be involved in the final discussion as to whether this technology should be used in Florida.

1. Gather the designs done for Activity 9: Build a MagLev Train Model.

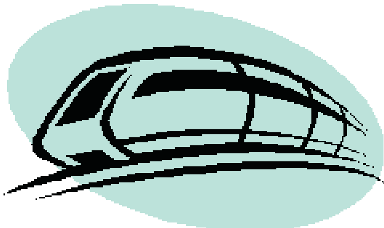
2. Before choosing the designs to support, meet with the Department of Transportation to get specifications of what features they think are necessary for the State of Florida to approve the plan.

3. Choose the four designs that you think are best suited for public presentation to diverse groups. You may suggest changes or modifications to the existing designs. Each Builder Group will be responsible for building one of the models.

4. Write a letter of support to each Builder Group stating why you support that design.

5. Give each of the four groups one of the design plans that you have approved, accompanied by the letter of support.

6. One person needs to work with each of the four design groups to oversee the work being done.



MAGLEV MODEL TRAIN COMPETITION

DEPARTMENT OF TRANSPORTATION

The Department of Transportation has two main jobs:

- ❑ Determine if MagLev technology is in the best interest of the State of Florida.

- ❑ Provide guidelines for the Builder Groups to follow.

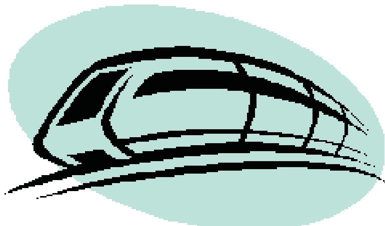
1. Decide on proposed route(s) for the train and identify the political districts that will be affected by the train system. You will need a map of Florida.

2. Develop specifications that the train system must meet; that is, decide what features you think Florida's system needs. Do you need for the train to carry large numbers of people long distances? Do you wish the train to be fast to move people quickly from place to place? Are your concerns environmental? Where in the state do you believe this system would be best utilized? Are you imagining a small train or a large train?

3. Meet with the design group to explain to them the conditions that must be met before the State will approve a design.

4. Write a letter to the members of the State legislators group telling them what kind of system you are supporting and why.

5. If you decide to make changes in the design of the system or the model itself, let the Design Group know so they can inform the Builders Group.



MAGLEV MODEL TRAIN COMPETITION

THE PUBLIC

Your group will be planning and hosting a public meeting of all concerned groups: the design group, the four builders groups, the marketing group, State legislators, and the Department of Transportation. This involves data gathering so that you will know the questions to ask and information to look for.

1. Begin gathering information that will enable you to be effective decision-makers. Look up MagLev train technology; call the Department of Transportation in Tallahassee; find magazine articles written about Europe's rapid transit system.

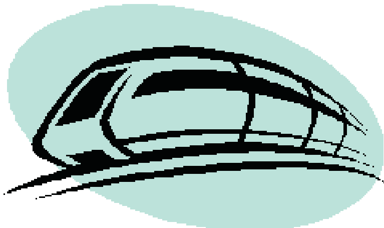
2. Visit the Design Group and the Department of Transportation in the classroom to study what they are doing. Take notes so that you will have something to back up your opinions at the public meeting.

3. Plan a day and time for the meeting, checking with all groups to make sure that they will be ready. Then design an advertisement for the local newspaper announcing the meeting.

4. Organize the agenda for the meeting and distribute a copy to each group.

5. Develop a list of questions and/or topics for discussion at the public meeting and distribute a copy to each group.

6. Decide who will moderate (ask the questions and make sure everyone has a chance to speak). If all four people are going to participate, divide up the responsibilities, or decide how to implement that.



MAGLEV MODEL TRAIN COMPETITION

BUILDERS GROUP

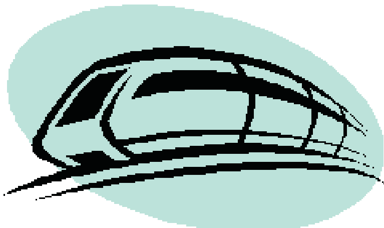
The job of your group is to build one of the MagLev train models based upon the plan given to you by the Design Group. There may be specific guidelines developed by the Department of Transportation group that you may need to follow. There is a certain date that this model must be ready to be presented at a public meeting.

1. Before you are given the design plan, you must discuss among yourselves the best materials to gather in anticipation of the actual work.

