Ecosystems: The Role of Abiotic Factors
from the series
Biology: The Science of Life

Teacher's Guide by
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Ecosystems: The Role of Abiotic Factors

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Ecosystems: The Role of Abiotic Factors
From the Series Biology: The Science of Life
Grades 5-9
Viewing Time: 15 minutes including a one-minute,
Five-question Video Quiz

INTRODUCTION TO THE SERIES

This series of programs was designed in accordance with the guidelines for teaching Life Science as proposed by the American Association for the Advancement of Science.

INTRODUCTION TO THE PROGRAM

This fifteen-minute program examines the role non-living, abiotic factors play in shaping ecosystems. Five abiotic factors are examined: water, air, soil, heat, and light. In addition, three air-mediated cycles are presented: the water cycle, the carbon dioxide/oxygen cycle, and the nitrogen cycle.

LINKS TO CURRICULUM STANDARDS

This program was designed to meet the curriculum standards of the California Public Schools, the McREL standards for the Life Sciences, and the National Science Education Standards.

A. California life science teaching standards Section C, Ecosystems,
1. What are ecosystems and how do organisms interact in ecosystems?

2. How do energy and matter flow within an ecosystem?
B. McREL Life Science Standard Six:
*The relationships among organisms and their physical environment.*

C. National Science Education Standard:
*Interdependence between organisms and their environments*

**SUMMARY OF THE PROGRAM**

This program is divided into several major topics that are presented in this order:
- Introduction
- Water, Abiotic Factor #1
- Air, Abiotic Factor #2
- The Water Cycle
- The Carbon Dioxide/Oxygen Cycle
- The Nitrogen Cycle
- Soil, Abiotic Factor #3
- Heat, Abiotic Factor #4
- Light, Abiotic Factor #5

**INSTRUCTIONAL NOTES**

Before presenting these lessons to your students, we suggest that you preview the program, review the guide, and the accompanying Blackline Master activities in order to familiarize yourself with their content.

As you review the materials presented in this guide, you may find it necessary to make some changes, additions or deletions to meet the specific needs of your class. We encourage you to do so; for only by tailoring this program to your class will they obtain the maximum instructional benefits afforded by the materials.
PRE-TEST AND POST-TEST

**Pre-Test** is an assessment tool intended to gauge student comprehension of the objectives prior to viewing the program. Remind your students that these are key concepts upon which they should focus while watching the program.

**Post-Test** is an assessment tool to be administered after viewing the program and completing additional activities. The results of this assessment can be compared to the results of the Pre-Test to determine the change in student comprehension before and after participation in this lesson.

STUDENT PREPARATION

Set up an Ecosystems/Abiotic Factors learning center using diagrams, charts, or captioned photographs to demonstrate key concepts relating to the physical aspects of ecosystems. Include examples of ways in which human activities can affect abiotic factors and thereby alter ecosystems.

STUDENT OBJECTIVES

After viewing the program and completing the follow-up activities, students should be able to:
1. Name the five main abiotic factors affecting ecosystems.
2. Explain important ways that each abiotic factor affects living things.
3. Explain how human activities have negatively impacted the abiotic factors of ecosystems.
4. Describe the water cycle, nitrogen cycle, carbon dioxide/water cycle.
INTRODUCING THE PROGRAM

A good way to introduce this program would be to discuss how intricately organisms are linked to their physical environments. Discuss how human activities can affect abiotic factors. Talk about how the range, distribution, growth rates, feeding habits, and population sizes of organisms are affected by abiotic factors. Discuss how both extinction and adaptation can result from changes in physical environments.

VIEW THE PROGRAM

Running Time: 15 minutes including a one-minute, five-question Video Quiz.

Hand out the Blackline Master #3, Video Quiz.

DISCUSSION QUESTIONS

The following are some suggested topics for post-viewing discussion:

• Conflicts encountered meeting healthy ecological goals: balancing economic versus biological needs
• National programs exist to nearly control every sort of pollution. How successful are they? What else can be done?
• How are abiotic factors being altered in the ecosystems of your locality? What steps are being taken to correct problems?

