**Formatting Hypotheses**

Some years ago, I found a nice short lesson on hypotheses that really allows the student to get a handle on this process skill. The book was Patterns and Processes by the BSCS group who wrote this edition for middle school'ers. Amazi ngly, for as clear as they present hypotheses in this book, they never seemed to have utilized the technique in any other BSCS publications. This has always seemed strange to me since BSCS labs often call on the student to write some sort of hypothesis based on the lab procedure.

Most commonly, hypotheses take three formats:

1. a question, "Does temperature affect fermentation?"
2. a conditional statement, "Temperature may affect fermentation."
3. an **If, then** statement, "If fermentation rate is related to temperature, then increasing the temperature will increase gas production.

The third type is more structured and I'll refer to it as a "formalized" hypothesis. A caution is necessary at this point. **Beware!** Not all "if-then" statements are hypotheses. For example, "If you warm yeast, then more gas will be produced." This is a simple prediction, not a hypothesis! The problem with this statement is that there is no proposition to test. What is related to what? Is temperature a variable? Is yeast a variable? I s gas production a variable?

Research models limit variables to two. The structure of a formalized hypothesis is useful because it makes the student focus on two variables that may be related. Furthermore, it forces the student to make a prediction of how manipulating one variable independent will affect the other variabledependent. Let's take another example from biology.

**If** the *diffusion rate*(dependent variable) through a membrane is related to*molecular size*, (independent variable)  **then** the smaller the molecule the faster it will pass through a membrane.

Notice that in the formalized hypotheses the "if" clause proposes a relationship between two things, the variables. The variables here are diffusion rate and molecular size. In the experimental design, we can manipulate molecular size by simply selecting soluble substances of different molecular size, e.g.., iodine, glucose, starch. The student will know what the dependent variable is because it is the thing she/he watches for results, i.e. movement of iodine (color), glucose (indicator change), and starch (indicator change).

If this hypothesis is stated as a question (Does molecular size affect diffusion through a membrane?) the student must infer what is to be manipulated and what is to be observed. Furthermore, the student doesn't have to make a prediction. Experience has taught me that few students infer what relationship is implied by a hypothesis in the question format. More likely, students interpret these hypothetical questions literally and try to answer them yes or no! Such as "does molecular size effect molecular movement through a membrane?" Answer:

"yes!" No inference is made, only a deduction is concluded which is a lower level of thinking.

Another value of a formalized hypothesis is that when a student is given such a hypothesis, he can be asked to design an experiment that will test the hypothesis. For example, describe an experiment that would test the following hypothesis.

If the rate of photosynthesisis related to wave lengths of light, then exposing a plant to different colors of light will produce different amounts of oxygen.

The use of the phrase "is related" is intentional in these examples. Other phrases such as "is affected" will work here, but I prefer "is related" because it reminds students that we are investigating relationships, not just cause and effect events. Students get into less trouble if they stick to this phrase. To download a student lesson on how to write hypotheses, click [Writing Hypotheses: a student lesson](http://www.accessexcellence.org/LC/TL/filson/writhypo.php).

**Teaching Strategies for Hypotheses**

Having students design every experiment would consume more time than is usually available. How can real science be imbedded on a regular basis? An alternative strategy to student design is to give out a lab paper the day before a lab. Students are to read over the procedure the night before, identify the variables, and write an appropriate hypothesis. Still some opportunities for student design are highly desirable and should be included periodically. For examples of student lessons where students write the hypothesis based on the procedure, click [Labs With Hypotheses](http://www.accessexcellence.org/LC/TL/filson/lab.php).

Students need to be reminded frequently, that a hypothesis is still valid even when results are the opposite of what is predicted because it will still shed light on the true nature of the relationship being tested. This lowers the risks of being wrong. For example, "If the period of a pendulum is related to its length, then the longer the pendulum the shorter the period." Actually the result s show just the opposite is true.

Hypotheses that predict unrelated variables are also useful. For example, "If the period of a pendulum is related to its mass, then increasing the mass will increase the period." As it turns out, the mass has no effect at all, as the student will discover while testing this hypothesis. For examples of hypotheses for various science disciplines, click on [Biology](http://www.accessexcellence.org/LC/TL/filson/biol.php), or [Physical & EarthSciences](http://www.accessexcellence.org/LC/TL/filson/physical.php). To learn how hypotheses can help students formulate conclusions, click on [Linking Conclusions to Hypotheses](http://www.accessexcellence.org/LC/TL/filson/linkconc.php).

Source: <http://www.accessexcellence.org/LC/TL/filson/formathypo.php>