2. Get information on MagLev technology by using websites, phone calls, or print media. You can also interact with the Design Group to gather the most data about how your train would be used.

3. After receiving both the design plan and specifications from the Design Group, construct the model. If you need help with this, consult the Design Group. If you are unsure of why the specifications are written in a certain way, consult the Department of Transportation.

4. Have your model ready for the public meeting.



MAGLEV MODEL TRAIN COMPETITION

MARKETING GROUP

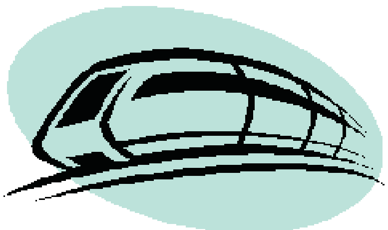
In anticipation of approval by the State of Florida, your group is designing a marketing campaign to make the public aware of this technology and informing them of their decisions.

1. First, discuss ways to anticipate what people will want to know about MagLev train technology.

2. From all the information that you gather from other groups, choose the information that you believe is the most important to transfer to the public (this also includes State legislators who represent the public).

3. Design a logo for the new Florida system of transportation and go to each of the four builders groups to see if they will put your logo on their design. If they want to know what is in it for them, you must have an answer ready. If you wish to try four logos (one for each model that will be presented) do so.

4. Come up with a plan (film, video, radio or TV spots, print advertising, etc.) to market the new trains. How will you educate the public? How will you publicize the new technology? What are the advantages that you can write about? What are the disadvantages that you can anticipate and explain.



MAGLEV MODEL TRAIN COMPETITION

STATE LEGISLATORS

Each legislator represents a different district, so depending upon whether you represent a district that is affected by the new transportation system or not, you must take a stand: Will you support the effort to develop and build a MagLev transportation system in the State of Florida?

1. Determine which of you will be representing a district that will be affected by the train system and which of you is representing a district that is NOT affected by the train system (you will have to meet with the Department of Transportation).

2. Anticipate questions that the people who live in your district will ask you. For example, is the system environmentally safe? Will it bring jobs to our area? What kinds of jobs? Will tourists like this system? Will we get more tourist dollars? What will we get out of this? Is there an alternative to the MagLev technology that other groups have not considered?

3. Decide whether your group will support the effort for a MagLev train system or not. Be prepared to defend your position at the public meeting.

4. Meet with the other groups to gather as much information as you can and then write an editorial for the local newspaper on your position. You could call a local legislator and ask him or her about the kinds of research done to learn about issues and the kinds of questions that they ask.

5. Be prepared to argue pro (for) or con (against) for the MagLev train system at the public meeting.

Inquiry 1

WHAT ARE COW MAGNETS?

Many people are not aware of cow magnets and how they are used. Comparing the cow's anatomy with that of humans (or any other animal that you are studying), can serve to link the study of magnetism with other areas of science.

Students use information about cow magnets that they acquire to complete a product of their choosing based upon their individual learning style. Any one of the "Assessments," or a combination, can be completed for this assignment. Background Information is provided for your use to guide the students. It is expected that students will perform their own research using the Internet or print media. Contacting an Agricultural Extension Office, the Department of Agriculture, a farmer, a veterinarian or a university or college is another way of gathering data.

Pass the cow magnet around for everyone to observe and handle. Keep the magnet accessible so students can continue to touch it and use it to inspire their work.

BACKGROUND INFORMATION

Ruminants have a 4-chambered stomach consisting of the rumen, reticulum, omasum, and abomasum. As a cow feeds, grass is passed to the rumen where it is broken down and turned into cud (small balls). The cud is returned to the cow's mouth where it is rechewed and passed to the reticulum. Then it passes on to the omasum and lastly to the abomasum where enzymes facilitate final digestion. The abomasum is sometimes called a *true stomach* because this is where real digestion occurs.

Dairy farmers realized that they had a problem related to digestion in cows. The cows ingested pieces of wire used to bale hay or from fences. The wire would pass along into the cow's second stomach and could puncture the animal's heart or other vital organs nearby. This condition is called *hardware disease* and before farmers used cow magnets, they lost many animals.

