What Does a Seed Need?

Activity Overview
Students select one species and design an experiment to determine a stratification regime that will result in the highest germination percentage.

Objectives
Students will:
- Develop, design, carry out a scientific investigation
- Communicate the results of their investigations
- Explore dormancy mechanisms and germination phase of a plant life cycle

Subjects Covered
Science and Math

Grades
6 through 12

Activity Time
Approximately 2 hours for designing the stratification experiment, 2-3 for setting up the experiments, 1 for setting up germination tests and 1-2 for recording and writing up the results. The entire experiments must run for at least three months.

Season
Late fall or early winter for seeds collected the previous growing season.

Materials
Film cans or ziploc bags, seed, 3-4 petri dishes or small plates per group, cotton absorbent paper towel or filter paper, thermometer, and cold space such as a refrigerator.

Equipment for various seed treatments might include: peat moss, vermiculite, sawdust (from non-treated wood), sand, sandpaper, rolling pin or other materials depending on experimental design.

State Standards
Science:

Identify questions using available resources (C.8.1)

Background

Seeds need appropriate environmental conditions to germinate. These conditions include appropriate oxygen concentrations, temperature, moisture and in come cases, light. Seeds from plants that bloom early in the growing season may germinate if the environmental conditions are suitable and they are planted immediately. However, most seeds will develop dormancy that prevents germination until certain environmental conditions are met. Biologically, this is a protection mechanism that prevents seeds from germinating when the conditions are not favorable for long-term growth. For instance, a seed that ripens in late fall may encounter a late, warm, wet spell ideal for germination but too late in the season for survival of the seedling. In this case the plant may only germinate if dormancy is "broken" with exposure to a prolonged cold spell delaying germination until after a cold "winter." This process of breaking dormancy by exposure to a cold spell is called cold stratification.

Some seeds will only germinate if moist-cold stratified, that is, exposed to cold, moist conditions. Still others require warm, moist stratification. Another dormancy-breaking mechanism, scarification, involves creating little cracks in the seed coat. In that case, germination is delayed until the seed coat has been broken.

Our current knowledge about what is necessary to break dormancy is based on practical experience in the field. However a myriad of questions remains about the best treatments for individual species. For instance, if a seed demands cold stratification, what is the ideal temperature? How long should it stay at that temperature? Is longer better? Can germination percentages be increased by increasing the humidity? For moist stratification, how much water is ideal? What temperature? How long? What is the ideal cold stratification medium? For seeds that require scarification what is the best way to scarify and how much scarification is ideal? The answers to each of these questions vary from species to species. There are many opportunities for student-led investigation leading to information that might be of practical significance in the field of ecological restoration.

Film canisters or ziploc bags are good for moist stratification. A refrigerator can provide cold temperatures. Slightly different temperatures are often found in different places in the refrigerator (the crisper, the butter shelf, etc.). Scarification can be done by rubbing the seed gently between two pieces of sandpaper, tumbling the seed in a canister of sand or rolling lightly with a rolling pin. Students may come up with other scarification techniques but should bear in mind that the point is to create small fissures on the seed coat and must avoid breaking, crushing or otherwise damaging the seed.

Identify data and sources to answer questions (C.8.2)
Design and conduct investigations (C.8.3)
State learning from investigations (C.8.6)
Evaluate questions, hypotheses, conclusions (C.8.9)
Ask questions, build hypotheses, design investigations (C.12.1)
Identify issues, questions, research; design & conduct investigations (C.12.2)
Evaluate data (C.12.3)
Use explanations & models to describe results (C.12.5)

Math:
Use reasoning abilities (A.8.1, A.12.1)
Communicate logical arguments (A.8.2, A.12.2)
Analyze non-routine problems & arrive at solutions (A.12.3)
Generate & explain equivalencies among fractions, decimals, percents (B.8.3)
Perform & explain operations on real numbers (B.12.3)
Work with data in real-world situations (E.8.1, E.12.1)
Organize & display data from statistical investigations (E.8.2, E.12.2)

Activity Description

All seeds need appropriate environmental conditions to germinate. These conditions include appropriate oxygen concentrations, temperature, moisture and in some cases, light. Seeds from plants that bloom early in the growing season may germinate if the environmental conditions are suitable and they are planted immediately. However, most seeds will develop dormancy that prevents germination until certain environmental conditions are met. Breaking seed dormancy is referred to as stratifying the seed.

Pick a plant and find out what is known about treatment necessary to stratify its seed. Stratification requirements of native species can be obtained from reference books listed under "Additional Resources."

The way those seeds are stratified will affect the number that germinate (the germination percentage.) You are charged with conducting a research experiment to find more detailed information about how to stratify the seed of your species such that you maximize germination.

