Unit M

Lesson 3: Developing a Model for Magnetism

Purpose and Materials Needed

In the previous lesson you discovered that magnet-rubbed (magnetized) iron nails behave differently from unrubbed (unmagnetized) iron 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 inside the nail.

In Lesson 1 you developed a model for the Mystery Tube. Scientists construct models all the time to help them understand new phenomena. As you saw in Lesson 1, 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 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 in new experiments. A critically important activity of scientists is to develop, test and revise models.

How can you develop a model for magnetism?

Predictions, Observations and Making Sense

Part 1: What is your initial model for magnetism?

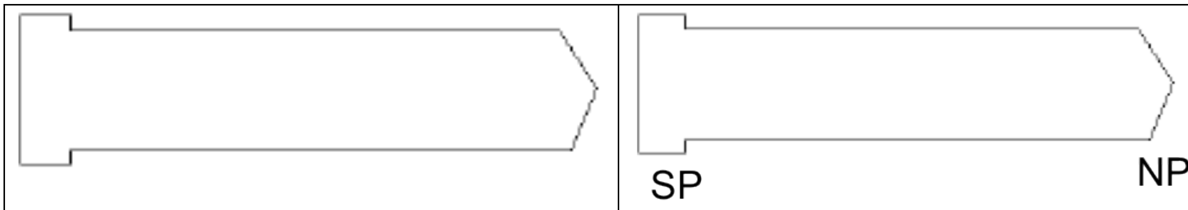
A **good model** in science meets the following criteria:

- The model (drawing and written part) should be clear and understandable. If you use 'symbols' in your drawing of a model, you should describe in words what the nature of those symbols are; that is, what they represent.
- The model should be plausible and causal; that is, it should make sense according to your own ideas about cause and effect. In the case of a model for magnetism, what you show happening when a nail is rubbed with a magnet should both make sense and explicitly indicate how moving the magnet along the surface of the nail causes something to happen in or on the nail.
- The model should account for (explain) all the observable evidence and not contradict any of that evidence.
- The model should guide accurate predictions about what would happen in new experiments.

You know from previous observations that a magnet rubbed nail becomes magnetized and is *two-ended*. Imagine that you rub the unrubbed nail in such a way that its point end becomes a North Pole. [You can always test this using the compass.] Below are two drawings of the nail, representing its state before and after rubbing with a magnet.

Individually, sketch what you think might be different about the iron nail in these two conditions (unmagnetized and magnetized). Think about what entities 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 and two-ended. Use symbols like + and -, or N and S, or some combination of them, to represent the entities. Do not use abstract symbols, like arrows or rectangles, etc., since it would be difficult to interpret what they mean. To make things concrete, assume you rubbed the nail so its point is a North Pole and its head is a South Pole.

Your first <u>individual</u> model:

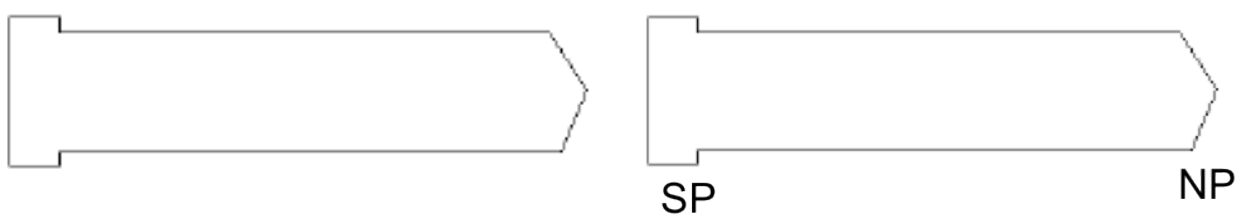


Unmagnetized (before rubbing)	Magnetized (after rubbing)

Describe <u>your</u> initial *model* in words, in particular how the "Magnetized" picture differs from the "Unmagnetized" picture, and how rubbing with a magnet causes this difference. Describe what you imagine the entities inside the wire represent. Your picture and written description is a representation of your own initial model for explaining what happens when a nail is magnetized.

Each member of your group should now describe her initial model to the other group members, carefully describing what the entities are and they become rearranged in some way (if at all) when the nail is magnetized. Then, try to decide on one model that represents the group's 'best' thinking.

Sketch your **group's best initial model**.



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

Discuss within your group how the model can 'explain' why rubbing an unmagnetized nail with a magnet results in it beoming *magnetized*.

Discuss within your group how the model represents 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).

CQ 3-1: Which is most similar to your group's initial model?

A. Plus (+) and minus (-) entities are randomly spread throughout the unrubbed nail; rubbing separates them to the two halves of the nail.
B. North (N) and South (S) entities are randomly spread throughout the unrubbed nail; rubbing separates them to the two halves of the nail
C. Some other type of entities are inside nail; rubbing causes them to re-orient or change in some other way than being separated to the two halves of the nail.
D. Something different from above

In the past we have found that most groups at this point suggest a model that has the following features. Inside the unrubbed nail there are two different types of entities, either plusses and minus, or norths and souths, and the individual entities are scattered randomly throughout the nail. During the act of sliding the magnet across the nail, the two types of entities separate from each other: one type goes towards one end, and the other type goes towards the other end. Because this initial model is so common we give it its own name, the ***separation model***.