Cow magnets are put into the cow's throat, swallowed and are lodged in the reticulum, although they can sometimes stay in the first stomach. They do not harm the animal. The magnet attracts the pieces of metal wire (and any other metal objects) that they swallow and keep them from doing any damage. If the magnets become totally covered by debris and can no longer attract metals, the farmer must make a decision as to whether or not it is worthwhile to operate. If the animal is valuable, the farmer may decide to have the magnet removed, the metal removed and then replaced. If, however, the animal is not, the cow is simply replaced. Once the cow dies or is slaughtered, the cow magnet can be retrieved and reused.

FOR YOUR PLANBOOK:

Materials:

- ❑ Cow magnet
- ❑ Supplies for projects
- ❑ Print and electronic research materials

National Science Education Content Standards: A, C, E, F, G

Florida Sunshine State Standards:

Science
Grades K-2
SC.C.2.1.1, SC.F.1.1.4, SC.G.2.1.2, SC.H.1.1.1

Grades 3-5
SC.C.2.2.2, SC.F.1.2.2, SC.F.1.2.3, SC.G.2.2.3, SC.H.1.2.2

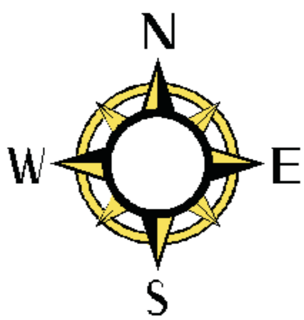
Homework:
It is intended that students will work on their chosen projects at home over a designated period of time based on the complexity of the project or the amount of time that you wish to devote to the activity.

Assessment:
The following suggested extensions are ideas of areas explore that relate to cow magnets. Ideally students wil generate ideas, plans for carrying out their ideas, and ways to present their findings to the class. All explorations require presentation to the class which could be done as a poster session, an oral report, role-playing "skit," musical composition, artwork, computer-assisted presentation, or multimedia presentation.

EXTENSIONS:

Technology:
The word *technology* for students usually means computers or computer-like machines. However, technology is any development used for a practical purpose that makes a task more efficient or more effective. The cow magnet can be considered a technological advancement because it saves farmers a great deal of money, saves the lives of cows, and solves a problem.

Have students research historical technological innovations and inventions that are sometimes overlooked when they study the cotton gin, the steamboat, electricity, etc. Brainstorm as a whole class seemingly simple technological designs that have made a difference in our lives. Students could start with cow magnets if they wish. Interviewing farmers who use them, agricultural extension workers who have information about them, farm bureaus and farm agents could provide information not available in textbooks or reference material.



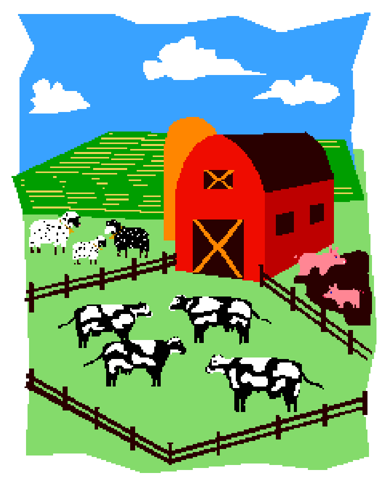
Other examples of "small" but important discoveries are the mechanical pen, the zipper, Velcro, the compass, Teflon, or tissues. Encourage students to look around and investigate something about which they are curious. Whether the students pursue the cow magnet as a technological invention or choose another invention or innovation, the research should reflect a variety of sources: websites, print media, videos, etc. Students are only limited by their imaginations for these explorations!

Allow students to choose their method of research and presentation as well as whether they work individually or in groups. This is a chance to address all learning styles in your classroom by encouraging choice and allowing students to design their own method of presentation.

Stomach stones:
Cow magnets serve another purpose — aiding digestion. Other animals, such as birds, swallow stones, which lodge in their gizzards and further grind food into digestible pieces. Most students are not aware of this phenomena. This is a natural connection to life science, comparative anatomy and animal behavior.

Additionally, there is some evidence that points to the fact that dinosaurs also ingested rocks to aid in digestion. This is another area for exploration that students may choose to pursue that would lead to research on geological time, connections of dinosaurs to modern birds, or fact versus fiction in movies and books.