Design an experiment to get more information about one part of the stratification requirements. For instance, if your seed needs wet stratification, how wet? Is sawdust, sand, vermiculite, peat, or something else a better medium for the wet stratification? What storage temperature is best? What is the best length of time for storage? If they require only dry stratification, would wet stratification improve germination percentages? What temperature is best for dry stratification? These are just a few of the questions that you may ask.

In designing your experiment, clearly state your hypothesis. You should be testing only one variable while trying to keep all others constant. Consider how many seeds you need to test for each treatment. Remember, you will want to calculate a germination percentage on your seeds at the end of the experiment so you need enough treated seeds to be able to get an accurate percentage. Record as much information as possible about how you treated your seeds. Try to keep your experimental procedures simple.

After treating your seeds you will want to try to germinate them to see if the treatment affected the germination percentage. To test for germination follow the instructions on the Germination Test Procedure sheet.

Record your data carefully and report your results in a written paper, oral presentation or scientific poster.

Germination Test Procedure

1. In a petri dish lay down two pieces of filter paper. (Note: it may be possible to use a heavy-duty paper or cloth toweling as a substitute for filter paper. But, it needs to be able to hold up to repeated handling when wet, and not contain any chemicals which would inhibit germination.)

2. On top of these papers place a sample of your seed. When testing prairie seed it is best to use 100 seeds, although as few as 50 seeds may be adequate. A large number of seed is necessary because there can be a great amount of variation in germination rates. (Note: It may be necessary to decrease this number even farther, if you do, expect less accurate results.) Try to spread out the seed as much as possible. Some seed contain germination inhibitors and closely spaced seed may inhibit the germination of each other.
3. On top of the seed lay down two more sheets of filter paper.
4. Wet the sandwich of filter paper and seed with distilled water. (Note: Chlorine and other chemicals in city water may adversely affect germination. Bottled drinking water and clean well water may be acceptable alternatives.) Use just enough water to soak the paper, but not enough to produce standing puddles. This is easily done by using a squirt/spray bottle, although flicking water with one's fingers can work well also.
5. Place the petri dish in a well lit area, but out of direct sunlight. Many seeds need light to germinate. But, watch out, too much bright light (such as direct sunlight) can turn your petri dish into a greenhouse oven! Room temperature is good for germination of most prairie seed. Avoid hot spots such as radiators or heat ducts. Likewise, a cold drafty windowsill may be too cool to allow germination.
6. Keep the filter paper well moistened. Initially it is a good idea to check the moisture level a couple times a day until you know how quickly it is drying out and needs watering.
7. After several days begin to look for emergence of the seedling root (or radicle). It is this event which defines germination. Keep an eye on the increase in percentage of seed germinated. When it becomes clear that no more seed are germinating, count the number of seed that have germinated, and determine the percentage. The time that it takes to reach this point can be affected by the species itself, and the environmental conditions during the germination test. Have patience, and check your seed at least once a day!

Extensions

- Test germination conditions to determine ideal temperature and moisture conditions for a given species.
- Create a class poster session for each student or group to report results at one time. Alternatively a seminar of presentations or class data base could serve the same purpose.
- Have students record their information to a data base containing information from previous years. Have students look at previous years' data to help them form their own questions.
- For younger students, stratify seeds according to standard protocol and determine a germination percentage.

Additional Resources

- Hartmann, H., Kester, D., Davies, F., Geneve, R. 2(002). *Plant propagation: Principles and practices.* 7th Edition. Prentice Hall. Upper Saddle River, NJ
- Hill, L. (1985). *Secrets of plant propagation: Starting your own flowers, vegetables, fruits, berries, shrubs, trees and houseplants*. Storey books: North Adams, MA.
- Riveredge Nature Center. (1999). *Begin with a seed: The Riveredge guide to growing Wisconsin prairie plants.* WonderCat Graphics: Wauwatosa, WI.
- Rock, H. 1(981). *Prairie propagation handbook*. 6th Edition. Wehr Nature Center, Milwaukee County Dept. of Parks, Recreation & Cultrue: Franklin, WI.
- Toogood, A. Editor: American Horticultural Society. (1999). *Plant propagation: The fully illustrated plant by*

plant manual of practical techniques. DK Publishers, New York, NY.

- Worth, Bonnie. (2001). *Oh say can't you seed?: All about flowering plants*. Random House Books,
- Carle, Eric. (2001). *The tiny seed*. Aladdin Picture Books.

Assessments

- Fill out a germination fact sheet, and write a short narrative of challenges and successes for your individual plant. Place in a binder for future classes and/or restoration projects.
- Describe dormancy mechanisms and the germination process of a plant life cycle.
- Develop a rubric for developing, designing and implementing a scientific investigation.