DESCRIPTION OF BLACKLINE MASTERS

Blackline Master #1, Pre-Test, is an assessment tool intended to gauge student comprehension of the objectives prior to viewing the program.
Blackline Master #2, Post-Test, is an assessment tool to be administered after viewing the program and completing additional activities. The results of this assessment can be compared to the results of the Pre-Test to determine the change in student comprehension before and after participation in this lesson.

Blackline Master #3, Video Quiz, is an assessment tool primarily intended to promote student attention to the program presentation.

Blackline Master #4, Crossword Puzzle, is a puzzle game based on information presented in the Vocabulary.

Blackline Master #5, Vocabulary List and Activity, involves important words pertaining to the abiotic factors in ecosystems.

EXTENDED LEARNING ACTIVITIES

Papers, oral reports, or presentations could be done on the following subjects:

1. The nitrogen cycle and how living things use the element nitrogen.
2. The physical and chemical properties of water.
3. How water is used in living cells.
5. Effects of light on animal behavior and physiology.
6. The role of climate change in extinction.
7. How organisms have adapted to meet the challenges of changes in the abiotic factors of ecosystems.
8. The roles of ozone as a protector and polluter.
ANSWER KEY

Blackline Master #1, Pre-Test
1. False, abiotic factors have large effects.
2. True
3. False, carbon dioxide is needed for photosynthesis.
4. False, oxygen is needed for aerobic respiration.
5. False, air is mostly nitrogen and oxygen plus small amounts of other gases.

Blackline Master #2, Post-Test
1. a  6. c
2. b  7. c
3. a  8. c
4. d  9. d
5. c  10. c

Blackline Master #3, Video Quiz
1. True
2. False, air is mostly nitrogen gas.
3. True
4. False, humus comes from organic materials.
5. True

Blackline Master #4, Crossword Puzzle

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The abiotic factors in ecosystems contribute to the physical part of the environment: They include such things as water, soil, air, heat, and light. Physical environments never remain the same for very long. They are continually subjected to the forces of erosion, weather, ocean currents, volcanic events, destructive human activities, and so forth. Naturally, some of these things will cause problems for organisms, because changes in the physical environment usually alter their feeding habits, population size, range, and rates of growth.

Often environmental changes can result in the complete extinction of a species. And sometimes they bring about the formation of new species through adaptation. In other words physical, abiotic factors, directly, and continually, influence the way that life develops on Earth. And that is why it is useful to understand some of the important roles they play in ecosystems.

**Water**

The first abiotic factor, water, is essential to life on Earth. And, even though water is a very commonplace substance, it is capable of doing many remarkable things. For example, within a relatively small temperature range it can exist as a solid in ice and snow, as a gas in clouds and fog, or as free flowing liquid water. In its liquid form water is an incredibly powerful force when it comes to shaping the landscape through erosion.
Most of our planet's surface is covered with water. As a result, for most organisms, water is a basic external medium where critical life activities take place: activities such as searching for food, escaping from predators, and mating. Water plays several other important roles in external environments as well. For example, water carries dissolved gases, such as the oxygen needed by aquatic animals and the carbon dioxide needed by aquatic plants. And bodies of water act as "heat sinks" to slow down the effects of large temperature changes, thereby helping to create a more stable environment for the living things that dwell in or around them.

But water's important role in external environments is more than matched by the many crucial roles it plays in the internal environments of organisms. The bodies of living things are mostly made up of water: This jellyfish, for example is 99% water. Water acts as a powerful solvent, both externally and internally: This means that many of the chemicals upon which life depends, can only be absorbed into cells, and react with one another, when they are dissolved in water. Water is even a key biochemical ingredient inside of cells, where it contributes its hydrogen and oxygen atoms to many vital processes such as photosynthesis.