Economic issues:
The farmer must make a choice when a cow magnet "fills up." Is it sound business practice to have a veterinarian perform a costly operation on the cow or is it a better decision to have the cow slaughtered? This type of decision is one that is made daily in the business world; a decision that requires determining how much something is "worth." The concept of worth is one that will require discussion because it is different for each person. An animal lover will say that sacrificing the cow because of monetary reasons is inhumane; on the other hand, a practical businessman will say that the cow is no longer a good investment, so it is time to cut the losses.



Students could debate this issue in front of the class and bring in other topics of this sort. For example, should developers be forced to give up building plans because of a bird's nest? Whose rights are violated when boaters are fined when they hit a manatee? Is the "cost" of technological development too great to bear (e.g., space junk or toxic waste)?

Careers:
Farmers, veterinarians, Department of Agriculture employees, or farm bureau agents would be the most obvious career connections for students to make.

Interviewing:
is one technique for students to use to collect information. First student will design an interview instrument by developing a set of questions. Then students will decide on a method to record the responses, for example, chart or graph, in writing, audiotape, or videotape.

Creative writing:
Have students write a story dealing specifically with cow magnets. The story could be in the form of a cartoon or short story format that deals with the adventure of a cow with a magnet inside. It could be a science fiction story (tells a good story; deals with human nature; considers strange and unusual occurrences; and has science facts). Encourage students to present their stories in creative ways: as a play, cartoon, or computer presentation, for example.

Reading:
James Herriot wrote a number of books about the experiences of a country veterinarian. The most famous of his collections are: *All Creatures Great and Small, Every Living Thing,* and *All Things Bright and Beautiful.* His stories are the basis for a long-running PBS series, *All Creatures Great and Small* that is available at local libraries.

"How We Were Tracked By A Tripod," by John Christopher (found in *Science Fiction Stories,* edited by Edward Blishen, ISBN 1-85697-889-3) tells about boys followed by machines that tracked them by following metal plates that had been implanted in their heads.

Encourage students to find their own fiction and nonfiction reading material. Now that they know how magnets are used with other animals, they may wish to research how magnets are used in human medicine. For example, magnets are used by orthopedic surgeons to stimulate bone growth.

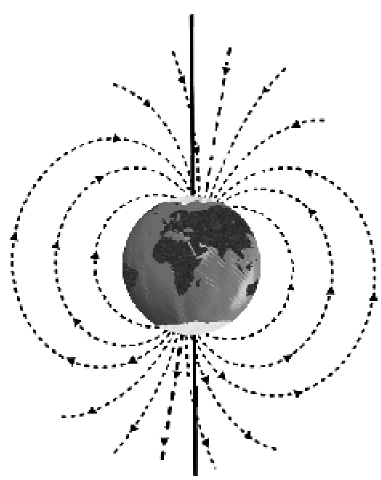
Inquiry 2

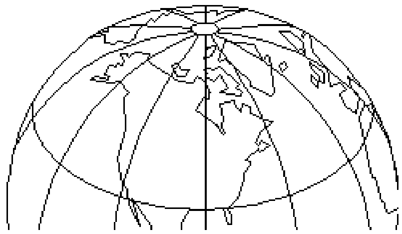
DO THE NORTH & SOUTH POLES EVER SWITCH?

This activity lends itself very well to making connections with Earth Science: in particular, the study of oceanography, plate tectonics and continental drift. You can make this connection for the students or simply propose it as a topic for further research. The reversal of present-day pole positions is a difficult concept, one that students may or may not be able to comprehend depending upon their level of sophistication. Since students are designing their own projects, however, they will relate this information to what they already understand in a way that makes sense to each one of them.

It is important that students be encouraged to design their own research project. Rather than choosing what they perceive as the easiest task, students should be encouraged to tap into their strengths (writing, art, music, computer graphics, or computer usage, for example). Depending upon your particular class, you may wish to contract with each student as to their vision of the project; or, you may be at a point where you can just assign a project and give guidance only where necessary. Projects can be done individually, in pairs, or in groups. This encourages students who are uncomfortable with group work the chance to demonstrate their individual strengths as well as to pursue a subject of particular interest.

This would be a good time to revisit your discussion of models and how they are used in science. A model does not have to be what we traditionally think of when we hear that word: car or ship models with pieces that are glued together or papier mâché representations. A model can be anything that allows students to look at or demonstrate an idea that is too large (or small) or too complex to observe directly.

