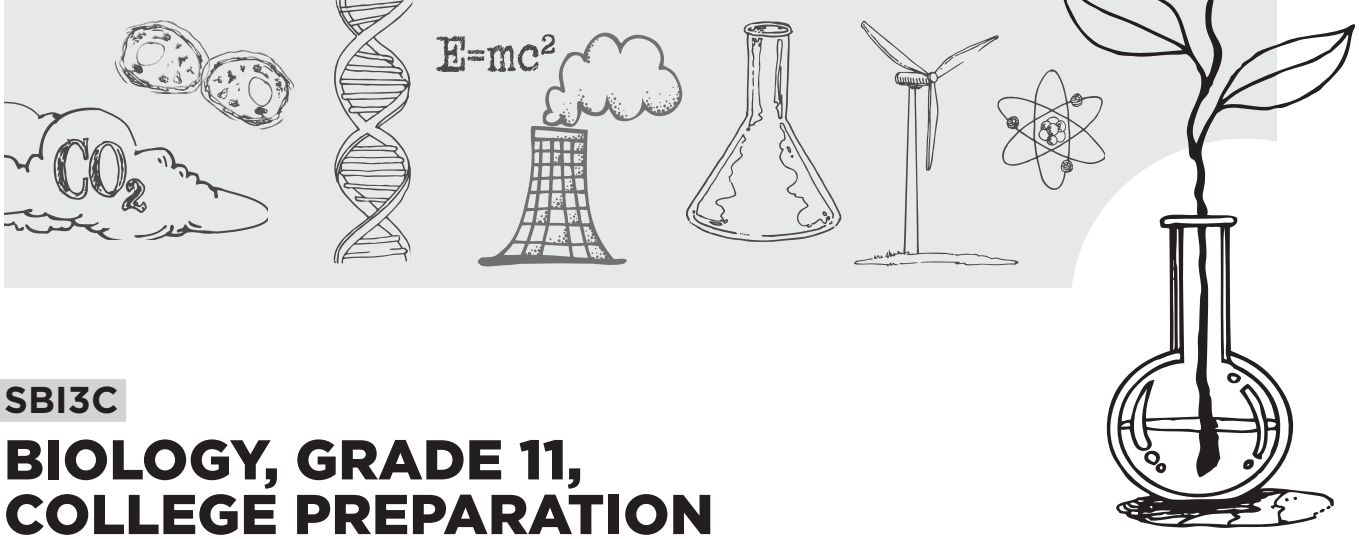


SBI3C

BIOLOGY, GRADE 11, COLLEGE PREPARATION

OVERVIEW: ENVIRONMENTAL EDUCATION OPPORTUNITIES IN GRADE 11 BIOLOGY

The sustainability of natural ecosystems is dependent upon the complex interactions among each constituent species, each fulfilling its own specific ecological niche. Compounds that are produced as waste by one species may be consumed or recycled by other organisms as they fuel their own metabolic processes. The homeostatic principles that apply to plants and micro-organisms within an ecosystem can be readily applied to human systems. However, human practices often interfere with the complex network of interactions within a natural ecosystem, causing changes in biodiversity and affecting the overall sustainability of the system.

Curriculum Expectations

- **Microbiology:** C1.1
- **Plants in the Natural Environment:** F1, F1.1, F1.2, F2.3
- **Genetics:** D1.2

GUIDING QUESTIONS

QUESTIONS	LEARNING CONCEPTS
What role do plants play in the sustainability of ecosystems (e.g., nutrient cycles, the water cycle, erosion control, wildlife habitats)?	Plants sustain ecosystems by providing food and oxygen for other organisms, restoring nutrients to the soil through metabolism and decomposition, preventing soil erosion around root systems, cooling the surrounding air by providing shade, and releasing moisture during plant transpiration.
ecoschools écoécoles CANADA	**Links to EcoSchools - School Ground Greening** Plant a native species or butterfly garden, or create an outdoor classroom to teach about ecosystem sustainability and promote biodiversity on your school ground.
How do human practices (such as agriculture, forestry, and urbanization) affect the sustainability of ecosystems?	Human practices may affect the natural balance of plants in an ecosystem, thereby reducing biodiversity. For example, non-native plants that are introduced to an ecosystem may compete with native species, and become invasive species. Urban development may reduce biodiversity by fragmenting natural ecosystems or eliminating them altogether.
What are some of the environmental benefits of urban green spaces?	Urban green spaces filter air, water, and sunlight, reduce the "urban heat island" effect, and provide food and habitat for local wildlife.
ecoschools écoécoles CANADA	**Links to EcoSchools - School Ground Greening** Plant a tree. In addition to conserving energy and moderating climate, trees also serve as long-term storage sinks for carbon dioxide.