**Air**

Air is the second key abiotic factor that contributes to ecosystems. Air provides an external medium in which flying organisms can move about and in which pollen and seeds can be dispersed. Air is a mixture of several different gases: 78% of air is nitrogen gas, 21% is oxygen gas, the remaining one percent consists mostly of carbon dioxide, water vapor, ozone, helium, argon, and krypton. Four of these substances, - nitrogen, oxygen, carbon dioxide, and water - endlessly circulate between the air and living organisms, creating important natural cycles upon which all life depends.
**The Water Cycle**
The survival of many living things requires a reliable supply of clean, fresh water. This critical task is accomplished by what is called the water cycle. In the water cycle, warmth causes the evaporation of liquid water into water vapor. Water vapor rises into the air where it can form steam, fog, mist, or clouds. But large amounts of water vapor also escape into the air from the leaves of plants in a process called transpiration and from animals as they carry out aerobic respiration. Whenever liquid water is converted into a gas it becomes purified. And when water vapor in the air is cooled, the purified water undergoes condensation and falls back to the Earth's surface as rain or snow, where it can be used by living things once again.

**The Oxygen/Carbon Dioxide Cycle**
Almost all organisms need oxygen to survive. In nature, oxygen is continually recycled thanks to what is called the oxygen/carbon dioxide cycle. The cycle begins when oxygen atoms from the environment are chemically transferred to carbon atoms in sugar during the important cellular process called aerobic respiration. This turns the sugar into carbon dioxide and water molecules that are released back into the environment. However, the main purpose of aerobic respiration is to free up the energy stored in the chemical bonds of sugar so the organism can use it. This is why oxygen is inhaled, and why carbon dioxide and water vapor are exhaled back into the air.

During the second part of the cycle, which takes place in plants and algae, the carbon dioxide and water from aerobic respiration are used in photosynthesis to make more energy-rich sugar, and to release new oxygen back into the environment. And so, via the complementary processes of photosynthesis and aerobic respiration, the oxygen/carbon dioxide cycle helps to sustain a large number of the Earth's living things.
The Nitrogen Cycle
A third important natural cycle is called the nitrogen cycle. All living things need nitrogen because it is a component of both DNA and protein. Yet even though air is more than three-quarters nitrogen, the element cannot be used by most living things in the form of nitrogen gas. However, there are some very primitive organisms called nitrogen-fixing bacteria that are able to use nitrogen gas to make new chemical compounds. Within the roots of plants called legumes, such as sweet peas and beans, nitrogen-fixing bacteria form rounded root nodules like these. From here the bacteria directly supply the plant with usable nitrogen. Once nitrogen has been incorporated into plant tissue, it is passed through food chains from consumer to consumer. Some usable nitrogen is returned to the environment whenever animals eliminate wastes. And during the process of decay, decomposer bacteria break down complex nitrogen compounds into much simpler compounds called nitrates that are easily absorbed by plants. The final link in the nitrogen cycle is forged when another class of bacteria called denitrifying bacteria break down nitrogen compounds in the soil and release nitrogen gas back into the air.

Soil
After air and water, soil is the third major abiotic factor that contributes to physical environments. Soil is the basic medium for most land-based ecosystems. Plants grow in it. Animals burrow through it and so on. Soil plays a key role in the nitrogen cycle because it is the site of both nitrogen fixation and denitrification. Soil is a complex and varied substance. It is formed from rock by the weathering action of wind and water. And by acid-secreting lichens like these that break down solid rock into tiny particles. Soil is a natural reservoir for the inorganic mineral elements that are essential to living things: Elements such as iron, zinc, calcium, and phosphorous. But the
best soil also contains a lot of organic material; material called humus that originates from living things. The formation of humus is helped along by a variety of animals, including worms, and termites like these, that help break down organic material into smaller and smaller pieces. Humus is not only rich in nutrients; it also gives soil the ability to retain water.

Soils with a lot of humus support abundant plant life. And, because plants are food producers, humus indirectly fosters abundant animal life too. In contrast, ecosystems where poorer soils predominate rarely support such an abundance of living things. As can be seen, soil is yet another abiotic factor that can exert a strong influence on the lives of countless organisms.

