# Appendices

# Appendix A: Writing Format for *Student Research*

## Directions for Teachers

Synopsis for Core Experiment summarizes the main concepts of the Core Experiment.

Appropriate Biology Level indicates the appropriate biology level for the activity, such as beginning, intermediate, or advanced.

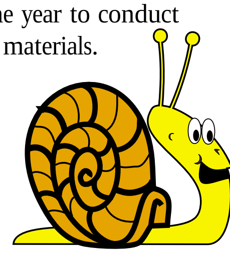
Objectives for Core Experiment describes measurable student outcomes of concepts, content, process, skills, and attitudes that students should understand and be able to explain at the conclusion of the activity.

Getting Ready includes:
- *Length of Lab*...suggested time in minutes and number of days to conduct the activity.
- *Materials Needed*...for a class of 24 students.
- *Preparation Time Required*...an estimated time for preparing the activity.
- *Directions for Setting Up the Lab*...directions for preparation of solutions, collection of materials, and construction of lab apparatus.

Safety Procedures includes lab-specific safety considerations.

Teacher Background includes:
- *Content Information*...non-technically written scientific content information.
- *Pedagogical Information*...list of common student misconceptions that are lab-specific with the correct concepts.

Teaching Tips includes lab-specific trouble spots that anticipate where students may have problems, alternative equipment and material, appropriate time of the year to conduct the lab, and where to purchase lab-specific materials.



Instructional Procedures for the Core Experiment includes:
- *Introduction*...strategies to introduce the lab to students and pique their interest such as demonstration, questions, or discrepant events. Instructions assist the teacher in providing enough content background information to the students with leading questions to facilitate the development of their own hypotheses and lab designs.
- *Hypothesis Generation*...strategies that the teacher can use to facilitate the development of good student hypotheses. A sample question, hypothesis, and rationale for that hypothesis are included as a guide.
- *Procedure*...a sample procedure for conducting the experiment for the Sample Hypothesis.
- *Data Analysis and Interpretation*...a sample analysis of student data and a discussion of that data for further understanding.
- *Test Questions* and *Answers to Test Questions*...questions with answers about the lab topic.

Student Design of the Next Experiment includes questions that assist students in developing other questions that may lead to the design of another experiment.

Suggested Modifications for Students Who Are Exceptional includes lab-specific suggestions for modifying the lab for students with special needs.

Answers to Questions and Analysis on Student Page provides answers to sections of the Directions for Student pages.

References and Suggested Readings contains sources specifically cited and quoted in the lab, as well as sources for further reading on the topic.

Variations of the Core Experiment includes up to 10 variations of the Core Experiment. Only information that is unique to each Variation of the Core Experiment is found in this section.

# ... Continued Appendix A: Writing Format

## Directions for Students

*These directions are written so that students are not required to write answers on these pages.*

Introduction includes major questions that focus the student on the lab. This section is not intended to provide answers to the lab or information on how to design the lab.

Objectives describes the expected student outcomes.

Safety Notes contains lab-specific and student-oriented safety considerations.

Materials Needed lists the materials needed for one student team.

Student Literature Search Summary with References provides suggestions for resources for student research of the literature.

Hypothesis Generation contains directions to help students design a lab-specific hypothesis.

Plan of Investigation asks students to design an experiment based upon the material presented in the teacher introduction section.

Questions and Analysis includes questions that help students analyze the quantitative data they have gathered. Answers are included in the teacher section.

Design of Variations of Core Experiment provides questions related to the Variations of the Core Experiment to assist students in designing additional experiments.

# Appendix B: Resources on NABT Web Site

For information on how to contact individuals who have used these activities, access the NABT Web site *www.nabt.org*. The site contains the activities and E-mails of scientists, writers, and field testers of the *Student Research* activities, where available.

# Appendix C: Standard Microbiological Practices and Aseptic Techniques

### Standard Microbiological Practices

(Adapted from *CDC-NIH Biosafety in Microbiological and Biomedical Laboratories*, 2nd ed., May 1988, 11-12.)

