Window Gardens

Overview

Students will use a plastic sandwich bag containing a damp paper towel taped to a window as a model system to observe the germination and early growth of radish seeds. Students will then be challenged to pose a question about seed germination and growth that they can answer using the hanging bag system.

North Carolina Standard Course of Study

4.01 Describe the flow of energy and matter in natural systems:

- Energy flows through ecosystems in one direction, from sun through producers to consumers to decomposers.
- Matter is transferred from one organism to another and between organisms and their environments.

7.02 Investigate factors that determine the growth and survival of organisms including:

- Light.
- Temperature range.
- Water

7.03 Explain how changes in habitat may affect organisms.

Textbook References

McDougal Littell

The concepts covered in this exercise are scattered throughout Unit D, *Ecology*, Chapter 1, *Ecosystems and Biomes*.

Prentice Hall

The concepts covered in this exercise are found in Chapter 12, *Ecosystems and Biomes*, Section 2 (pp 426-431), *Photosynthesis and Light*.

Background

The evolutionary innovation of the seed is one of the major factors that have allowed land plants to spread to all corners of the globe. Seeds provide protection for the sexual reproductive stage of a plant's life cycle as well as a means to distribute the plant in space and time. All seeds contain an embryo, or baby plant in a dormant state. This embryo is protected from drying out by the seed coat. Seeds also contain stored food to support the embryo and young growing plant.

The major groups of seed plants are distinguished by aspects of their seed formation, and morphology (shape and structure). The gymnosperms, or naked seed plants, produce seeds that are exposed on cones when mature, as in pine trees. The angiosperms, or flowering plants, produce seeds protected in ovaries that are associated with fruits of various forms. Some examples of angiosperms are maple trees, sunflowers, and grasses.

This seed and fruit strategy has proved very successful for the flowering plants, as they are the largest and most diverse plant group accounting for 80% of the known green plant species. Non-seed plants such as mosses and ferns reproduce using spores (the brown sacks seen on the underside of fern leaves release these spores) that are less resistant structures than seeds. The reproductive stages of these plants also depend on water for fertilization to occur.

The flowering plants and their seeds are the main source of food for humanity. The easiest way to get acquainted with these seeds is to look at one. Soak some dried lima bean seeds overnight (two beans per student will provide enough material for student investigations). The dormant seeds will swell when placed in water and the tough seed coat may also split. Once the seed coat has been removed (students should feel how tough this seed coat is) the two halves of the bean can be opened to reveal the small embryo with recognizable leaves, stem, and root tip. The radicle, or root tip, emerges first, followed by the plumule, consisting of the shoot and leaves. See Figure 1. (*Radicle* and *radish* both come from the same Latin root word, *radicula*, meaning 'root!' The symbol for square root in mathematics, $\sqrt{\ }$, is also called a radical, though spelled slightly differently.) The two halves of the bean are the cotyledons or seed leaves that contain the *endosperm*, the stored food for the embryo and young plant. Flowering plants are divided into groups based on the number of seed leaves, or *cotyledons*, that they have. The monocots like corn, grain, and grass plants have one cotyledon. The dicots, like beans, radishes, and cucumbers have two cotyledons. After germination, these cotyledons can show up as small leaves or remain underground depending on the plant species. Whatever their appearance, they are providing food for the young plant. Conveniently, the food stores found in a seed can also provide nutrition for humans and other animals.

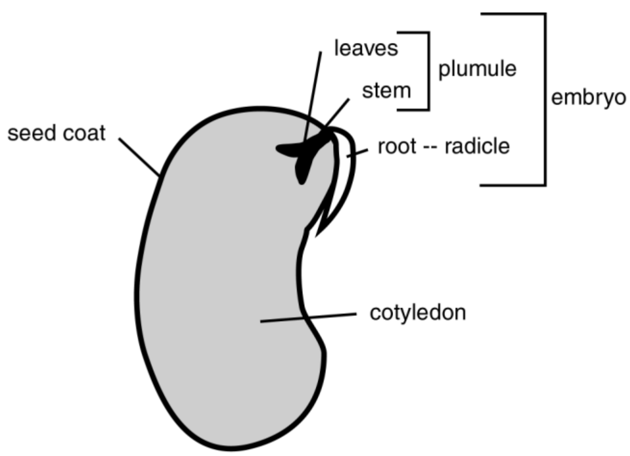

Figure 1.
Germinating bean, one cotyledon
removed to show developing embryo

Seeds germinate when the proper conditions to break their dormancy have been met. This varies between plant species. Some seeds are only dormant for a few days while others can remain dormant for hundreds of years. Explorers have found 10,000 year old seeds in the arctic that they have thawed out and germinated. The tough protective seed coat is the initial barrier to germination and some seeds must be mechanically scratched, frozen, or even treated with acid to allow germination to proceed. Seeds must also be exposed to the appropriate light, moisture, temperature, and oxygen levels for the dormancy of the embryo to break and for germination to occur. Once the proper conditions are met, the embryo uses the stored food and begins to grow (see Figure 2).