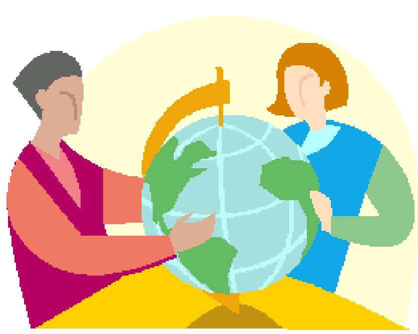




BACKGROUND INFORMATION

Although most of us are familiar with the North Pole and South Pole, the Earth's magnetic poles have switched several times throughout geologic history as is evidenced by magnetic stripes on the ocean floor. Magnetic stripes are indicators of polar wandering because of the iron content in basalt—the most common rock on the ocean floor. Basalts have a high iron content and as they are deposited on the ocean floor by volcanic eruptions cool and freeze leaving a magnetic "fingerprint." Each time there is an eruption; new layers of basalts are laid down on the ocean floor resulting in stripes that represent the direction of the magnetic field lines at the time of the eruption.

The actual reversal takes place relatively quickly (1000 years) once the process begins, although the entire process can take on the average 500,000 years. The study of paleomagnetism investigates polar wandering by counting back from mid-ocean ridges to determine the relative age of the stripes. Absolute dating can be done using potassium$_{40}$/argon$_{40}$. When scientists looked at rocks 1,000,000 years old, they found that the magnetic field at that time was close to today's position but when other rocks were tested, it was apparent that the north and south poles had switched positions. This disparity in rock layers is just one piece of evidence to support Alfred Wegener's theory of continental drift. He proposed that continents moved around on the Earth's surface after observing similar fossil evidence in rock layers from different locations (specifically Africa and South America). This led to the later theory of plate tectonics and the supercontinent of Pangaea, which supported Wegener's continental drift (5-10 cm per year) and is confirmed by magnetic rock layers.



FOR YOUR PLANBOOK:

Materials:

- ❑ Reference materials

National Science Education Content Standards: A, B, C, D, F, G

Florida Sunshine State Standards:

Science
Grades K-2
SC.C.1.1.2, SC.H.1.1.4, SC.H.2.1.1

Grades 3-5
SC.C.1.2.1, SC.C.2.2.4, SC.H.1.2.2, SC.H.1.2.5, SC.H.2.2.1, SC.H.3.2.2, SC.H.3.2.4

Language Arts
Grades K-2
LA.A.1.1.4, LA.A.2.1.5, LA.C.3.1.2

Grades 3-5
LA.A.1.2.4, LA.A.2.2.8, LA.B.1.2.1, LA.B.2.2.1, LA.B.2.2.5-LA.B.2.2.6, LA.C.3.3.2

Homework:
Have students work on projects at home.

Assessment:
Have students design a model, map, or other visual a demonstrates how scientists made the connection betw magnetic stripes on the ocean floor and the theory o continental drift. The model could compare the fossil evidence with magnetic rock layer evidence that supports Alfred Wegener's theory. Products should show the relationship between magnetic material on the ocean floor and how the continents have moved over the past 400,000,000 years. Encourage students to look for additional information using web sites, print material, videos, etc.

The theory of plate tectonics differs somewhat from continental drift theory in that it is not just the continents that are moving but, in fact, the entire tectonic plate floating on the upper part of the mantle. Have students come up with a way to present the difference between continental drift and plate tectonics to the class. Encourage students to use computer graphics (QuickTime movies from the worldwide web, for example) as a means to present information to a large group. This assessment lends itself well to artwork (clay models or other media) that represents continents and the plates upon which they rest. Students may choose to write a research report and present it orally.

Have more advanced science students with a chemistry background research and report on the difference between relative and absolute dating. Specifically, the difference between $Carbon_{14}$ dating and the dating done using $Potassium_{40}$ $Argon_{40}$. Students will design a model or activity that presents the information. The product, in order to be successful, will clarify this information for the class. Encourage the students to include with their product an evaluation of some sort so that they can determine whether or not they were successful in explaining the topic to others. This could be in the form of a quiz or short essay question(s) or a survey that has several student-oriented questions.

EXTENSIONS:

Creative writing

Assign a fiction story about how the magnetic stripes on the ocean floor affect an animal that uses magnetoreceptors (see Inquiry 3: What is Animal Magnetism?) to migrate. This might take the form of an animal that has adventures because he goes off course because of the stripes; animals that exhibit special characteristics because the magnetic fields interfere with one another. In order for this assessment to be completed successfully, students must include information on magnetic fields and magnetic stripes.