For groups that invented some form of a separation model, some groups probably used + and – symbols as the entities, and other groups may have used N and S symbols as the entities. For consistency in comparing models, it would be a good idea to agree on one set of symbols. Batteries have + and - labels at their ends, and 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 labels in their model (if appropriate).

Re-draw your group's initial model, **using N and S labels** for the entities (if appropriate). You might also decide to adopt a different model from your original one, and that's fine; just draw it below.

Unmagnetized (before rubbing)

Magnetized (after rubbing)

In the next unit you will develop a model for static electricity, and in that case use of the + and – symbols would be more appropriate.

Part 2: Testing the initial model.

In Part 1 you developed a model that you believe best explains some observations you have already made. The model should have been clear and understandable, plausible and causal, and explanatory, as described at the beginning of Part 1. The other important criterion of a good model is that it is predictive; that is, it leads to accurate predictions about the outcomes of new experiments. You will be testing that criterion in this part of the lesson.

> 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.

To help your group make a prediction based on its initial model (rather than on some other intuition), you should use the following procedure. On a separate 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 the entities inside 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? (One-ended means that the entities are the same on each end, suggesting each end would behave the same. If you think something different, try to describe it in words.)

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.)

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 a **prediction** about what you would find if you actually did this and tested each piece of the cut nail separately.

CQ 3-2. What does your torn-in-half model drawing predict would happen if the actual rubbed nail were cut in half? [Assume that the act of cutting does not rearrange the entities in any way. They stay where they were before cutting.]

A. The head half piece would now be one-ended, and the point half piece would also be one-ended (but with opposite types of entities).
B. The head half piece would now be two-ended, and the point half piece would also be two-ended (each piece has different kinds of entities at each end).
C. One half piece would be one-ended and the other half piece would be neither one-ended nor two-ended.
D. Neither half piece would be one-ended or two-ended.
E. Something else would happen

Your instructor will show you a movie **(UM_L3_Mov1)** from which you can determine whether your prediction was accurate or not. In the movie the person first magnetizes the nail by rubbing it with a bar magnet. He then brings first the tip of the rubbed nail, and then the head of the rubbed nail, near the E-label on the compass.

What does the compass needle do in each case?

Is the point end of the rubbed nail a North Pole or a South Pole?

Do the observations suggest that the rubbed nail is two-ended, one-ended, or something else?

Next the person carefully cuts the nail exactly in half. He will now test each half piece.

What happens when he brings each end of the head half piece near the E-label on the compass?

Do the observations suggest that the head half piece is two-ended, one-ended, or something else?

What happens when he brings each end of the point half piece near the E-label on the compass?

Do the observations suggest that the point half piece is two-ended, one-ended, or something else?

What can you conclude from this experiment?

CQ 3-3: When a rubbed nail is cut in half, what can you conclude?

A. Each half piece is still two-ended.
B. Each half piece is one-ended.
C. One half piece is one-ended, and the other is two-ended.
D. Conclude something else. [Describe what.]

Your group used its initial model to make a prediction about what would happen if the rubbed nail were cut in half. If what actually happened differs from your prediction then your group needs to revise its initial model.

Does your group's initial model need to be revised: yes or no?

If you answered 'yes,' before revising it we want to provide you with some additional evidence to guide you.

Your instructor will show you another movie **(UM_L3_Mov2).** The person starts, as before, by magnetizing the nail so its point end is a North Pole. The person will now cut the rubbed nail into two **unequal** pieces, one longer, one shorter. He'll then bring each end of each piece near the E-label on the compass.

What happens when each end of the *longer piece* is brought near the E-label on the compass?

Do the observations suggest that the longer piece is two-ended (, one-ended, or something else?

What happens when each end of the shorter piece is brought near the E-label on the compass?

Do the observations suggest that the shorter piece is two-ended, one-ended, or something else?

What can you conclude from this experiment? When a rubbed nail is cut in unequal length pieces, is each piece still two-ended, one-ended, or something else (describe)?

The person in the movie could have cut the rubbed nail ***anywhere*** along its length. In each case, however, you would have concluded that each cut piece is two-ended.

Your group now needs to be creative and revise your initial model so it could account for all the new evidence.

Your group's revised model:

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

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

One member of your group should take a picture of the group's revised model with a cellphone camera and e-mail according to your instructor's directions. On the subject line type, "Group N **revised** model," where N represents your group number.

Summarizing Question

CQ 3-4. Can <u>your</u> <u>group's</u> revised model explain the observation that cutting the magnetized nail anywhere along its length will produce two pieces that are each magnetized (two-ended)?

A. Yes it can.
B. No it cannot.
C. We are not sure.

Your instructor may share some of the class' revised models. You may wish to copy down some of these other models if you think they will be helpful.