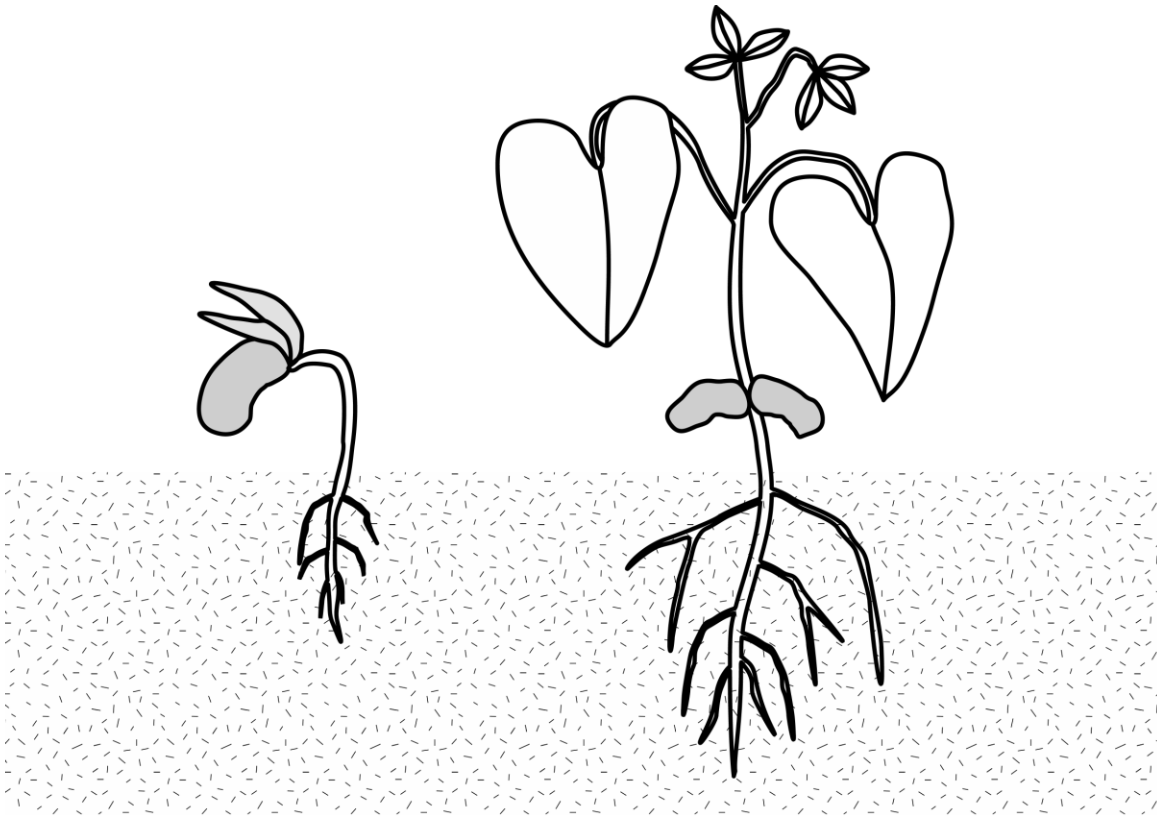

Figure 2.
Seedling with plump cotyledons and first true leaves (left);
Young plant with withering cotyledons (right).

Materials

Part I

- Plastic sandwich bags
- Paper towels
- Radish seeds
- Hand lenses
- Stereomicroscope microscopes (optional)
- Science notebook

Part II

- A collection of garden seeds (including radish) and collected seeds (students can bring left over garden seeds from home, but be sure to note the "packed for" date as old seeds can germinate more slowly or in reduced numbers compared to fresh seeds)
- Plastic sandwich bags
- Paper towels
- Various solutions for wetting the towels (i.e. salt, sugar, soda, liquid soap)
- Material to cover the plastic bags (aluminum foil, colored paper)
- Space available in other germination areas (refrigerator, dark cabinet, incubator)
- Science notebook
- Photocopy of “When planning an investigation . . .”

Procedure

Part I

This activity is a demonstration of the hanging bag germination system which students will use in Part II. Teachers could preface this activity with a "dissection" of soaked lima beans so students can gain a basic idea of seed structure. A discussion covering student suggestions of what conditions seeds need to germinate should also precede the set up of Part I.

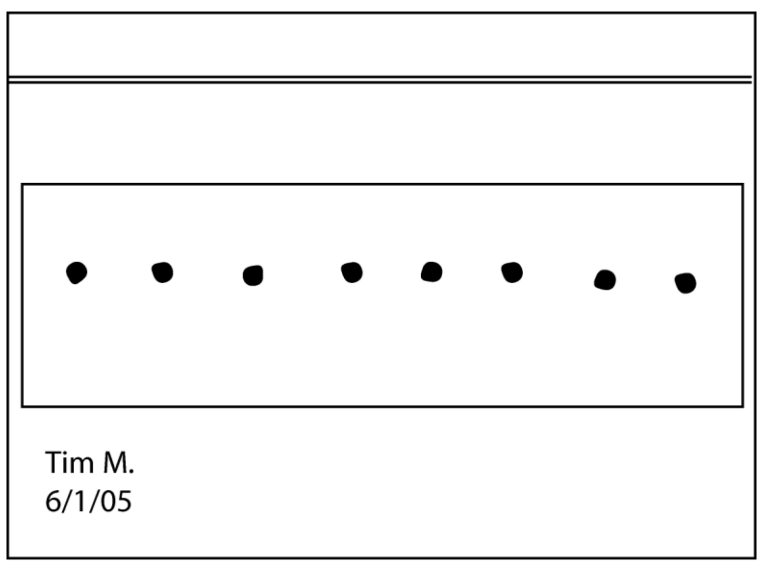

Figure 3.
Starting seeds in a plastic sandwich bag.

Each student should take one sandwich bag. These polyethylene bags allow exchange of atmospheric gasses but prohibit the movement of water vapor out of the bags. If sealed properly they do not need to be opened during this experiment. Students should cut a paper towel so that it is 1 to 2 inches high and just fits from side to side in the bag. They should then moisten the towel so it is damp but not running with water and fit the towel into the middle of the bag as shown in Figure 3. Students should then place 8 radish seeds spread out as evenly as possible on the damp paper towel. The bags should then be sealed with tape or zip-locked. Students should label a piece of masking tape with their name and the date and place it on the bag. The bags should then be taped to a window with the seeds facing into the room so they can be easily observed.

The following day, students can begin making daily detailed observations of the stages of germination. They should make detailed drawings and record written observations in their science notebooks. They should also look for variations among each other's bags. It is beneficial to start this activity on a Monday so students can catch the initial stages of germination during the school week as radish seeds germinate and grow rapidly.

After about a week to ten days when the seeds have grown into small plants, the experiment can be finished with a closer inspection of the plants by taking them out of the bag. This is a good opportunity to get a look at different plant parts, especially roots and root hairs. Students can use hand lenses and stereomicroscopes to study the delicate root hairs while the plants are still in the bag. The plants may be slightly stuck to the paper towel because of these root hairs, structures that greatly increase the surface area of the roots for absorbing water and minerals.

Part II

In this activity students are asked to employ the techniques learned in Part I and use inquiry to develop an experiment that investigates germination. The possibilities of what can be investigated are only limited by the materials and space available. The main point is that students develop the question and design the experiment themselves. Students are required to present their experiment in the form of a question that they hope to answer by doing the experiment. They should be asked to first write out their question in their science notebooks and then write a plan of the steps they will take to answer the question. Students must be able to justify their experimental design based on the question. All experimental designs must be approved by the teacher. The concepts of *testing only one thing at a time* and *experimental control* should be stressed. Teachers can work with their students to be sure the experiment is a fair test and is aimed at answering the question posed. Guidelines for planning an investigation are included at the end of this exercise.

Students will probably need some guidance in determining how to ask a question. They should be directed away from ambiguous words like *best*, which is not well defined as a measure, to more specific ways of quantifying. As an example, one student may want to ask if it is better for radishes to grow in soil or in a bag. A more specific way to word the question and to quantify the answer is to ask whether radishes germinate faster or in larger numbers in soil or in a bag. These parameters are more easily measured. Some experimental possibilities include comparisons of germination: in a bag versus in soil, inside vs. outside on the window, big seeds vs. small seeds, different wetting agents vs. water, light vs. dark, room temperature vs. refrigerator, etc. Each bag should be labeled according to its *treatment* or if it is a *control*. In this experiment, water might be the control vs. treatment with grape soda, or room temperature might be the control vs. growth in a refrigerator.

Students should make daily detailed observations and drawings of their experiment. They should be urged to quantify all data, as in how many seeds have germinated in how many days. After the experiments have run a week or two, students should be ready to write up their results in a formal lab report. They should use their lab notebooks as the source of their information. The report should include the initial question and whether their experiment answered that question. It should also include a section addressing what other experiments they could do to answer their question.

Reflection/Discussion

A good web resource for basic botany as of August 2005 is *The Great Plant Escape* at: http://www.urbanext.uiuc.edu/gpe/index.html.

When planning an investigation be sure to consider:

1. **What <u>question</u> will you investigate?**

2. **What do you <u>predict</u> might happen?**

3. **What <u>materials</u> will you need?**

4. **What is your <u>procedure</u>?**

5. **How will you <u>measure</u> what happens?**

6. **How will you <u>analyze</u> and <u>present</u> your results?**