QUESTIONS	LEARNING CONCEPTS
Explain how the reactants (carbon dioxide, energy, water) and products (glucose, oxygen) of photosynthesis affect levels of greenhouse gases in the atmosphere.	The sugars generated by photosynthesis act as fuel for metabolic processes that produce gaseous carbon compounds. In addition, processes such as decomposition and combustion of biomass (e.g., forest fires) release carbon into the atmosphere. If the amount of carbon released exceeds the amount of carbon consumed, the plant becomes a carbon source.
Do different plants play different roles?	During photosynthesis, plants remove carbon dioxide from the atmosphere, acting as carbon sinks. Most herbaceous (non-woody) plants do not provide long-term storage of carbon; however, trees/forests are capable of sequestering carbon for long periods of time.
Describe how changes in the environment can result in adaptive variations in plant structures.	Environmental variables can cause variation in structures within a single plant. For example, root systems, leaf structure, and plant size may vary according to environmental factors such as temperature, moisture, and light.
What can we learn from natural systems to help reduce the impact of social systems on the environment?	An ecosystem, a plant, and a cell each represent a natural system. Each system works by cycling matter through different components and using energy to fuel this process. In an ecosystem, organisms use many compounds throughout their life cycle and, in turn, produce waste products. Some organisms use potentially toxic compounds, subsequently forming smaller and safer components as waste. Other organisms in the ecosystem may use these compounds in their own life cycle for their own metabolic processes. Bioremediation mimics this natural process by finding and enhancing existing organisms that can metabolize toxic compounds into safer products. However, introducing sufficient quantities of the remedial organism may cause noticeable shifts and stresses at other equilibrium points. Human practices can compromise a natural system so quickly that it becomes vulnerable to collapse. For example, many technological processes that produce compounds such as CFCs, PCBs, and refined oil form waste products that have too few or too slow biodegradable pathways. Alternatively, some production rates are too high (e.g., dioxin as a by-product from burning municipal solid waste). These toxic products then accumulate or bioaccumulate, or their concentration alone shifts the ecological equilibrium of the ecosystem, thereby limiting the diversity of living things that can survive in the affected area.
ecoschools écoécoles CANADA	**Links to EcoSchools - Environmental Stewardship** Implement a composting program to demonstrate how the waste products of decomposers (bacteria, earthworms, etc.) recycle and restore nutrients in an ecosystem. **Waste Reduction** Encourage students to bring boomerang or litterless lunches to divert waste products that have too few or too slow biodegradable pathways in the natural environment.
What are some of the effects of genetically modified organisms or GMOs (e.g., herbicide-tolerant plants, insect-resistant plants, bioengineered microorganisms) on the environment?	GMOs may out-compete native species, thereby reducing the biodiversity of an ecosystem. Reducing diversity may increase the vulnerability of organisms to diseases and pests, or may trigger new breeds of resistant diseases and pests.
How might the introduction of GMOs affect the biodiversity of an ecosystem?	Because GMO technologies are relatively recent, the long-term effects on ecosystems are unpredictable and largely unknown.

LEARNING ACTIVITY:
OBSERVING THE INFLUENCE OF ACID RAIN ON PLANT GROWTH

Biology Grade 11 College Preparation

Background

In the 1970s, communities first became aware of the devastating effects acid rain was having on environments across North America and Europe. Today acid rain is still a concern. Sulfur dioxide (SO_2) and nitrogen oxides (NO_x), emitted during fossil fuel combustion, are major contributors to acid rain. These compounds react with other molecules in the atmosphere to form sulfuric and nitric acid, and can be distributed around the world via atmospheric currents.

