JUNIOR MAGNET KIT
CAT NO. PH 0800

Experiment Guide

GENERAL BACKGROUND:

Learning objectives:

- Magnets can attract other magnetic objects, or repel them.
- Iron is the most common magnetic metal. (Teacher's note: Nickel and Cobalt are also common and exhibit magnetic properties, as well as neodymium, gadolinium, and samarium)
- All magnets have a magnetic north pole and a magnetic south pole.
- The opposite poles (a north and a south) attract whereas like poles (both north or both south) repel.
- Magnetic poles always exist in pairs. It is impossible to have a north pole without a south pole.
- Magnets are objects that produce an area of magnetic force called a magnetic field.
- Magnetic fields by themselves are invisible to the human eye.
- Iron filings can be used to show magnetic fields created by magnets.
- Magnets only attract certain types of metals; other materials such as glass, plastic and wood aren't attracted. (Technically everything can be made to have some magnetic properties, look up levitating frogs for more details . . . but for beginning students the proceeding statement is sufficient.)
- Most metals are not attracted to magnets; these include copper, silver, gold, magnesium, platinum, aluminum and more. They may however magnetize a small amount while placed in a magnetic field.
- A magnetic field gets stronger the closer you are to the magnetic field.
- Earth has its own magnetic field. Scientists believe this is caused from the Earth's core which is believed to be an iron/nickel alloy.
- Earth's magnetic field can be used to help navigate north, south, east and west directions using a compass.
- A compass is really a tiny magnet on a pivot point.
- Compasses are unreliable in the presence of magnetic objects.

The first written account of humans mentioning the properties of magnets was around 600 BC by the Greek, Thales of Miletus.

Lodestones are made of magnetite and therefore attract iron. In 1086 AD, the Chinese are credited with first using a lodestone to create a compass for navigation. Up until that point magnets were objects of mysticism. There are written references to magnets possessing a soul. In the 4^{th} century BC the “South Pointer” compass was used for spiritual navigation only.

The earliest account of Europeans using a compass for navigation was in Ad1180 by Alexander Neckam. The magnet led Columbus to America, Vasco da Gamma around the horn of Africa and into India, and even led Ferdinand Magellan in his circumnavigation of the globe.

From these humble beginnings we now use magnets and the properties of magnetism to move large masses of metal, tell us when to change the signals on a stop light, and run our cellphones and television sets.

There are two types of magnets, permanent and temporary magnets. This magnet kit will deal with permanent magnets.

What makes something magnetic? Electrons are always spinning. A moving electrical field produces a moving magnetic field. Electrons prefer to be in pairs in an atom. Usually the magnetic field of one electron is cancelled out by the other electron in the pair, which spins in the opposite direction. However there are some elements that have several unpaired electrons and these elements are easily permanently magnetized. These elements include iron, nickel, and cobalt. Permanent magnets are made out of these elements. Permanent magnets can also occur naturally. The first magnets discovered by man were dug out of Earth.

Magnetite and other permanent magnets have domains in them, which are small sections of the metal in which the magnetic field is aligned as shown in diagram 1. A piece of magnetite would be a weak magnet if only a few of the domains are aligned, but getting most of the domains remagnetized by placing the domains in a strong magnetic field makes a stronger magnet as shown in diagram 2.

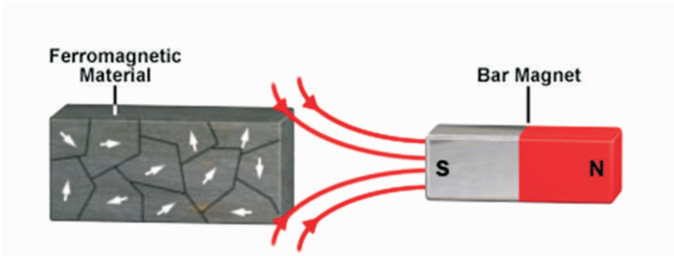

Diagram 1: Before the ferromagnetic material is placed in the magnetic field, each magnetic domain is point in different directions.

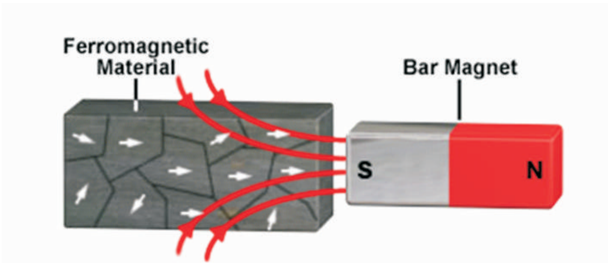

Diagram 2: After the ferromagnetic material is placed in the magnetic field, the magnetic domains slowly align in the same direction.

The more domains that are in the same direction the stronger the magnetic field of the magnet. In this way, a stronger magnetic field can change the polarity of a magnetic with a weaker magnetic field.

REQUIRED COMPONENTS (INCLUDED)

Name of Part	*Quantity*
Ring magnets	3
Metal squares (one each of Al, Zn, Cu, Fe)	4
Bar magnets	2
Horseshoe magnet	1
Iron filings	1 jar
Lode stone	1
Small compass	2

RECOMMENDED COMPONENTS (NOT INCLUDED)

Name of Part	*Quantity*
Camera	
White paper	4
String	1
Scissors	1
Balloon	1
Assorted rocks	1
Various objects around the classroom to test for magnetic properties	several
Pencil unsharpened	1

CAUTIONS: Magnets should be kept away from computers, computer disks, televisions, audio and video cassettes, credit cards, and other electronic equipment, or things that store information electronically.

Magnets can chip, break, or demagnetize if dropped or hit against something hard. Handle magnets with care.

When storing magnets, using the supplied magnet keepers. (The small metal strips attached to the ends of the horseshoe and bar magnet.) This will keep the magnetic field strength of the magnet stronger and also help protect your possessions from damage caused by the magnets.

Store magnets in a dry cool place, magnets can oxidize and high temperatures can also cause magnets to become demagnetized.

Never swallow magnets, this can be fatal.

Ceramic magnets are brittle and can chip easily. Do not allow magnets to collide into one another. Throw out any magnet with a sharp edge caused by breaking or chipping.

ACTIVITY 1: What Sticks?

TEACHER NOTES

MATERIALS NEEDED:

Magnet Kit with iron filings removed
Rocks from outside, different shapes and sizes
Various pieces of metal
A balloon blown up

Before starting, remove anything that could be damaged by magnets such as electronic equipment from the “testing” area.

To reduce the amount of mess made with this experiment it is suggested that the iron filings be removed from the kit.

Ask students: How do the magnets in the kit interact with other materials? In a student science journal or on a sheet of paper have the students record their observations in a table similar to the one below. Typical student responses are in italics. Focus on getting students to describe what they see in detail. The more descriptive they are and the more careful their observations the more they will learn and the more questions they will come up with and be able to answer themselves. Encourage different groups of students to test different things, for example, you want at least one group to test other magnets and how they react, you want at least one group to be interested in the load stone as opposed to other rocks, and one group to try different types of metals. If students have already studied static electricity, you may want to have students test a magnet with a balloon, and a balloon charged by rubbing it against one's hair. Students will be much more interested in answering questions they ask themselves, and answering these questions will help them learn the science principles behind magnetism.

