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Cellular Respiration in Fast Plants

Part II: Developing and Implementing Your Research Plan

The real fun in science is designing and carrying out ways to answer to your own questions—questions based on your curiosity. The next section will help you develop and implement a research project on cellular respiration.

Generating Questions for Research

At the conclusion of the Part I of the investigation, you were asked to provide two possible questions about cellular respiration in germinating seeds. Asking good questions is one of the underappreciated skills of a scientist. Trying to arrive at the right question asked in the right way is often a barrier to someone doing his or her own scientific inquiry. *A good question for scientific inquiry is asked in a way that actually suggests how the question can be answered. A good question is also one that is focused enough to investigate.* The next couple of pages should help you chose a good question for cellular respiration research.

Reviewing the Variables

Below is a table of variables that provides a starting point for developing research questions on cellular respiration. A number of variables that you may wish to investigate are listed in the table. Look them over and think of related questions that you could research. Enter your two best questions into your laboratory notebook. Make sure that they qualify as "good questions."

Environmental Variables	Seed Variables	Organism Variables
1. Temperature	1. Stage of germination	1. Type of seed
2. Light (possible confusion with photosynthesis)	2. Age of seeds	2. Mixed seeds
3. Conditions for germination	3. Condition of seeds	3. Allelopathy (see your instructor)
4. Pressure	4. Seed size	4. Other tissues
5. Oxygen availability	5. Others	5. Other organisms
6. Time of the day		
7. Others		

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Suggested Topics

In the previous section, you examined variables to investigate for independent research. However, you may still be having some difficulty trying to get started with your research. Listed below are a few ideas that you might want to investigate. Notice that the questions are limited and provide a suggestion for developing an answer.

1. Do Wisconsin Fast Plant® seeds just starting to germinate consume oxygen at a greater rate than seeds that have been germinating for several days?
2. Does the temperature of germinating seeds affect the rate of cellular respiration?
3. Do Wisconsin Fast Plant seeds (which store energy as oil) respire at a different rate than small grass seeds such as foxtail? (grass seeds store energy as starch)
4. Do small seeds of spring flowers, weeds, and grasses respire at a different rate than summer or fall plants?
5. Do monocot plants respire at different rates than dicot plants?

Decide on the question you want investigate for independent research and enter it into your laboratory notebook.

Formulating Hypotheses

Just as your work on measuring cellular respiration allowed you to generate an appropriate research question, your research question can now aid you in developing a good hypothesis to guide your research or experimental design. A good, working hypothesis helps the investigator limit an investigation to the effect of one variable at a time. This allows the results to be clearly interpreted. To develop a working hypothesis, you need to establish the variables that you are studying and make a prediction on how those variables interact. At this stage in your scientific career it is best to keep the hypothesis as simple as possible. Forming a hypothesis is a two-step process.

1. Define your variables. Determine which variable will change as you manipulate another. Consider the following question "Does the temperature of germinating seeds affect the rate of cellular respiration?" The temperature of the germinating seeds is the manipulated variable (independent variable) and the rate of respiration is the experimental, or changing variable (dependent variable).
2. State the relationship between the two variables in an "**If . . . then**" format. *If* the manipulated variable affects the experimental variable in such and such a way *then* the experimental variable should change in such and such a manner when the manipulated variable is changed.
   For example, for the temperature-related question:

   If the rate of respiration of germinating seeds is dependent upon temperature, then when seeds are held in water baths of different temperatures, the seeds at the warmer temperature (30˚C) will consume oxygen at faster rate than seeds at lower temperature (20˚C).

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Contrary to popular belief, a hypothesis is not just an educated guess—it's a very limited and defined prediction.

Controlling for Weather Variables

Because a microrespirometer is so sensitive to changes in gas volume, it is also extremely sensitive to changes in temperature and air pressure. Thus you might want to use a control microrespirometer to measure and correct for temperature and pressure changes that occur while using the microrespirometer. The control microrespirometer is set up just like the experimental except that it contains nonliving matter instead of sprouting seeds.

1. Add the 0.5 mL of beads or baked seeds (a volume similar to the sprouting seeds in the experimental) to a second microrespirometer. You do not need the KOH for the control. Reinsert the syringe plunger and push it in to the "0" mark.
2. Place 3–4 washers around the barrel of the control.
3. Place the assembled control in the water bath next to the experimental microrespirometer. Make sure the capillary tube is open (not sealed) until the syringe and water bath are the equalized.
4. Add the soapy manometer fluid to seal the capillary tube of the control microrespirometer at the same time that you seal your experimental. Since the control is not consuming oxygen, you may need to manipulate the plunger to get the manometer fluid into the capillary tube. Move the manometer plug to the middle of the capillary tube by moving the syringe plunger. Mark a beginning point and note any positive or negative changes in the control while you are measuring the oxygen consumption in your experimental.

Developing and Implementing Your Plan

Complete the following chart and submit it as a research proposal for your teacher's approval.

Hypothesis:
Materials:
Variable(s) manipulated:
Variable(s) held constant:
Methods or procedure:

Once you have the approval of your teacher, you may carry out your research plan.

Student Presentation

Research biologists keep a record of their work in their laboratory or field notebook. They communicate the final results of their work to others a number of ways. They may publish an article or make a presentation at a meeting. To keep others informed about work that is just getting started, biologists often use a form of presentation known as a poster. Check with your teacher for direction about how you should report your work.