While pure water has a pH of 7.0, typical rain water is slightly acidic because CO_2 in air forms carbonic acid, resulting in a pH of approximately 5.6. Due to the additional contributions of SO_2 and NO_x, acid rain has been recorded at pH levels between 4 and 5. Acid rain has been found to have damaging effects on the environment. Acidified lakes and streams have seen decreasing populations of fish and other organisms as species either die or see their food supply reduced. Forests and plants are also susceptible to the impacts of acidification. In this activity, students will examine the impact of an acidic environment on plant growth. The findings of this study can be extrapolated to study the greater impacts of acid rain on the environment.

Curriculum Links

- **Overall Expectations** – A1, F1-F3
- **Specific Expectations** – A1.1-A1.11, F1.2, F2.1-F2.3, F3.1

TEACHING & LEARNING STRATEGIES: PRIOR LEARNING

Prior Learning

This task requires students to have a basic understanding of acids and bases, pH, and plant biology.

Fundamental Skills

Students need to be able to follow experimental protocol, collect qualitative data and make connections to real world problems.

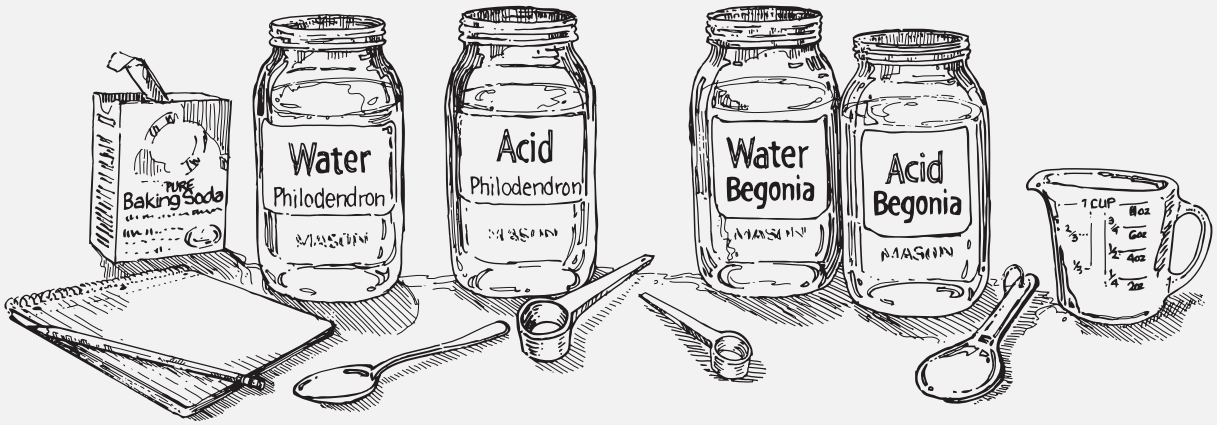
Systems Analysis

Students need to be able to identify parts of a system and connections between or among systems. In particular, students need to be able to identify relevant outputs from human systems, such as air emissions, that act as inputs into one or more other systems, such as terrestrial ecosystems.

TEACHING & LEARNING STRATEGIES: STUDENT TASKS

Materials: (per student or per group)

- 4 cups or jars
- Distilled water
- White vinegar
- Baking Soda or Ammonia
- Stirring spoon
- Measuring cups
- Notebook and pencil
- 2 cuttings of a philodendron plant (1 leaf and small amount of stem)
- 2 cuttings of a begonia or coleus plant (1 leaf and small amount of stem)



Methods

1. Pour 1 teaspoon of vinegar into 2 cups of distilled water, stir well, and check the pH with an appropriate tool (pH paper or a pH meter). The pH of the vinegar/water mixture should be about 4. If it is below pH 4, add a sprinkle of baking soda, or a drop of ammonia, stir well, and recheck the pH. If it is above pH 4, add a drop or two of vinegar and again recheck the pH.
2. Measure out an additional 2 cups of distilled water and check the pH. If the pH is below 7, add about 1/8 teaspoon baking soda, or a drop of ammonia, stir well, and check the pH of the water with the pH indicator. If the water is still acidic, repeat the process until pH 7 is reached. Should you accidentally add too much baking soda or ammonia, either start over again or add a drop or two of vinegar, stir, and recheck the pH.
3. Put one of the following labels on each cup or jar:
   a. water philodendron
   b. acid philodendron
   c. water begonia (or coleus)
   d. acid begonia (or coleus)
4. Pour about a cup of distilled water with pH of 7 into the water-philodendron and water-begonia cups.
5. Pour about a cup of the vinegar/water mixture into the acid-philodendron and acid-begonia cups.
6. Put one philodendron cutting into each philodendron labeled cup, covering the stem and part of the leaf with the liquid.

7. Put one begonia cutting into each begonia-labeled cup, covering the stem and part of the leaf with the liquid.
8. Set the cups where they are not likely to be spilled and where they will receive some sunlight.
9. Every 2 days, check to be sure that the plant cuttings are still in the water or vinegar/water. You may need to add more liquid if the cups become dry.
10. After 1 week, compare the new root growth of each plant in distilled water with the new root growth of its corresponding plant in acid water. Record the results.
11. After 2 weeks, again observe the plant cuttings for new root growth, and record the results.

Analysis

Write a final lab report indicating overall observations, results and conclusions.

Questions to consider:

- Which plant cuttings had the fastest root growth, those in distilled water or those in acid water?
- What impacts did the acidic water have on the plant and why?
- How could an acidic environment impact a plant's ability to perform its vital functions, such as nutrient retention and photosynthesis?
- What are the long-term implications of acid rain on ecosystems?

Extension

Using a third jar for each type of plant, have students perform the experiment using locally collected rainwater, perhaps from a rain barrel installed at the school as part of a School Ground Greening project. Discuss the acidity of local rainwater and impacts on local ecosystems.

Acknowledgement/Source

US EPA. 2012. Acid Rain Experiments – Experiment 7 – Observing the Influence of Acid Rain on Plant Growth. URL: www.epa.gov/acidrain/education/experiment7.html

This information and activity was adapted from an activity provided by the United States Environmental Protection Agency (US EPA). More information and activities can be found on the US EPA's Acid Rain website: www.epa.gov/acidrain/index.html

RECOMMENDED RESOURCE

Quagmire: A Simulation Game for Wetland Decision Making

This resource, produced by Clean Nova Scotia, outlines a role-play scenario in which students assume the roles of various stakeholders (e.g., government, industry, business, farmers, and environmental organizations) to research and debate the proposed development of a saltwater marsh. (Source: Clean Nova Scotia)

http://navigatingunfamliarseas.weebly.com/uploads/2/7/2/0/2720513/quagmire_game.pdf

BROKEN LINK? *Google search* "Navigating unfamiliar seas" → Simulations, Role-Plays and Structured Problems → Quagmire Game (download file)

Resources

WETLAND ECOSYSTEMS 111: EVOLUTION, DIVERSITY, AND THE SUSTAINABILITY OF ECOSYSTEMS

This resource is produced by Ducks Unlimited. This unit combines a field trip to a wetland ecosystem with a variety of classroom activities. (Source: Ducks Unlimited Canada)

www.greenwing.org/dueducator/lesson_plans.html

BROKEN LINK? *Google search* "Greenwing.org" → Ducks Unlimited Educators → Complete Curriculum → Educator's Guide, Grades 9–12 (download file)

CANADA'S FORESTS – A FINE BALANCE

Canada's Forest Teaching Kit Series, Volume 5, Lessons 6 to 9 offers students hands-on opportunities to investigate species at-risk and analyze the costs/benefits of setting aside protected areas. (Source: Canadian Forestry Association)

www.canadianforestry.com/kits/english/volume5-e.html

BROKEN LINK? *Google search* "Canadian Forestry Association teaching kits" → BROWSE CFA Teaching Kits Volume 1 through 8 → English → Volume 5

BIOTECHNOLOGY, GMOS, AND FOOD

This lesson by the UBC Home Economics Teachers Collaboration is designed to make students aware of the controversy around genetically modified foods, the source of this controversy, the arguments for and against genetic modification, and underlying value positions. A dynamic role-play activity allows students to engage in a debate, presenting their respective arguments and exposing the pros and cons of GMOs. (Source: British Columbia Teachers' Federation)

www.bctf.ca

BROKEN LINK? *Google search* "British Columbia Teachers' Federation" → Site Search: "Biotechnology, GMOs, and Food" → First Draft of Lessons to Integrate International Development Issues

This resource is an adaptation of the EcoSchools *Climate Change in Grade 11 and 12 Science* produced by the Toronto District School Board (TDSB). The TDSB has donated this resource to the Ontario EcoSchools Program as part of its in-kind contribution to the project.

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