Identifying Variables and Constants

In any experiment there are two types of variables that have a cause-and-effect relationship: the independent variable and the dependent variable. The independent variable is changed or manipulated, and can be thought of as the cause. It follows the *If* in a hypothesis. The dependent variable is what you measure, and can be thought of as the effect. It follows the *then* in a hypothesis. Constants are all of the other factors that must remain the same so that the only systematic difference is the independent variable.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>If a hamster is given a choice of food items to eat, then it will choose the item with the highest protein content, because protein is an important component of a hamster’s diet.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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</table>
Identifying Variables and Constants

Students need to know that scientific experiments are designed so that only one factor (the independent variable) changes or is manipulated; all other conditions are constants. By limiting variability in this way, scientists can be reasonably sure that differences between groups are the result of the independent variable. The data collected during the experiment are the measurements of the dependent variable. You can guide students through the identification of variables and constants by discussing various issues, such as:

- the cause-and-effect relationship between independent and dependent variables
- the manipulation of independent variables is not always possible, such as in the second example on the bottom of this page
- there is no one correct cause-and-effect relationship between variables
- constants typically include factors such as amounts, environment, and measurement tools, among others

TRANSPARENCIES

Page B25 includes one hypothesis that is already filled in, with space to write the independent variable, dependent variable, and constants in an experiment that would correspond to the hypothesis. The page also includes a completely blank space for you to write your own hypothesis, independent variable, dependent variable, and constants.

Page B26 includes the same hypothesis, as well as the independent variable, dependent variable, and representative constants for that experiment. There is also a blank hypothesis and variable identification procedure that you can work through with students. Use this version if you would prefer to give students a completed example of the variables and constants in an experiment.

TIPS FOR USING THE TRANSPARENCIES

Students may need help differentiating between independent and dependent variables. You can tell them that one way to remember the difference is that the dependent variable depends on what happens to the independent variable. Students will probably need help identifying constants. You can guide them by asking questions, such as:

- What other factors might influence the dependent variable?
- How can measurements and observations be kept consistent?

CUSTOMIZE FOR YOUR CLASSROOM

Here are some additional examples that you can write onto the transparency:

**Hypothesis** If the wavelength of light is changed, then the rate of plant growth will change, because plants need light to grow.

**Independent Variable** wavelength of light

**Dependent Variable** plant growth

**Constants** amount of light received, amount of water used, metric ruler used to measure growth, soil, and container used

**Hypothesis** If people smoke cigarettes, then they will breathe harder while climbing stairs, because smoking damages the lungs.

**Independent Variable** cigarette smoking

**Dependent Variable** number of breaths per minute

**Constants** number and angle of stairs, climbing rate, temperature, humidity, gender and ages of people, activity levels of people, heights and weights of people, stopwatch used
An *analogy* is an extended comparison between two subjects. Analogies can help you remember words and concepts. For example, the parts of a cell and their functions can be compared to the parts of a factory.

Read the concepts on the left side of the chart and fill in the right side with your own analogies.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Definition</th>
<th>Analogy (is like)</th>
</tr>
</thead>
<tbody>
<tr>
<td>endoskeleton</td>
<td>internal skeleton made of bone or cartilage</td>
<td></td>
</tr>
<tr>
<td>nucleus</td>
<td>membrane-bound organelle that stores most of a cell’s DNA</td>
<td></td>
</tr>
</tbody>
</table>
Analogies

An analogy is an extended comparison between two subjects. It is often used to help explain unfamiliar concepts, theories, and words by comparing them to more familiar ones. For example, one can compare Earth’s layers to the layers of a hard-boiled egg. After students gain experience in using analogies, ask them to list another process, concept, or theory and then think of their own analogies.

TRANSPARENCY

Page D24 includes instructions for using an analogies table. For example, you might have students read the first concept and its definition, and then prompt them to think of their own analogies by saying, “An endoskeleton is like…” In addition to using this transparency to model the strategy for students, you can photocopy it to use as a worksheet.

CUSTOMIZE FOR YOUR CLASSROOM

Here are some additional concepts or terms and suggested analogies that you can write onto the bottom rows of transparency page D24.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Definition</th>
<th>Analogies (is like)</th>
</tr>
</thead>
<tbody>
<tr>
<td>geologic time scale</td>
<td>shows age of Earth</td>
<td>24-hour clock; roll of paper; a road with different mileage markers</td>
</tr>
<tr>
<td>parts of a living cell</td>
<td>structures for generating energy, disposing of waste, reproducing</td>
<td>different parts of a factory; team with specialized players</td>
</tr>
<tr>
<td>molecules</td>
<td>building blocks of matter</td>
<td>interconnecting toys; marshmallows and sticks; steel structure and bricks in a building</td>
</tr>
</tbody>
</table>
**Compare/Contrast Chart**

A *compare/contrast chart* is similar to a Venn diagram, though it offers more space for writing details. The chart uses boxes at the top to identify the terms or concepts to compare and contrast. Arrows point down from these boxes to a single box that describes shared characteristics. The arrows from this box point to individual boxes below, aligned to the boxes at the top, which detail how the terms or concepts are different.

**TRANSPARENCY, PAGE C74**

Page C74 includes instructions for filling out a compare/contrast chart along with a blank compare/contrast chart. In addition to using this transparency to model the strategy for students, you can photocopy it and give it to students to fill in as a worksheet.

**CUSTOMIZE FOR YOUR CLASSROOM**

Here is an additional compare/contrast chart that you can draw for your students who are using transparency page C74.

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**Bacteria**

- Bacteria come in three common shapes: rod, spiral, and spherical
- Bacteria have a polymer called peptidoglycan in their cell walls

**Archaea**

- Archaea come in many shapes
- Membranes of archaea contain lipids that are not found in any other type of organism on Earth

How are they alike?

Most bacteria and archaea are small, single-celled organisms that have cell walls and plasma membranes.
Compare/Contrast Chart

1. Write the terms or concepts that you will compare and contrast in the boxes at the top.
2. In the single box, list and describe characteristics that these two terms or concepts share.
3. In the boxes below the single box, list and describe ways in which the two terms or concepts are different.

How are they alike?

How are they different?
Developing a Hypothesis

When you develop a hypothesis, you propose an explanation to a scientific problem. First, make an educated guess to address one possible explanation for observations related to the problem. Then make a prediction based on the educated guess. Your prediction can be thought of as an “If . . . , then . . . ” relationship between variables. Finally, make a hypothesis. The hypothesis includes a reason for the relationship in your prediction.

### Problem
Why are birds migrating northward from their wintering grounds earlier in the year?

<table>
<thead>
<tr>
<th>Make an educated guess—</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make a prediction—</td>
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<td>Write your hypothesis—</td>
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### Problem

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Developing a Hypothesis

Students should be made aware that the development of a hypothesis is a very important step in designing and conducting an experiment. The hypothesis is the foundation of the experiment. It expresses the factors that will be studied. As a result, students should strive to write hypotheses that are clear, testable, and specific. Writing a formal hypothesis is very helpful to students because it prompts them to think ahead about what can be tested and how it can be measured. There are several issues that you can discuss with students to guide them through the development of a hypothesis, such as

• writing the hypothesis in the form of an “If…, then…, because…” sentence
• thinking about the phrase that follows If as the cause, or independent variable
• thinking about the phrase that follows then as the effect, or dependent variable
• determining whether it is possible to test that relationship with the time and materials that are available

TRANSPARENCIES

Page B21 includes one problem that is already filled in, with space to write an educated guess, prediction, and hypothesis. The page also includes a completely blank space for you to write your own problem, educated guess, prediction, and hypothesis.

Page B22 includes the same problem, as well as an educated guess, prediction, and hypothesis for that problem. There is also a blank problem and hypothesis development procedure that you can work through with students. Use this version if you would prefer to give students a completed example of the steps involved in writing a hypothesis.

TIPS FOR USING THE TRANSPARENCIES

Initially, students may need help to work through the process of writing a hypothesis. You can do this by asking questions for each step of formulating a hypothesis, such as:

• What factors cause birds to start their annual migration?
• What requirements (available resources, temperatures) do birds require at their breeding grounds?
• How can this relationship be explained and tested?

CUSTOMIZE FOR YOUR CLASSROOM

Here are some additional examples that you can write onto the transparency:

Problem Why does bread become moldy more quickly when it is left out on a counter than when it is in the refrigerator?

Educated Guess Temperature may affect the growth of mold.

Prediction If bread is kept above room temperature, then it will become moldy more quickly.

Hypothesis If bread is kept above room temperature, then it will become moldy more quickly, because warmer temperatures promote the growth of mold.

Problem What affect does phosphorus have on plant growth?

Educated Guess Phosphorus, an ingredient in fertilizer, will help plants grow faster.

Prediction If plants are treated with phosphorus, then they will grow faster than plants not treated with phosphorus.

Hypothesis If plants are treated with phosphorus, then they will grow faster than plants not treated with phosphorus, because phosphorus is a nutrient that aids in plant growth.