About 10-15 minutes should give the students enough time to get a good list going. Tell students that they will share their findings with the class after the allotted time is up.

As a class compose a list of things that attracted to the magnets, things that were repelled by the magnets, and things that the magnets had no effect on. Now is a good time to introduce the terminology attract, repel, north pole, and south pole.

Object magnet interacted with with the magnet	**How the object behaved when interacting**
Rock in the kit (lodestone)	*The lodestone stuck to the magnet*
Notebook	*The magnet had no effect on the paper, but it stuck to the wire on the edge of the notebook*
Piece of copper (Cu)	*The magnet had no effect on the Copper*
Piece of Zinc (Zn)	“
Piece of Aluminum (Al)	“
Piece of Iron (Fe)	*The iron stuck to both ends of the magnet*
Compass	*One end of the magnet with the S on it pulled the pointy end of the compass towards the magnet and followed it around and the other end of the magnet with the N on it pulled the not pointy end of the compass toward the magnet and followed it around*
Rock (from outside)	*No interaction*
N side of the magnet	*The side of the magnet marked 'N' pushed the 'N' side of the other magnet away from it and stuck only to the 'S' side of the magnet.*

FOLLOW UP QUESTIONS:

1. Name at least three things that were attracted to the magnets.
2. Name at least one thing that was repelled by the magnet.
3. Do magnets need to touch an object to attract it or repel it? Give evidence to support your answer.

Name:____ Date:______________

ACTIVITY 1: WHAT STICKS?

MATERIALS NEEDED:

Magnet Kit with iron filings removed

Objects around the room

Answer the following question by testing different objects in the kit and around the room. Be prepared to share your findings with the class.

QUESTION: How do the magnets in the kit interact with other materials?

Object magnet interacted with with the magnet	How the object behaved when interacting

FOLLOW UP QUESTIONS:

1. Name at least three things that were attracted to the magnets.

2. Name at least one thing that was repelled by the magnet.

3. Do magnets need to touch an object to attract it or repel it? Give evidence to support your answer.

ACTIVITY 2: ATTRACTIVE OR REPULSIVE?

TEACHER ANSWERS

One of the reasons magnets are so fun to play with is its properties of attracting and repelling other magnets. Most students come into the classroom knowing that opposite poles attract and like poles repel, however these fun activities will make sure all students are on the same page when it comes to identifying the basic properties of magnets. Give students 2 minutes in the beginning of class to answer the following questions and go over the answers quickly to make sure everyone is using the same vocabulary.

Preview Questions: Answer these questions based on your preexisting knowledge of magnets.

1. On your bar magnets there is one end labeled with an "N", this end is a called the *north pole* of the magnet.
2. On your bar magnets there is one end labeled with an "S", this end is called the *south pole* of the magnet.
3. Every magnet that ever existed has a north and south pole. True or False?

PROCEDURE:

1. Remove two bar magnets from your kit and identify the north pole and south pole. Place the magnets flat on your piece of paper and slowly bring one south pole of your bar magnet near the south pole of the other bar magnet as shown in diagram 3 below.

Diagram 3

Describe what happened:

The second bar magnet moved back away from the first bar magnet I was holding.

2. Bring the north pole of your bar magnet towards the south pole of the second bar magnet.

Describe what happened:

When the bar magnets were about ½ an inch away from each other the second bar magnet slide towards the first bar magnet and the magnets stuck together.

3. Bring the north pole of your bar magnet towards the north pole of the second bar magnet.

Describe what happened:

The second bar magnet moved back away from the first bar magnet I was holding.

FOLLOW UP QUESTIONS:

1. If the north pole of a compass is attracted to the end of the bar magnet, then that end of the bar magnet is a *south pole.*
2. Opposite poles of a magnet attract / repel. (Circle the word that best completes the sentence.)
3. The same poles of two magnets attract / repel. (Circle the word that best completes the sentence.)
4. If a magnet is not labeled with an N or S, how can you tell which end is the north pole of the magnet?

   Bring a bar magnet with known poles near the unlabeled magnet, and if the north pole attracts, it is a south pole. If the north pole repels, it is another north pole. Technically repelling is the only true test of another magnetic pole, since a piece of iron that is not a magnet would attract to a bar magnet, and a balloon with a static charge would also attract a bar magnet.

PROCEDURE CONTINUED:

4. Determine which end of your compass is the north pole of your compass and explain how you determined this. Check your answer with your teacher before continuing on.

   The end of my compass with the arrow is the north pole of my compass because it is attracted to the south pole of my magnet and repelled by the north pole of my magnet. Teacher's Note: This is true of most compasses, however some compasses may have been repolarized and the point of the compass may be the south pole.

5. Use your compass to explore the other magnets in your magnet kit, including the lode stone, the ring magnet, and the horseshoe magnet. In the space provided below, sketch each of the other magnets in the case so that the north pole of your magnet is on the left side of the paper and the south pole of the magnet is on the right side of the paper.

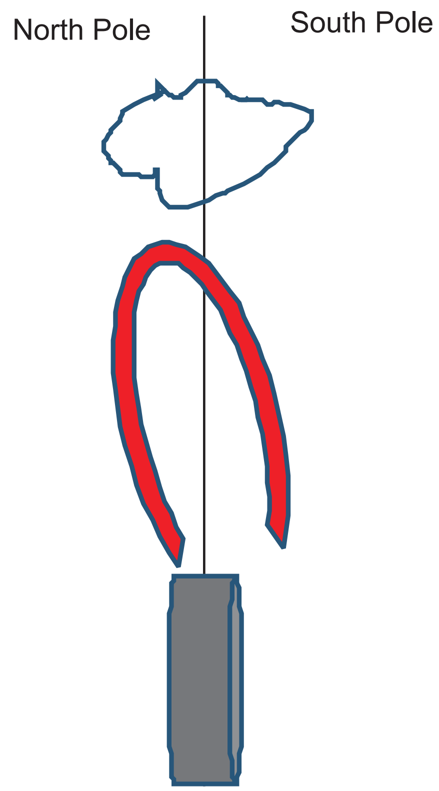

Diagram 4

6. Take out the other compass in your kit. Try to align them so that the two arrows point towards one another. Is it possible to do this? Why or why not?

   It is impossible to get the two poles to point towards one another. They are both attracted towards the magnetic south pole, so when separated by a distance they both point in the same direction. If they are moved towards one another then each compass needle is a tiny magnet, and the arrows are both magnetic north poles, therefore they will repel each other. If, however, one of the needles is remagnetized so that the point of the needle is a magnetic south pole, then the two ends will point towards each other.

FOLLOW UP QUESTIONS:

1. A forest ranger uses a belt with an aluminum buckle when navigating with her compass deep out in the woods. Bring your compass needle towards some of the metal objects in the kit. Why would the forest ranger want an aluminum buckle instead of an iron one?

   The aluminum in our kit had no effect on direction of the compass needle, but the compass needle was attracted to the iron, if there is iron in normal belt buckles, the forest range's compass would not point north, but be attracted to the belt buckle and the forest ranger might get lost in the woods.

2. Inside Earth is a gigantic magnetic. In the absence of other magnetic fields, a compass needle is attracted to this gigantic magnet. The north pole of the compass needle is attracted to the geographic North Pole. Using this information, label the magnetic north and south pole of Earth on the bar magnet in the picture below.

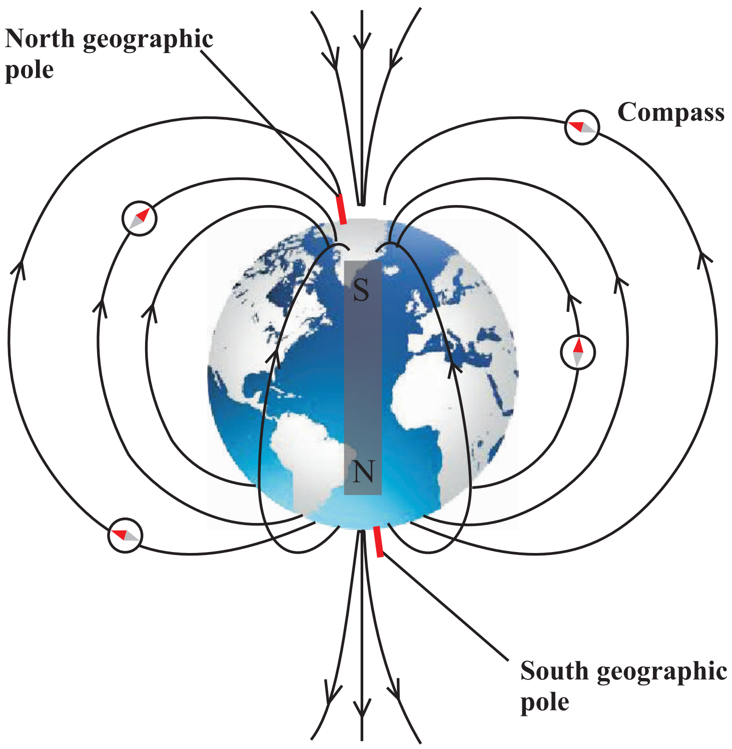

Diagram 5

Name:____ Date:________________

ACTIVITY 2: ATTRACTIVE OR REPULSIVE?

One of the reasons magnets are so fun to play with are their properties of attracting and repelling other magnets. Take two minutes to answer the preview questions below.

Preview Questions: Answer these questions based on your preexisting knowledge of magnets.

1. On your bar magnets there is one end labeled with an "N", this end is a called the ________________________________ of the magnet.
2. On your bar magnets there is one end labeled with an "S", this end is called the ________________________________ of the magnet.
3. Every magnet that ever existed has a north and south pole. True or False?

PROCEDURE:

1. Remove two bar magnets from your kit and identify the north pole and south pole. Place the magnets flat on your piece of paper and slowly bring one south pole of your bar magnet near the south pole of the other bar magnet as shown in diagram 3 below.

Diagram 3

Describe what happened:

____

____

2. Bring the north pole of your bar magnet towards the south pole of the second bar magnet.

   Describe what happened:

____

____

3. Bring the north pole of your bar magnet towards the north pole of the second bar magnet.

   Describe what happened:

____

____

FOLLOW UP QUESTIONS:

1 If the north pole of a compass is attracted to the end of the bar magnet, then that end of the bar magnet is a ________________________.
2. Opposite poles of a magnet attract/repel. (Circle the word that best completes the sentence.)
3. The same poles of two magnets attract/repel.(Circle the word that best completes the sentence.)
4. If a magnet is not labeled with an N or S, how can you tell which end is the North Pole of the magnet?

____

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PROCEDURE CONTINUED:

4. Determine which end of your compass is the north pole of your compass and explain how you determined this. Check your answer with your teacher before continuing on.

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____

5. Use your compass to explore the other magnets in your magnet kit, including the lode stone, the ring magnet and the horseshoe magnet. In the space provided below, sketch each of the other magnets in the case so that the north pole of your magnet is on the left side of the paper and the south pole of the magnet is on the right side of the paper.

North Pole	South Pole

6. Take out the other compass in your kit. Try to align them so that the two arrows point towards one another. Is it possible to do this? Why or why not?

____

____

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____

FOLLOW UP QUESTIONS:

1. A forest ranger uses a belt with an aluminum buckle when navigating with her compass deep out in the woods. Bring your compass needle towards some of the metal objects in the kit. Why would the forest ranger want an aluminum buckle instead of an iron one?

____

____

____

____

2. Inside Earth is a gigantic magnetic. In the absence of other magnetic fields, a compass needle is attracted to this gigantic magnet. The north pole of the compass needle is attracted to the geographic North Pole. Using this information, label *the magnetic* north and south pole of Earth on the bar magnet in the picture below.

Diagram 6

ACTIVITY 3: THE EARTH IS A GIANT MAGNET

TEACHER NOTES

Tie a rope around the bar magnets and hang the magnets in different places around the room as shown in diagram 7. Allow them to rotate freely. Make sure they are far enough away from each other that their magnetic fields are not interacting with one another. The magnets will eventually come to rest with the north end of the bar magnet pointing towards the North Pole. Let students come in and make some observations about the magnets, have them write their observations down individually and then share their thoughts with a neighbor and then with the whole class. Make a list of observations. Students should notice that all the magnets are pointing in the same direction.

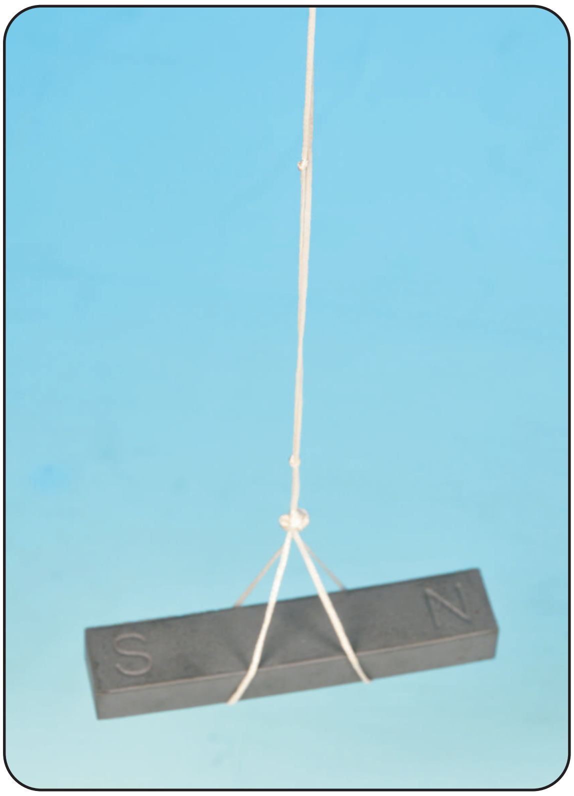


Diagram 7

Propose questions to the students such as: Why are the magnets all pointing in the same direction? What could we change about this set up to have them point in different directions?

Have students write down their ideas by themselves first and come up with a few hypotheses. Students may want to try finding other long thin objects to see if they line up North to South, such as a pencil or pen or ruler. (They won't line up) Students may want to spin the magnets to see if they always end up pointing north towards the North Poles. (It will.) Some students may want to see if a compass will affect the direction that the magnet aligns. (There is actually enough magnetic force from the compass needle to cause the bar magnet to move in response to the compass.) Allow students to come up with a question they want to investigate. Give students five minutes to investigate and report back on their findings to the class. Students should state the question they asked, give a brief explanation of what they did to answer their question, explain what happened, and finally draw a conclusion based on their results.

Answer: The magnets line up facing the North Pole because Earth has a magnetic field. Inside Earth is an iron core that is rotating and it creates a large magnet in the center of Earth. This Earth sized magnet helped early explorers navigate around the globe using lodestones. Lodestones are made of magnetite and therefore attract iron and are themselves magnets. In 1086 AD, the Chinese are credited with first using a lodestone to create a compass for navigation. The earliest account of Europeans using a compass for navigation was in 1180 by Alexander Neckam. The magnet led Columbus to America, Vasco da Gamma around the horn of Africa and into India, and even led Ferdinand Magellan in his circumnavigation of the globe. Imagine yourself in the middle of the ocean during the day. Everything in every direction looks the same: flat water everywhere. A compass allowed early navigators to discern a direction and to follow that path for long enough to make it somewhere new.

FOLLOW UP QUESTIONS:

1. What direction does the north pole of a bar magnet face if left to rotate freely on its own?

   North

2. What end of a bar magnet does the north pole of a magnet attract to?

   The south end of a bar magnet

3. If Earth is viewed as a gigantic magnet, and the north pole of every magnet points towards the geographic North Pole, which end of the Earth's magnet must be at the geographic North Pole, the magnetic north pole or the magnetic south pole?

   The south end of the magnet is located at the North Pole

4. On the diagram below, label the north and south poles of the magnet inside Earth and then draw at least 5 magnetic field lines around Earth showing the direction the magnetic field lines point.

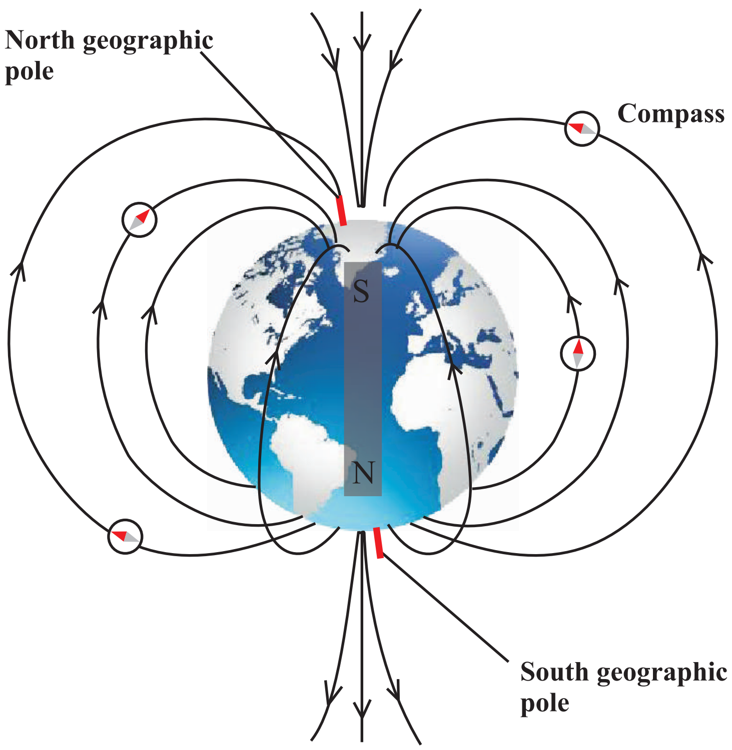


Diagram 5

5. A compass needle always points north when allowed to freely rotate. It is reasonable to say that a compass needle is a tiny permanent magnet? Explain your answer.

   It is reasonable to say that a compass needle is a tiny permanent magnet. A compass needle's north pole is attracted to any south pole of a magnet brought near it, whether it is that of Earth or of a nearby magnet and the north pole of the compass needle is repelled by another north pole. Since the needle attracts and repels other magnets, it is therefore a magnet itself, and not just a piece of metal that has induced magnetism in the presence of a magnetic field.

Name:____ Date:________________

ACTIVITY 3: EARTH IS A GIANT MAGNET

OBSERVATIONS:

Question your group wants to test:

PROCEDURE FOLLOWED:

DATA:

CONCLUSION:

FOLLOW UP QUESTIONS:

1. What direction does the north pole of a bar magnet face if left to rotate freely on its own?

   ____

2. What end of a bar magnet does the north pole of a magnet attract to?

   ____

3. If Earth is viewed as a gigantic magnet, and the north pole of every magnet points towards the geographic North Pole, which end of the Earth's magnet must be at the geographic North Pole, the magnetic north pole or the magnetic south pole?

   ____

   ____

4. On the diagram below, label the north and south poles of the "bar magnet" inside Earth and then draw at least 5 magnetic field lines around Earth showing the direction the magnetic field lines point.

Diagram 6

5. A compass needle always points north when allowed to freely rotate. It is reasonable to say that a compass needle is a tiny permanent magnet? Explain your answer.

ACTIVITY 4: SEEING MAGNETIC FIELDS

TEACHER NOTES

The answer to question 3 in activity 1 “Do objects need to touch a magnet in order to attract or repel it?” will lead naturally into activity 4. Magnetic forces can act at a distance, which means they provide a push or pull (also known as a force) at a distance. The space around a magnet in which the magnet will apply a force to another magnetic object is called the magnetic field. Explain to students that even though we cannot see magnetic field lines with our eyes, there is a special way we can make the magnetic field lines visible: using iron filings.

WARNING: Spread filings on only the white paper and discard of filings immediately when done. Never stick a magnet into the filings or pour filings directly on the magnet. Iron filings are often rusty and will discolor any surface they are on. Also, once iron filings stick to a magnet, it is impossible to get all the filings off and the magnets will then get everything they come in contact with dirty. Have students wash hands after using iron filings and magnets.

DATA:

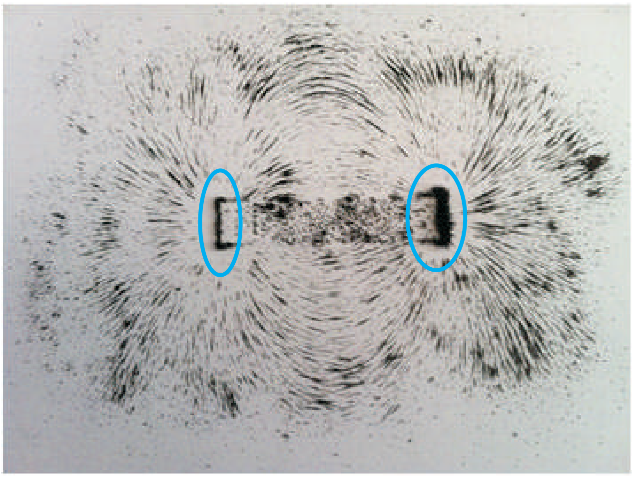


Diagram 8a:Bar Magnet

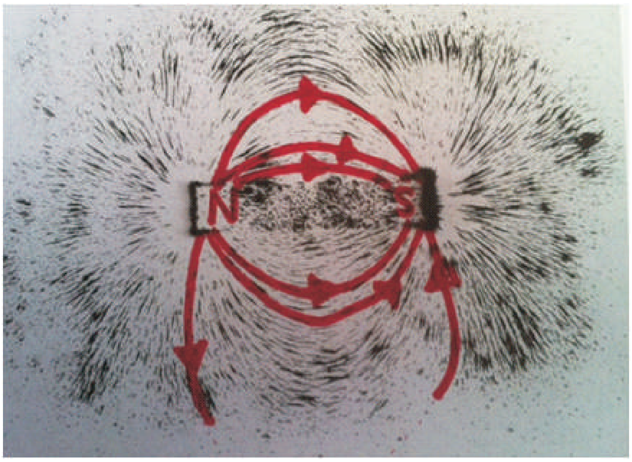


Diagram 8b: Bar magnet with field lines drawn in

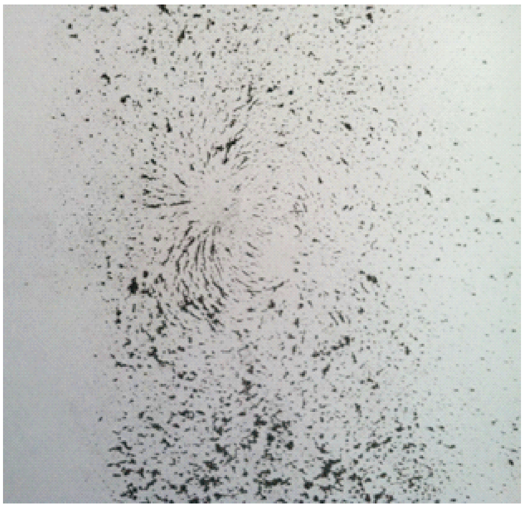
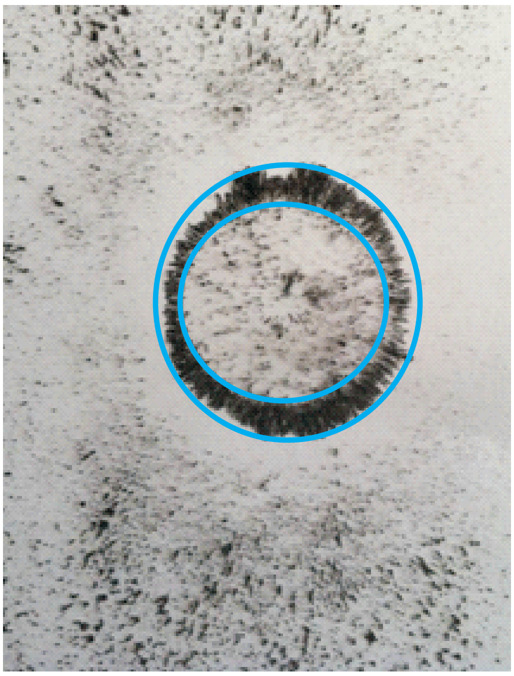


Diagram 9a: Lodestone

A compass can be used to determine the location of the north and south pole of the loadstone. Each loadstone's magnetic field may be different.

Diagram 9b: Lodestone with field lines drawn in.



Lodestone

Diagram 10a Ring magnet flat O-shaped surface

One flat side of the disk magnet is a North Pole and the opposite side is a South Pole. This view of the magnet will help students to understand that magnetic field lines are three-dimensional and the paper only shows a two-dimensional image. Have students show the image of the side of the magnet sprinkled with iron fillings to be able to draw field lines.

A Compass can be used to determine if the North or South Pole of the magnet is being viewed.

Diagram 10b: Ring magnet with north pole labeled

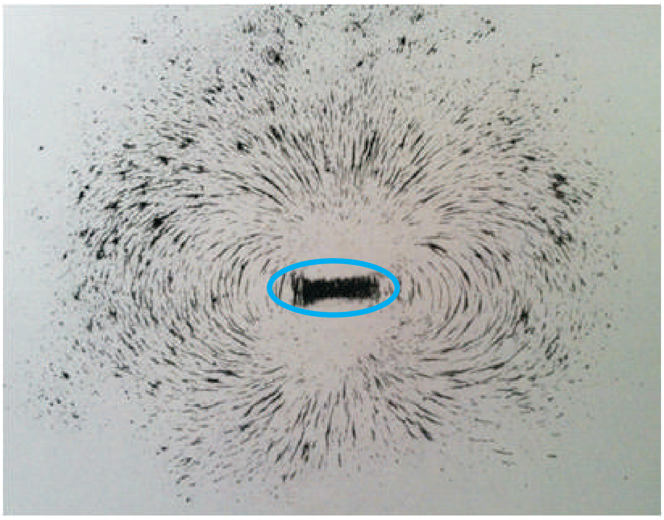


Diagram 10c Ring magnet side view

It can be tricky to get this side view of the ring magnet because the magnet does not stand on its end well and tends to roll. Placing the magnet between two books to hold the magnet in place will help yield good results.

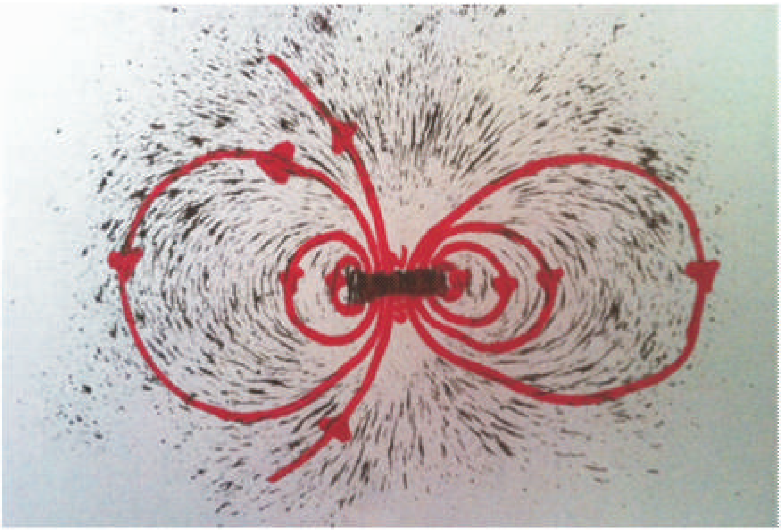


Diagram 10d: Ring magnet side view with field lines drawn.

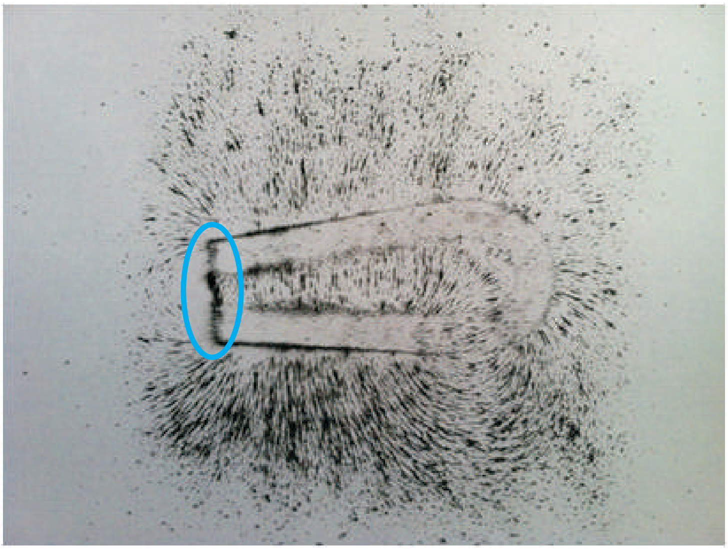


Diagram 11a: Horseshoe magnet

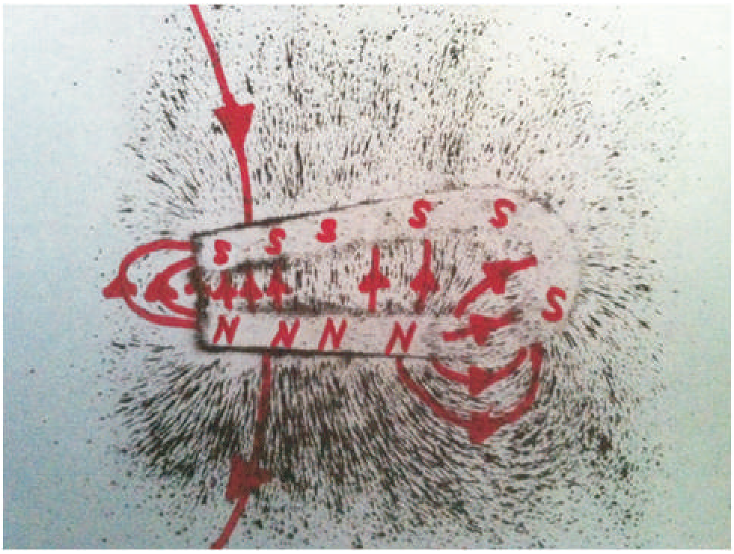


Diagram 11b: Horseshoe magnet with field lines drawn.

Diagram 12a: South and north pole of the bar magnet facing each other.

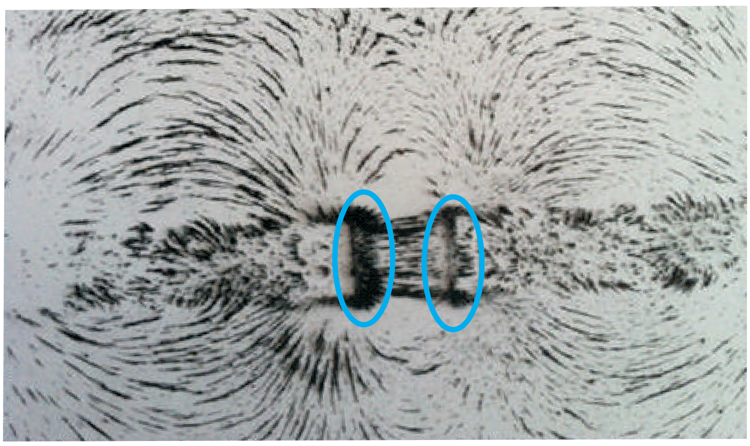


Diagram 12b: Two opposite poles next to each other with field lines drawn in.

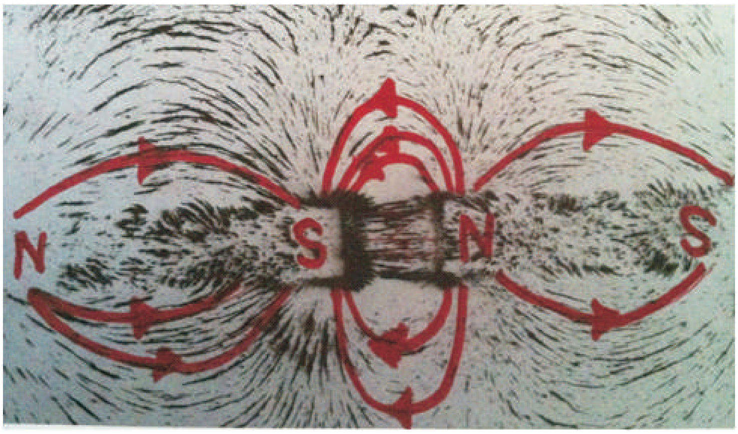


Diagram 13a: Two south poles next to each other

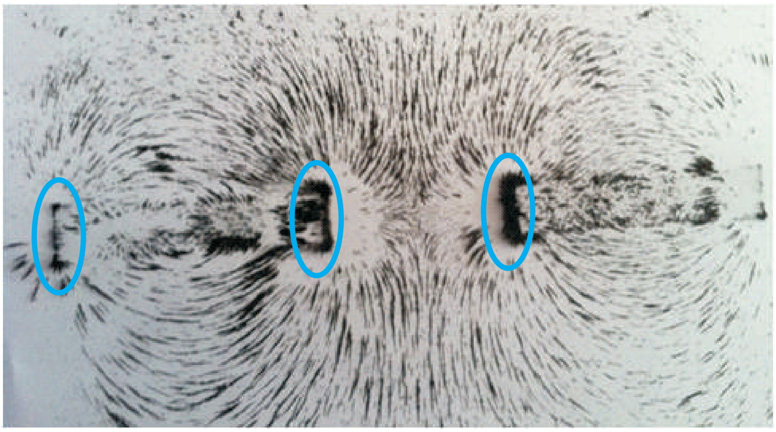


Diagram 13b: Two south poles next to each other with field lines drawn in

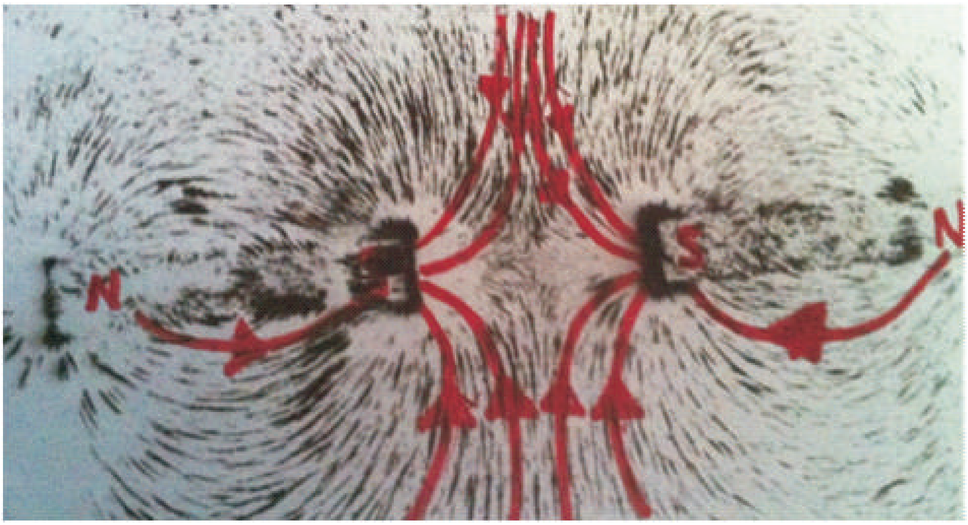


Diagram 14a: Two north poles facing each other

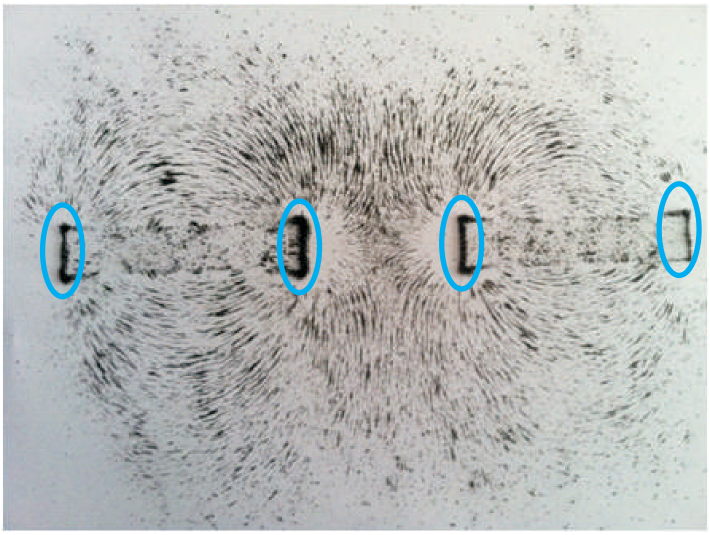
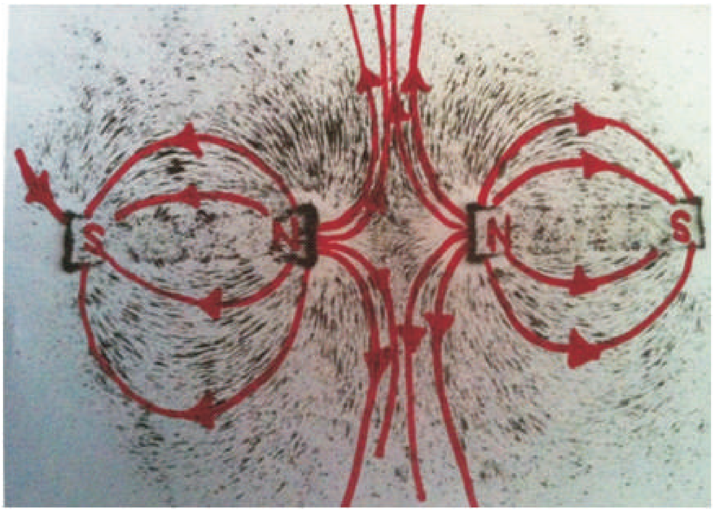


Diagram 14b: Two north poles facing each other with field lines drawn in



FOLLOW UP QUESTIONS:

1. Label the north and south pole in each of your drawings.

2. There are a few rules regarding drawing magnetic field lines.
   a. The lines always go out of the north pole an into the south pole
   b. The lines never cross
   c. The lines always form complete loops.

   Draw at least five magnetic field lines in each of your iron filing pictures following the rules listed above. If a line you are tracing goes off of your page, or you cannot clearly tell where the line is going, stop drawing the line and do not complete the loop.

3. It takes a strong magnetic force to get iron filings to stand on end. Therefore the strongest magnetic field occurs where this happens. Go back through your drawings/pictures and circle the places where the strongest magnetic field occurred using a blue marker or crayon.

4. The magnet attracts the iron filings. The stronger the magnetic field, the more iron

filings the magnet can hold. In general, where in your drawings are the magnetic fields the strongest? Give evidence to support your claim.

Near the poles of the magnets or in between two poles of opposite poles of a magnet, the iron filings are standing straight up off the paper and clumped closely together, there is a space near the poles of the magnets where the iron filings won't stay put but are always pulled to the end of the magnet and it leaves a white space. This is where the magnetic fields are the strongest.

5. Which magnet was the weakest? Justify your answer using evidence from your observations.

   The lodestone was the weakest magnet because it did not make any of the iron filings stand on end.

6. Instead of iron filings, the diagram below shows a bar magnet with several magnetic field lines drawn around it. Using this picture and the pictures you drew finish the following statement. The closer together the magnetic field lines are, the *stronger* the magnetic field is.

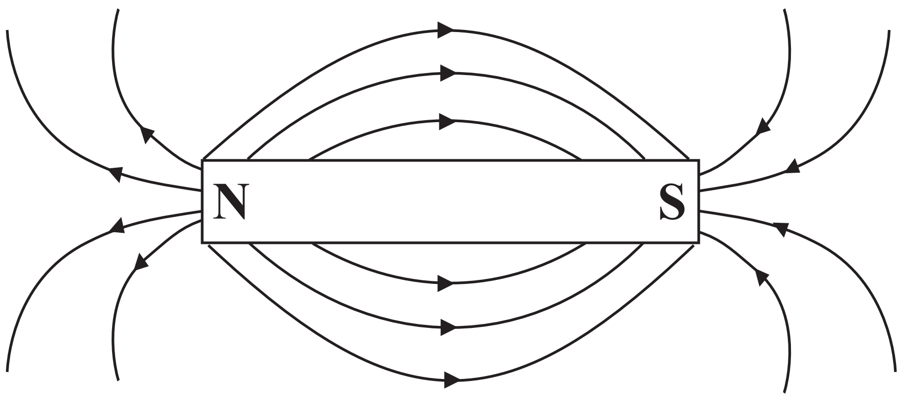


Diagram 15

7. There are some magnetic field lines that appear to go off the page and do not form complete loops. Explain how these field lines still form complete loops.

   The magnetic field lines that go off the page are two large to fit on the page, but even these field lines loop back around and connect to a south pole. As the field lines get further away from the north pole, the magnetic field gets weaker and does not align the iron filings as well, so it is harder to see the magnetic field. Instead of guessing where the magnetic field lines are or using a gigantic piece of paper, only part of the magnetic field lines are drawn.

NAME:______________________________________ DATE:_______________

ACTIVITY 4

MATERIALS NEEDED:

5 sheets of white paper
One ring magnet
Two bar magnets
The lodestone
One horseshoe magnet
A cup
Jar of iron filings
Camera (optional)

Question: What do magnetic fields look like?

PROCEDURE:

1. Pick one of your magnets and place it on a white sheet of paper. Place another white sheet of paper completely covering the magnet.
2. Very lightly cover the surface of the paper by sprinkling the filings from the jar, cover at least 3 inches on every side of the magnet as well as on top of the magnet.
3. With one finger, lightly tap the top paper until the image becomes clear.
4. Take a photograph or draw the shape of the iron filings for your data collection.
5. Remove the filings by carefully bending the top paper in half so it forms a trough with the filings in the middle and then tip the filings from the paper into the cup.
6. Repeat steps 1-5 with a different magnet until you have captured the image of the magnetic field lines around all of the magnets.
7. Now place two opposite polls of the bar magnets next to each other and place a white sheet of paper completely covering both magnets.
8. Repeat steps 2-5.
9. Capture the image of the iron filings over two north poles facing each other and two south poles facing each other using the same method you have used above. The poles should be about 1.5” apart from each other under the white paper for best results.

FOLLOW UP QUESTIONS:

1. Label the north and south pole in each of your drawings.

2. There are a few rules regarding drawing magnetic field lines.
   a. The lines always go out of the north pole an into the south pole.
   b. The lines never cross.
   c. The lines always form complete loops.

   Draw at least five magnetic field lines in each of your iron filing pictures following the rules listed above. If a line you are tracing goes off of your page, or you cannot clearly tell where the line is going, stop drawing the line and do not complete the loop.

3. It takes a strong magnetic force to get iron filings to stand on end. Therefore the strongest magnetic field occurs where this happens. Go back through your drawings/pictures and circle the places where the strongest magnetic field occurred using a blue marker or crayon.

4. The magnet attracts the iron filings. The stronger the magnetic field, the more iron filings the magnet can hold. In general, where in your drawings are the magnetic fields the strongest? Give evidence to support your claim.

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5. Which magnet was the weakest? Justify your answer using evidence from your observations.

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6. Instead of iron filings, the diagram below shows a bar magnet with several magnetic field lines drawn around it. Using this picture and the pictures you drew finish the following statement. The closer together the magnetic field lines are, the <u>*stronger*</u> the magnetic field is.

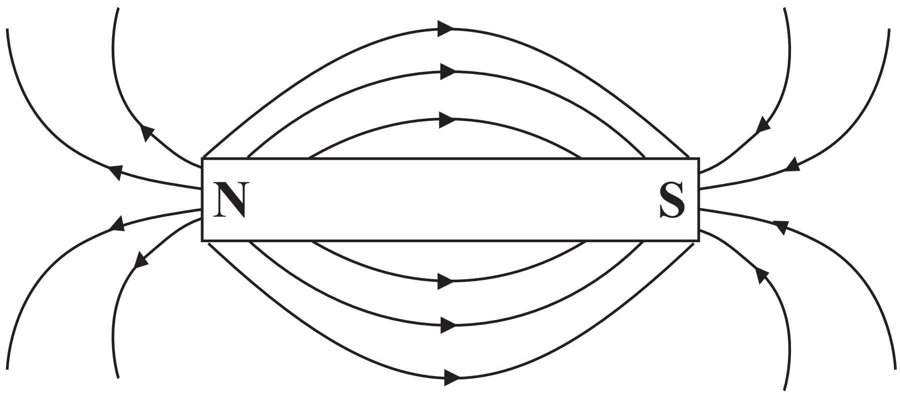

Diagram 15

7. There are some magnetic field lines that appear to go off the page and do not form complete loops. Explain how these field lines still form complete loops.

ACTIVITY 5: INTERACTING FORCES

TEACHER NOTES

A pencil that will fit through the hole in the ring magnets is needed for this experiment. Have students place one ring magnet over a vertical pencil, then place a second magnet onto the pencil. If this magnet attracts, then pull the magnets apart and flip the top magnet over so that the second magnet is suspended in the air. Repeat this process until all three magnets are on the pencil and repelling the magnet below it. There should be space between each magnet.

When the pencil is vertical, the space between the top and middle magnet is greater than the space between the bottom and middle magnet. If the pencil is turned sideways, the space between the magnets is the same, this is because vertically, the magnetic force is fighting the force of gravity on the magnets.

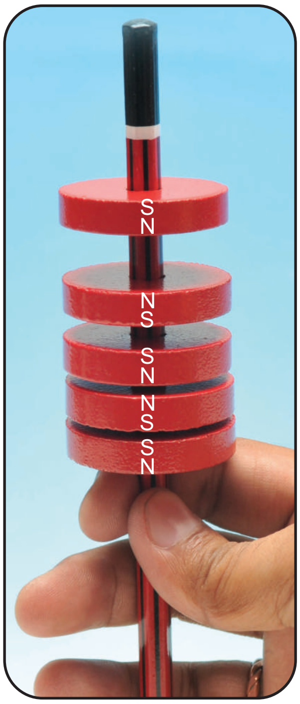

Diagram 16: Vertical arrangement of ring magnets on a pencil

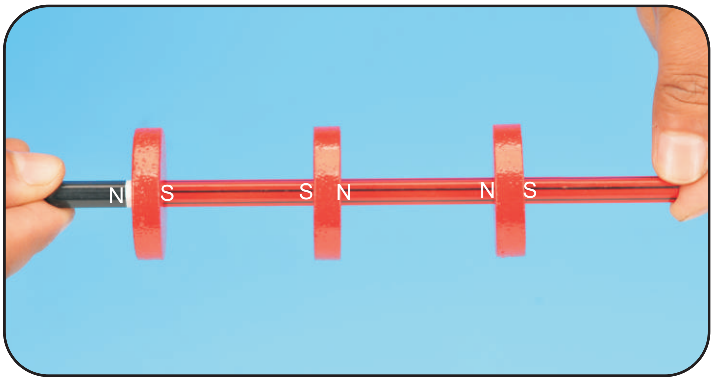

Diagram 17: Horizontal arrangement of ring magnets on a pencil