Reading and writing.

Have students research articles on whale (and other mammals) beaching and ask the question, "Could there be some connection between Earth's magnetic field and this phenomena?" "Could there be a connection to magnetic stripes?" Probably the evidence will be inconclusive but this is an area of great interest among marine biologists at this time. An extensive print and website search will yield a great deal of information

Have students read *The Prince of Whales* by R.L. Fisher (ISBN 0-812-56635-1) or *When the Whales Came* by Michael Morpurgo (ISBN 0-590-42912-4). Both stories deal with whale migration; *When The Whales Came* with whale beaching in particular. Have students develop a book talk that presents both the story and science facts that could explain the phenomena dealt with in each book. Book talks are generally done to entice others to read a book. They usually contain a brief summary of the plot and a critique of information in the book (in this case), writing style, and examples to support each opinion offered. Notecards or an outline would be appropriate aids for the speaker.

Inquiry 3

WHAT IS ANIMAL MAGNETISM?

Many animals often travel great distances for a variety of reasons. Ducks fly south in formation often to the same nesting places. Whales, butterflies, and turtles are believed to use the earth's magnetic field to orient them when migrating. The idea that animals may have internal compasses that enable them to complete the same route time after time is one that scientists have been exploring for a very long time.

Students will be required to complete a project on the subject of animals and magnetism that is suitable to be presented to the entire class. Below are some suggestions that you may wish to share with your students. However, introducing them to the subject and letting each student or each group of students, design their own project would be the ideal. The due date that you assign plus the level of your students will determine the complexity of the projects.

BACKGROUND INFORMATION

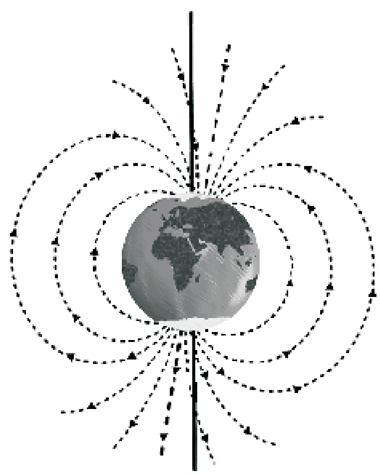
One way that animals are believed to travel great distances is called directional orientation. This implies the ability to travel in a certain direction without using landmarks of any sort. Scientists believe that animals are able to use the sun, the stars, and the earth's magnetic field as compasses. Birds are the most often used example of this phenomenon. They travel thousands of miles in a particular direction and stop when they have flown a prescribed distance.

Recently, there have been articles written on the monarch butterfly. A recent study demonstrated that in conjunction with its own internal clock, the monarch uses the sun as a compass to navigate. Monarchs fly 2400 miles across North America each spring. Such a long passage lead scientists to study the circumstances necessary for the monarch to make this journey. Although scientists have purported that the monarchs use the sun as a compass, they have also demonstrated that monarchs are able to continue their journey even when it is cloudy. They believe this is due to an internal backup compass. This study has led to an increased interest in the way in which other animals navigate over long distances.

Animals other than birds that exhibit this ability are turtles, whales, and dolphins. Bees are believed to be influenced by some kind of magnetoreception as are some types of bacteria. Salmon, sharks, rays, and other fish are also influenced by the earth's magnetic field either alone or in conjunction with other influences such as magnetite deposits, light, or electricity. It is also thought that some animals are sensitive to polarity: the fish swims in a certain direction because the magnetic field is becoming stronger or weaker.

Some animals actually have magnetite in their bodies, usually in the skull. This could enable animals to carry around with them a permanent magnet that acts as a compass as they migrate. The magnetite might align with the earth's magnetic field and stimulate some other receptor so that the animal is aware of the direction and strength of the magnetic field. Some bacteria navigate in this manner. The permanent magnets in these cells act like a compass needle. The bacteria then swim in the direction toward magnetic north (in the Northern Hemisphere).

A good source for information on magnetoreception is *Perspectives on Animal Behavior* by Judith Goodenough, Betty McGuire, and Robert Wallace (John Wiley & Sons, 1993, ISBN 0-471-53623-7).