1. Access to the laboratory should be limited or restricted at the laboratory director's discretion when experiments are in progress.
2. Decontaminate work surfaces once a day and after any spill of viable material. It is prudent to have students wipe the benches down with 10 percent bleach (1 volume of bleach plus 9 volumes of water from the tap) or disinfectant at the beginning and end of each class or session. Make sure no student is allergic to bleach before using and that gloves are worn when using the bleach.
3. Decontaminate all contaminated liquid or solid wastes before disposal. This is done by steam-sterilizing in an autoclave for 30 minutes at 15 pounds per square inch (psi) of pressure at 121°C. When cool, the wastes are ready for disposal. An alternate method of sterilization is to soak wastes in 10 percent bleach for one hour, then rinse before disposal.
4. Mouth pipetting is prohibited.
5. If you have any cuts on exposed hands or arms, be sure to wear gloves or do not handle DNAs or cells.
6. Do not eat, drink, smoke, or apply cosmetics in the work area. Food may be stored only in designated cabinets or refrigerators located outside the work area.
7. Lab participants should wash their hands both before and after handling viable materials and before leaving the laboratory.
8. Perform all procedures carefully to minimize the danger of aerosols. For example, do not force the last drop of liquid from a pipette. Place the pipette tip in the receiving vessel close to the liquid layer, then release the last drop.
9. Wear laboratory coats, gowns, or uniforms to prevent contamination or soiling of street clothes. These can be laundered in hot water with soap and bleach.

### Special Practices

1. When autoclaving materials for disposal, loosen bottle caps and open the bags so steam can circulate to prevent the buildup of steam pressure and the possibility of explosion. If decontamination is to take place away from the laboratory, tightly seal contaminated materials in a durable, leak-proof container for transport. Autoclave for 30 minutes to be sure that all materials have been heated long enough to destroy spores and other contaminants.
2. Check with the school's engineer concerning the building's insect and rodent control program. Do not conduct any rDNA experiments without such a program. Put away all materials when not in use; insects and rodents may be attracted to spillage from contaminated materials.

### Containment Equipment

Special containment equipment generally is not required for manipulations. A biosafety cabinet is not necessary.

### Laboratory Facilities

1. The laboratory should be designed so that it can be cleaned easily.
2. Bench tops should be impervious to water and resistant to acids, alkalis, organic solvents, and moderate heat.
3. Laboratory furniture should be sturdy with the spaces between benches, cabinets, and equipment accessible for cleaning.
4. Each laboratory should have a sink for handwashing.
5. If the laboratory has windows that open, they should be fitted with screens.
6. Safety equipment should include a first-aid kit, fire blanket, all-purpose fire extinguisher, eyewash station, shower, and lab aprons for each student.
7. Each student should have his/her own safety goggles. Safety goggles should not be shared.
8. The laboratory must provide adequate work space for each student. Space should be available for all students to conduct the experiment simultaneously.

### Aseptic Techniques

Remember! YOU are the major source of contamination. Hands, face, hair, clothing, the outsides of all objects—and even the air—contain microbes that can grow on the culture media. The following rules apply to teachers and students who work in the lab:

1. Use sterile media, vessels & tools.
   Purchase or prepare sterile culture media. You may also need to have sterile additives, pipettes, cylinders, flasks, or bottles and sterile deionized or distilled water for diluting. Sterile media poured into non-sterile vessels will be contaminated. Check the material to determine the best sterilization method.
2. Keep hands far from the working ends of tools & vessels.
   Most pipettes have a "double line" of safety. You can easily hold and operate a pipette upstream of this marking. Do not touch the tip or column of the pipette with any object, even hands or the bench top. If something may have touched the pipette, use a fresh, sterile one. Many suppliers package pipettes individually.
3. Keep the work area neat.
   A properly organized work area helps to keep the process aseptic. Items can be moved so that they are nearby when needed or out of the way so they do not accidentally become contaminated.
4. Only uncover vessels when conducting a transfer.
   Flame caps and necks of vessels before and after conducting a transfer. Lift the lid of the petri plate as seldom and at as shallow an angle as possible. Bacteria and mold spores are in the air. Culture media are a source of nutrition for these airborne contaminants. After some practice, pipetting can be done easily while holding the vessel cap open end down.
5. Hold vessels as horizontally as possible when making a transfer.
6. Do not pass hands or arms over open vessels, caps or tools.
   Hands, face, hair, arms, and sleeves naturally and normally harbor microbes, which can contaminate the experimental culture. Keep hands out of pockets and away from face and hair while working.
7. Do not pipette out the last drop.
   When the last drop in a pipette is blown out, large amounts of aerosols and droplets are produced.

Reprinted with permission from Horn, T.M. (1993). *Working with DNA & Bacteria in Precollege Science Classrooms*. Reston, VA: NABT.

# Appendix D: Tips for Conducting Multiple Student Research Activities

### Some Tips for Sanity

This is not an exhaustive list, but may save you some time and increase your students' success in research.

- Take the time to insure that your students have selected a "doable" project.
- Have your students work with a mentor. It is impossible for one teacher to handle multiple topics and activities effectively.
- Have students use one, but no more than two of the *Student Research* activities. This will allow you to make optimum use of equipment, resources and your time.
- Contact and enlist the assistance of resource people via E-mail. Make them aware that your students will be contacting them directly for assistance.
- Work with other disciplines, such as the English, Computer, and Mathematics Departments. If planned in advance, these departments can utilize the skills and knowledge that they teach your students. For example, the Mathematics Department can assist with the correct methods for data analysis, statistics, and proper display of data. The English Department can assist with writing the scientific report in correct, clear grammatical form and style. Have the English Department clarify to the student that this is not a research paper as written for the typical English class, but a technical scientific paper to report the results of their laboratory research.
- Enlist the help of parents and make them aware of the research their child is doing.
- Set deadlines and keep students to them.
- Establish a Scientific Review Committee to review student topics, research plans, and research and to assist with necessary paperwork for use of organisms and human subjects.
- Work with the librarian to develop and strengthen student literary search skills. Keep in touch with the librarian on student progress with their literary searches in the library and on the Web.
- Consider group experiments to maximize time and equipment.
- Have students collaborate and update each other on a regular basis on their specific research.

# Appendix E: Competitions for Student Research Activities

Students may wish to enter their work into a competition. There are many competitions that the students may enter including their own school, regional, and state science fairs. Many professional societies, private industries, and government institutions conduct student science competitions. Some major competitions that provide opportunities for students to present their projects are:

*American Junior Academy of Science* and individual *State Junior Academy of Science,* American Association for the Advancement of Science, 1200 New York Ave., NW, Washington, DC 20005, 202.326.6400.

*International Science and Engineering Fair*, Science Service, 1719 N Street, NW, Washington, DC 20036, 202.785.2255, *www.sciserv.org/iisef.htm.*

*Intel Talent Search*, Science Service, 1719 N Street, NW, Washington, DC 20036, 202.785.2255, *www.sciserv.org/stsl*.

*The National Junior Science and Humanities Symposium (JSHS)*, The Academy of Applied Science, PO Box 2934, Concord, NH 03302-2934, 603.228.4520, FAX 603.228.4730, E-mail: *cousens@jshs.org*.

# Appendix F: *Student Research* Evaluation Form

Please return the following evaluation form to NABT so that we may evaluate how the *Student Research* activities are implemented and their success with students to:

Kathy Frame, NABT Director of Education
12030 Sunrise Valley Drive, Reston Plaza One, Suite 110, Reston, VA 20191
Telephone: 703.264.9696; E-mail: *kframe@capaccess.org*. This form is available on the NABT Web site at *www.nabt.org*.

| **INSTRUCTOR: OVERALL REACTION TO THE CORE ACTIVITY AND VARIATIONS**<br>**Title of activity used:**<br>**Topic or unit where the activity was used:**<br>**Course title(s): Subject title(s):**<br>**Grade level(s): Number of students:** | Check the appropriate response) | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | |
| 1. Overall, do you consider the activity a success in your classroom? | successful | | | | | | failure |
| 2. Did you use each part of this activity the way it was written? | exactly | | | | | | highly modified |
| —core activity | exactly | | | | | | highly modified |
| —variation(s) of core activity | exactly | | | | | | highly modified |
| 3. Did you find the core activity | | | | | | | |
| —easy to use? | very easy to use | | | | | | difficult to use |
| — lengthy? | too long | | | | | | too short |
| —original? | very original | | | | | | not original |
| Comments: | | | | | | | |
| 4. Did you find the variations | | **1** | **2** | **3** | **4** | **5** | |
| —easy to use? | very easy to use | | | | | | difficult to use |
| —lengthy? | too long | | | | | | too short |
| —original? | original | | | | | | not original |
| Comments: | | | | | | | |
| 5. Was the overall design of this activity? | well organized | | | | | | poorly organized |
| 6. How did you implement the activity with students? | individually | | | | | | as a class |
| Please explain: | | | | | | | |
| 7. Does the activity fit into the curriculum? | easily | | | | | | not easily |
| 8. Could it be used with several topics of study in biology? | very flexible | | | | | | limited in use |
| Are there additional topics to those covered in the classroom textbook? If so, please state. | | | | | | | |
| 9. Does it allow for crossing through the curriculum? | interdisciplinary | | | | | | limited to science |
| Please make suggestions as to how it could be used in conjunction with other subjects. | | | | | | | |
| 10. Would you use this activity again? | definitely | | | | | | never |
| If you responded 3, 4, or 5, how would you modify it so that you would use it? | | | | | | | |
| 11. Would you encourage other teachers to use it? | | | | Yes | No | | |
| | | **1** | **2** | **3** | **4** | **5** | |
| 12. Will the typical high school biology teacher be able to use this activity? | easily | | | | | | with difficulty |
| 13. Were illustrations and graphs/charts: | easy to understand | | | | | | confusing |
| | clearly labeled | | | | | | poorly labeled |
| **STUDENT RESPONSE TO THE CORE ACTIVITY AND VARIATIONS** | | | | | | | |
| 14. After completing the activity, did students want to learn more about the concepts of the activity? | | | | Yes | No | | |
| | | **1** | **2** | **3** | **4** | **5** | |
| 15. Were the students enthusiastic when responding to the activity? | very enthusiastic | | | | | | not enthusiastic |
| 16. Did students find the activity: | interesting | | | | | | boring |
| | relevant to life | | | | | | irrelevant to life |
| | too challenging | | | | | | not challenging |
| 17. Did this activity make it easy to motivate students to study the topic? | easy | | | | | | difficult |
| 18. Does the activity appeal to all students across cultures, gender, and socioeconomic levels? | | | | Yes | No | | |
| Comments: | | | | | | | |
| 19. Did the activity help to develop students' skills in: | | **1** | **2** | **3** | **4** | **5** | |
| —working with others? | useful | | | | | | not useful |
| —developing hypotheses? | useful | | | | | | not useful |
| —implementing lab design? | useful | | | | | | not useful |
| —understanding graphs? | useful | | | | | | not useful |
| —drawing graphs? | useful | | | | | | not useful |
| —drawing conclusions from data? | useful | | | | | | not useful |
| —thinking creatively, critically? | useful | | | | | | not useful |
| —focusing on a task? | useful | | | | | | not useful |
| 20. Were there any particular difficulties, such as student frustration or difficulty with investigative science? | | | | Yes | No | | |
| If so, please comment briefly. | | | | | | | |
| 21. Does the activity lend itself to more lab investigations? | | | | Yes | No | | |