

**Use Appropriate Technology**

An important component of any scientific investigation is the use of appropriate technology that aids in the collection, analysis, and presentation of data. The group could use computers and spreadsheets to organize the raw data and summarize it by using statistical analysis. Graphs and charts could be produced that would clearly and concisely communicate the results.

**Formulate and Revise Explanations and Communicate the Results**

The final task for the group would be to analyze the results and communicate them in an accurate and effective manner. This would be accomplished by constructing a reasoned argument, careful and logical writing, and the use of charts and graphs. The discussion might include other plausible explanations, but these would need to clearly identify and support the best explanation of the observed results. Other components of the report might include an explanation of the statistical analysis, an oral presentation, and the appropriate response to critical comments. Discussion questions are an important way of stimulating and directing dialogue about a topic or concept.

**Investigate Further**

Lab exercises often lead to other questions or suggest alternative methods for performing the investigation. For example, using the goals and steps given above, the group might wish to investigate whether nitrates, nitrites, or ammonia are most efficiently used by the plant; or they might choose to determine if delivery to the roots or the leaves is the best way to get the nitrogen into the plant.

# APPENDIX I

## LAB INVESTIGATIONS AND EXERCISES

Labs are an important part of your course work because they are a way to help you apply the themes and concepts you are studying in class to biological processes. Some important goals of lab exercises include helping you to: make systematic observations of the natural world; learn how to use scientific apparatus; make predictions and hypotheses; gather, analyze and interpret data; communicate experimental results; and pose questions for further investigation. They require you to identify assumptions, use critical and logical thinking, and consider alternative explanations.

As an example, suppose you are a member of a group that is investigating the effects of different amounts of nitrogen on the growth of a particular species of plant. How would your investigation proceed to meet the goals given above?

### Identify Questions and Concepts

Your group would first define and agree on the problem to be investigated. Questions such as "What percentage of nitrogen would cause the plants to grow the tallest?" help to focus the investigation on one particular aspect of the plant's response to the added nitrogen. Next, you would develop several hypotheses, or educated guesses, that describe the plant's responses. Hypotheses are presented in an if... then... format; for example, "If plants are given additional nitrogen then they will grow taller than plants that receive no additional nitrogen."

In developing a good hypothesis it might be necessary to conduct a review of textbooks or other resources. For example, a review would help clarify what role nitrogen plays in plant growth.

### Design and Conduct the Investigation

Using the hypothesis, the group would next design an experiment to compare the effects of different amounts of nitrogen added to the plants. It would need to identify constants (controlled variables), those factors that remain consistent throughout the experiment. Constants would be such factors as the species of plant used, the volume of nitrogen applied to the plants, the amount of light each plant receives, room temperature, and the form in which the nitrogen is delivered. Also, the group would need to identify the variables. An independent variable is a factor that is purposefully changed, in this case the percentages of nitrogen. There might be several levels of the independent variable, for example, nitrogen concentrations of 1%, 3%, 5%, 7%, and 10%. A dependent variable is the variable that responds to the change in the independent variable. In this experiment, the height of the plant would be the dependent variable.

The experiment would also need to have a control, a group of plants that receive no additional nitrogen (in other words, a group in which the independent variable is not changed). Controls are a way to detect or measure the influence of unanticipated factors, and they establish a base line for comparing the experimental effects to no treatment.

Finally, the group would need to include repeated trials (replication) in the experimental design. These repeated trials reduce the probability that a change occurred because of chance, some random factor, or because of individual variations within the plants.