FOR YOUR PLANBOOK:

Materials:

- ❑ Resource materials
- ❑ Project supplies

National Science Education Content Standards: A, B, C, D, G

Florida Sunshine State Standards:
Science
Grades K-2
SC.F.1.1.4, SC.F.2.1.2, SC.G.1.1.3, SC.G.1.1.4, SC.H.111 - SC.H.114

Grades 3-5
SC.C.2.2.2, S.C.F.1.2.3, SC.F.2.2.A, SC.G.1.2L3, SC.H.1.2.1 - SC.H.1.2.4

Language Arts
Grades K-2
LA.A.1.1.4, LA.C.3.1.3, LA.D.2.1.3

Grades 3-5
LA.A.1.2.4, LA.A.2.2.2, LA.A.2.2.5, LA.B.1.2.1, LA.C.3.2.2, LA.D.2.2.4, LA.E.2.2.3

Homework:
Students will work on their projects at home.

Assessment:
Although the method of presentation is up to each student based on his or her learning style, each student or group of students should have a presentation for the whole class. The presentation will include information on how the earth's magnetic field influences animal behavior to indicate that students have determined the relationship between migratory patterns and magnetism. There should be some discussion of an internal compass to show that students can think critically about information on magnetism. Students will demonstrate that they have designed a project and executed that design.

EXTENSIONS:

Research:
Regardless of how students decide to present findings, this subject requires research in scientific journals (for example, *Nature* or *Scientific American*). Web sites could be explored as could textbooks, or encyclopedias. Explain to students that looking up information on web sites and printing this information is not creating a report and would be unacceptable.

Reading and Writing
Using web sites, or print media, students explore information about animals that use the earth's magnetic field to guide their migratory journeys. There are many outstanding science magazines that can be accessed through school, public, or university libraries. Expository reading in science is an important skill for students to develop. Information can be presented in a variety of ways that encourage analysis of information and the relationship between that information and the subject being studied.

Have students highlight articles as they read, then summarize, and present a poster summarizing the articles. By pulling out the most important information, students will be forced to identify what is closely related to the study of magnetism. Students will be critical readers as well as demonstrate that they can paraphrase and summarize pertinent information.

Some students could create an annotated bibliography for other students to use in the future. In doing so, the student will list sources as well as a short explanation of what can be found at that source. Students will have to distinguish between articles and books that delve into the subject and those that just mention it.

The Prince of Whales by R.L. Fisher (ISBN 0-812-56635-1) is a clever story of a young whale that sets out by himself as he is forced to leave his pod. The pod leaves for their annual migration and the single whale, Toby, must proceed alone. Although this fantasy does not deal with magnetic reception specifically, students could make the connection. A possible product could be a diorama, drawing, or a book talk that states the relationship between Toby's journey and the study of magnetism used to support migratory patterns of whales.

Have students create a science fiction or creative writing story that involves an animal that uses the earth's magnetic field to find it's way. Stories should include all characteristics of science fiction (tells a good story, deals with human nature, includes science fact, and presents something strange or unusual).

Students can create an illustrated booklet for younger children that deals with this subject. This would require that students be able to explain to others how animals use the earth's magnetic field to navigate. Stating explanations and then finding a way to present them to another person will strengthen the need for students to clarify their own ideas.

Art
Have students create a diorama of insects, birds, or mammals that use the earth's magnetic field to find direction. The relationship between magnetism and animals' ability to find direction must be clearly displayed plus students will orally explain their project to the rest of the class. Explanations should include why they chose that particular animal, how that animal differs from others, and how it uses either an internal or external compass.

Computer presentation
A multimedia presentation could include movies, video clips, a slide show, or any combination of these with text. This could be viewed on individual computers, through a monitor for large-group viewing, or in any other way that the students design themselves. Once they have collected information, students individually or in groups should design a plan for implementing the presentation of the information. Have students present the plan to you for approval, making sure that the task can be completed in the time allotted. Students with computers at home will be more inclined to choose this option.

A computer version of an annotated bibliography could be accomplished through a detailed search of websites that provide information on "animal magnetism." Using the technique of listing the site and then critiquing the site for usefulness, complexity, readability, accuracy, etc., requires that students analyze what they are reading and compare sites. Many websites contain similar information; how well that information is presented (spelling, grammar, etc.) and how sources are presented so that students have confidence that the information is accurate are important skills for middle school students to learn.

Notes: