ACTIVITY 3: Developing a Model for Magnetism

Purpose

In the previous activity, you investigated some magnetic phenomena and discovered that magnet-rubbed (magnetized) nails behave differently from unrubbed (unmagnetized) nails. Thus, rubbing the nail with a magnet must change the nail in some way. But, *how* does it change the nail? To answer this question, you need to develop a model: a picture and description of what you think is going on in the nail when it is rubbed.

A good model can do two important things: (1) it can be used to **explain** observations from experiments already done; and (2) it can guide the making of **predictions** about experiments that have not yet been done. After scientists make their predictions based on their initial model, they (or other scientists) perform the experiments. If the predictions are confirmed through the new experiments, the scientists retain their model because it can explain their new observations. However, if the results of the new experiments differ from the predictions, scientists use the new evidence to revise their model so it can explain the new set of observations (as well as the previous observations). Then they use their revised model to make new predictions. They develop confidence in their model only after it can be used repeatedly to make predictions that are confirmed by new experiments. Thus, a critically important activity of scientists is to develop, test, and revise models.

In Activity 1 of this unit, you followed this procedure in developing a model for the Mystery Tube. (Note that, while you do not know if your model corresponds to what was actually in the tube, if it worked to explain all your observations, then it was a 'good' model.) In this activity, you will begin the process of developing, testing, and revising your own *model for magnetism*.

How can you develop a model of magnetism?

Initial Ideas

To begin this activity, you should spend a few minutes **individually** considering your own initial model for what happens when a nail is magnetized. You should represent this model using both diagrams and a written description.

Imagine that a nail is rubbed with a magnet in such a way that its pointed end becomes a north pole. Below are two drawings of the nail, representing its state **before** and **after** rubbing.

Sketch what you think might be different about the nail in these two conditions (unmagnetized and magnetized). Think about what entities (small particles) might be inside the nail, and what might happen to them in the process of rubbing with a magnet, that causes the nail to become magnetized.

Your individual model:

	
Unmagnetized (before rubbing)	**Magnetized (after rubbing)**

Describe your initial model in words, in particular how the "Magnetized" picture differs from the "Unmagnetized" picture and how rubbing with a magnet causes this difference. If you are showing some type of entities inside the nails, describe what you imagine these entities represent and how they might get rearranged.

Share your model with other members of your group and also listen to them describe their models. Here are some things to consider about communicating your model so that others can understand and evaluate it.

Assumptions: You should clearly state any assumptions that are being made. In your model for magnetism this might be the nature of any entities involved and how they can move (if at all).

Reasoning: You should explain any changes shown in your diagrams (and/or described in your written/verbal description) in terms of **why** they occur. In your model for magnetism this might be **how AND why** any entities involved get rearranged (if at all).

Clarity and Consistency: Your diagrams and written/verbal descriptions should be clear, understandable, and consistent with each other.

Of course, your model should also be **explanatory**. That is, you should be able to use it to explain all (or at least most) of the observations you have already made.

After each member of your group has shared their own model, discuss and decide on a single model that your group thinks is best. Your instructor may give you a separate worksheet to help you work together on this.

If the group's best model is different from your own initial model, draw a representation of the group's model and briefly describe it in words.

Your group's first model:

	
Unmagnetized	**Magnetized**

Description:

How does this model explain why rubbing an unmagnetized nail with a magnet results in it becoming *magnetized*?

How does this model represent that an unmagnetized nail is *one-ended* (both ends behave the same way), but a magnetized nail is *two-ended* (the two ends behave differently)?

Prepare a presentation board showing your group's best model and participate in a whole class discussion.

After listening to other groups present their models, discuss with your group what you now consider to be the "best" model. Draw it below and briefly describe it.

Current 'Best' Model of nails:

	
Unmagnetized	**Magnetized**

Description:

Why you think this model is best?

Using consistent symbols

Before testing what you now consider to be the best model (by using it to make a prediction) we need to consider the symbols being used by the class in their models to represent any entities in the nails. Up to now some groups may have used + and – symbols to represent two different types of entities, and other groups may have used N and S symbols in the same way. However, for consistency in comparing models, it would be a good idea to agree on one set of symbols. You probably realize that plus (+) and minus (–) charges have to do with electric charges and that batteries have + and – labels at their ends, whereas magnets have N and S labels at their ends (poles). Since we are focusing on magnetic effects here, not electric effects, to keep things simple, we suggest everyone uses **N and S symbols** in their model (if appropriate).

If necessary, redraw your current best model for an unmagnetized and magnetized nail below (the one you decided was best after the class discussion). Remember, if you previously used + and – symbols, simply translate them to N and S symbols.

Unmagnetized

Magnetized

Collecting and Interpreting Evidence

Exploration #1: Using your model to make a prediction

Important: ***When you make predictions you must base them on your current model. Do not change your model as a result of just thinking about the situation, because then you are not testing your model. If the outcome of the experiment turns out to be exactly what you had predicted, then don't modify your model. On the other hand, if the outcome is different from your prediction, even in small ways, then you need to consider how to revise your model. Finally, for this process to be useful, the predictions you make should be precise, not vague and general. Only then will the experiment really test your model appropriately.***

STEP 1. To help your group make a prediction based on your current model (rather than on some other intuition), you should use the following procedure. On a separate blank piece of paper draw a **large** version of your current model for a **magnetized nail**. Next, draw a thick vertical line through the exact middle of your model drawing, and then tear your drawing in half, exactly along that line. You should end up with two drawings, each representing half of the magnetized nail. Separate these two halves on your table.

Copy your drawings of the two halves of the model below, showing your model's representation of the two halves of the nail.

Head half of magnetized nail

Point half of magnetized nail

Now look at each half piece and answer these questions based on your model drawing.

Does your model of the **head half piece** (on the left) suggest that it, **by itself,** is one-ended, two-ended, or something different? (If different, try to describe it in words.) How does it indicate this?

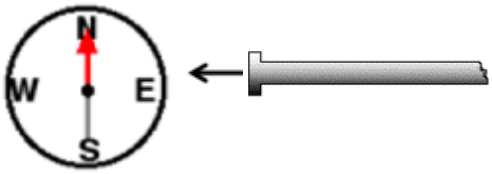
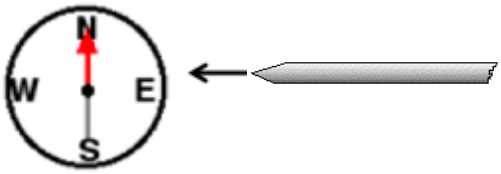
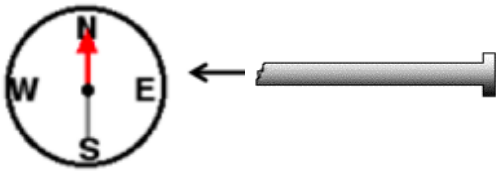
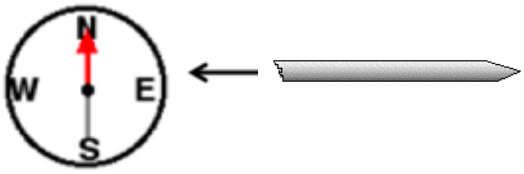
Does your model of the **point half piece** (on the right) suggest that it, **by itself,** is one-ended, two-ended or something different? (If different, try to describe it in words.) How does it indicate this?

Your drawings above represent what your model suggests would be in each piece of a magnetized nail that is cut in half. You will now use these to make some **predictions** about what you would find if you actually did this and tested each piece of the cut nail separately.

Using your diagrams on the previous page, indicate on the picture below whether each end of the two cut pieces should be a N-pole (**N**), a S-pole (**S**) or have no pole (**NoP**). You should label **all four ends** – the original head and point, and the two cut ends. Briefly explain why you labeled all four ends as you did. (Remember: **do *not* change your model at this time**.)

Prediction for poles on two halves of cut magnetized nail

Now, suppose you brought each end of both halves of the cut magnetized nail toward the E-label of a north-pointing compass. In each case, according to your model, do you predict that the **N-pole end of the compass needle** would be attracted (rotate toward), be repelled (rotate away), or would nothing happen? Write your prediction (*attract*, *repel*, or *nothing*) next to each picture below and briefly state why your current model would predict that. (Again, do ***not*** change your model when using it to make a prediction.)

Head piece – head end 	*Point piece – point end* 
Head piece – cut end 	*Point piece – cut end* 

STEP 2. Discuss with your group what your model drawings indicate about how the magnetic strength of each half of a cut magnetized nail would compare with the magnetic strength of a whole (uncut) magnetic nail.

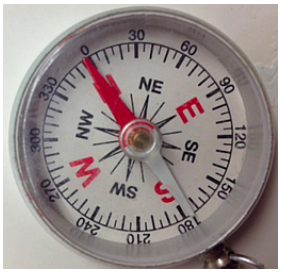
Do you think the magnetic strength of each cut half would be weaker than, the same as, or stronger than that of the whole nail? Describe how your model drawings support your thinking.

Now that you have made some definite predictions based on your current model, you will perform the corresponding experiment to see whether your model is good as it is, or whether you need to consider modifying it.

Exploration #2: What happens when a magnetized nail is cut in half?

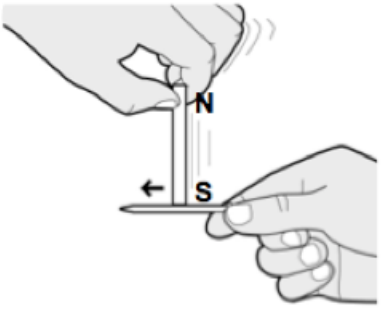
You will need:

- Bar magnet
- Three unrubbed nails
- Compass
- Small piece of tape



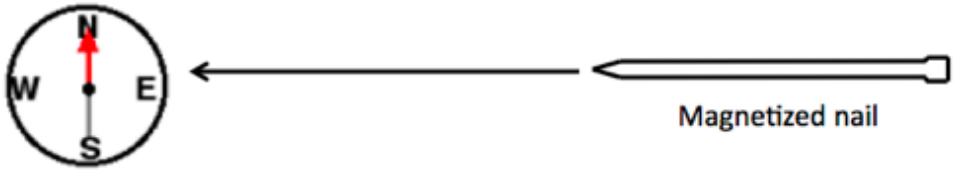
STEP 1. Lay your compass on the table and rotate it so that the N-pole end of the compass needle is aligned with the "N" marking (for the North direction) on the casing of the compass (as in the picture above). ***You should leave the compass in this position for the rest of this activity.***

Rub **one** of your nails with the magnet so that the pointed end becomes a N- pole. ***A convenient way to do this is to rub from the head to the pointed end using the S-pole of the bar magnet.***



Remember to put your magnet far away after rubbing the nail and compass after you are done.

To check that your nail is magnetized as expected, slide each end of it toward the E-label on the compass.

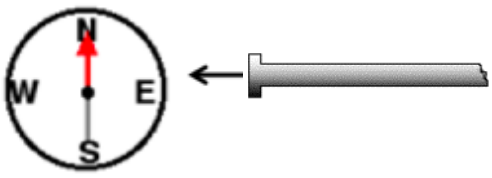
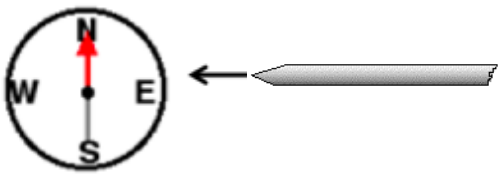
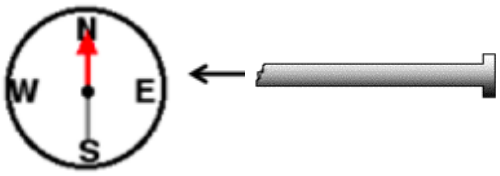
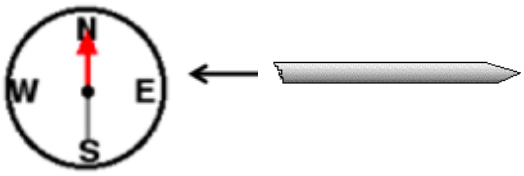


Is the point end of the magnetized nail a N-pole and the head end a S-pole? How does the behavior of the compass needle indicate this?

STEP 2. Now ask your instructor to cut your magnetized nail in half. ***Before* your instructor cuts the nail, however, you must show him or her how you used your current model to guide your predictions** After the nail is cut, make sure you keep both halves away from the magnet.

STEP 3. Slide each end of the head piece of the cut nail toward the E-label on the compass. Repeat this with the point piece of the cut nail.

Use the pictures below to record your observations. Write *attract*, *repel*, or *nothing*, to indicate the observed behavior of the **N-pole end of the compass needle**.

Head piece – head end 	*Point piece – point end* 
Head piece – cut end 	*Point piece – cut end* 

Do the two halves of the cut nail appear to be one-ended, two-ended, or something different? How do you know?

Mark the four 'ends' in the diagram below according to whether each was a N-pole, S-pole, or no pole.

Check your observations with those of at least two other groups to make sure you all agree. If necessary, repeat the experiment and re-record the observations.

How did **your** observations compare with **your** predictions?

STEP 4. Magnetize a second nail in exactly the same way as before, but leave it uncut. Now use the compass to test the magnetic strength of each half of your cut nail as compared to the magnetic strength of the uncut nail. (To ensure it is a fair test, make sure you do all tests with the N-pole end of each piece/nail held the same distance from the compass.)

How did the magnetic strengths of the cut pieces compare to that of the whole nail? How do you know?

STEP 5. If your observations were exactly the same as your predictions, and if your predictions were truly based on your current model, you should not change your model at this time. However, if your observations were *different* from your predictions, then your group needs to discuss how you might change your model so it can explain both your new observations **and** your previous observations.

If you have no need to change your model at this time, simply redraw it below. However, if your model needs to be modified in light of these results, after discussing with your group, draw your new model below.

Model of nail after observations of cutting magnetized nail in half

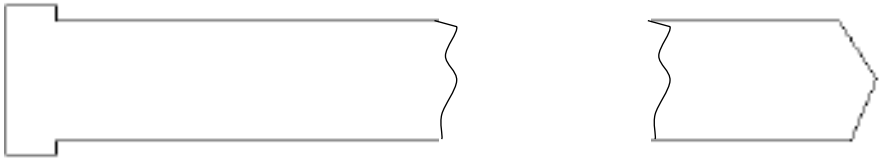
	
Before Rubbing	**After Rubbing**

Briefly describe in words how the model you drew above can account for the observations you have just made about the two halves of a cut magnetized nail.

Exploration #3: What happens when a magnetized nail is cut in unequal length pieces?

STEP 1. To help you think further about your model, you should now consider the following. Suppose a full length magnetized nail (with its point end again a N-pole) were cut into two pieces of **unequal** length (say a 1/4-length piece and a 3/4-length piece, or a 1/3-length piece and a 2/3-length piece, or some other division).

On the diagram below, sketch how your current model would represent the two unequal pieces after cutting. Label the four ends as either N, S, or NoP (no pole), and briefly explain how your model shows this.



Longer piece **Shorter piece**

Now suppose you were to cut just the longer piece of the nail in two again, so you have a shorter head piece and a piece taken from the middle of the nail.

On the diagram below sketch how your current model would represent these two pieces after cutting. Label the four ends as either N, S, or NoP (no pole) and briefly explain how your model indicates these choices.

Head piece **Middle piece**

STEP 2. Now test your predictions by magnetizing another nail, having your instructor cut it in two pieces according to your directions, and then testing the ends of the two pieces with your compass as before.

Do these results suggest that the longer piece is *one-ended*, *two-ended*, or something else? What about the shorter piece?

Mark the four 'ends' in the diagram below according to whether each was a N-pole, S-pole, or no pole.

Longer piece **Shorter piece**

STEP 3. Next stick a small piece of tape (or otherwise mark) on the longer piece of the cut nail, **near the cut end**. (This is so you will be able to tell the two ends apart after cutting.) Have your instructor cut the longer piece of your magnetized nail according to your directions, and then testing the ends of the two pieces with your compass as before.

Do these results suggest that the head piece is *one-ended*, *two-ended*, or something else? What about the middle piece?

Mark the four 'ends' in the diagram below according to whether each was a N-pole, S-pole, or no pole.

Check with some other groups. Do their observations seem to suggest that the results of both experiments you did in this exploration depend on exactly where the magnetized nail was cut or are every group's results the same?

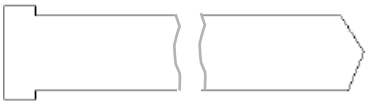
Summarizing Questions

S1. When a magnetized nail is cut into pieces, is each piece one-ended, two-ended, or something different, or does the result depend on exactly where the nail is cut? What evidence supports your answer?

S2. Work with your group on revising your model (if necessary) so that it can explain all the observations you made in this activity. Remember it should also still explain those observations made previously. Again, your instructor may give you a separate worksheet to help as you discuss this.

a) Sketch your revised model below, showing an unmagnetized nail, a magnetized nail, and a magnetized nail that has been cut in an **arbitrary** location.

Model of nail after observations of cutting magnetized nail in two pieces

		
Unmagnetized	**Magnetized**	**After Cutting**

b) How does your revised model represent that both pieces of a cut magnetized nail are *two-ended*?

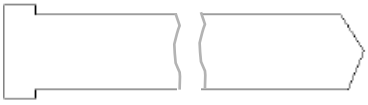
b) How does your revised model represent that each piece of a cut nail has a weaker magnetic strength than the whole nail before it was cut?

c) How does your revised model account for the observation that cutting a magnetized nail **anywhere along its length** would still give two pieces that are both *two-ended*? (If it cannot account for this, say why not.)

Prepare a presentation board showing your model ready for the class discussion.

Participate in a whole class discussion. After listening to other groups present their models and explanations, draw what you consider to be the "best" model below and describe why you think it is best.

New Model of nails

		
Before Magnetizing	**After Magnetizing**	**After Cutting**