Heat
Heat is a fourth major abiotic factor that affects ecosystems. Most heat energy on the Earth’s surface originates in the sun. The effects of heat are very obvious. For tropical environments where warmth predominates possess quite different life forms from those of cold mountain environments. And temperate environments, where warm and cool months tend to even out, support their own special life forms. One reason heat has such powerful effects on organisms is that the biochemical processes of life are very temperature dependent: Too much or too little heat causes biochemical reactions to fail. And temperature extremes can bring about the physical destruction of cells and tissues as well. But besides actually causing harm, temperature can influence organisms in a great many ways. For example, in ecosystems subjected to long harsh winters most mammals will develop extra fat reserves to store energy, and grow more fur to help them keep warm. Without adequate warmth seeds will not sprout. And several kinds of fruit trees native to temperate regions actually need both a cold and a warm period
in order to flower and bear fruit. So it is easy to see why heat is such an important abiotic factor in shaping ecosystems.

**Light**
Light is the fifth of the major abiotic factors affecting organisms. Nearly all natural light on Earth is a form of energy that is radiated by the sun. Plants and algae cannot survive without light. So they are never found growing in completely dark places such as caves, or in deep water where the light does not penetrate. The main reason light is so important to living systems is that it is needed for photosynthesis. Therefore the production of food and oxygen both depend on light. Of course, light is essential to lots of other biological processes as well, such as flowering in plants, the sense of sight in animals, and the migration of birds. And so, light, like the other abiotic factors of water, air, soil, and heat plays a very significant role when it comes to creating the Earth's ecosystems.

**Video Quiz**
1. True or False? Water is a product of aerobic respiration.

2. True or False? Air is mostly oxygen gas.

3. True or False? Transpiration is a process that occurs in plants.

4. True or False? Humus in soil comes from eroded rock.

5. True or False? Nitrogen-fixing bacteria live in the roots of certain plants.
ECOSYSTEMS: THE ROLE OF ABIOTIC FACTORS
from the series Biology: The Science of Life
Pre-Test

Directions: Answer each of the following either true or false:

1. In ecosystems, non-living (abiotic) factors usually have insignificant effects on living things. True_____ False_____  

2. Carbon dioxide is a greenhouse gas. True_____ False_____  

3. Carbon dioxide interferes with photosynthesis. True_____ False_____  

4. Both plants and animals use nitrogen gas in aerobic respiration. True_____ False_____  

5. Air is oxygen. True_____ False_____
1. Is part of the nitrogen cycle:
   a) waste elimination by animals
   b) photosynthesis
   c) aerobic respiration
   d) evaporation

2. Is part of the carbon dioxide/oxygen cycle:
   a) dentrification
   b) photosynthesis
   c) condensation
   d) transpiration

3. Is part of the water cycle:
   a) transpiration
   b) nitrogen-fixation
   c) aerobic respiration
   d) migration

4. Does not help in soil formation:
   a) decay
   b) nitrogen-fixation
   c) lichens
   d) transpiration

5. Legumes are ________________________.
   a) small isolated ecosystems
   b) very large ecosystems
   c) a kind of plant
   d) animals that thrive in leafy areas

6. Is not an abiotic factor in ecosystems:
   a) shade
   b) sunlight
   c) mushrooms
   d) rain

7. Is not a property of water:
   a) holding dissolved gases
   b) contributing matter to new chemicals in cells
   c) encodes genetic information
   d) acting to slow down effects of abrupt temperature changes.

8. Abiotic factors in ecosystems never affect:
   a) the migration of organisms
   b) the size of populations of organisms
   c) the amount of light the sun produces
   d) the temperature of an ecosystem.

9. Air does not ordinarily contain:
   a) water vapor
   b) carbon dioxide
   c) xenon
   d) nitrogen-fixing bacteria

10. Is an important property of heat:
    a) has weight
    b) occupies space
    c) has the ability to do work
    d) is a major component of matter
ECOSYSTEMS: THE ROLE OF ABIOTIC FACTORS
from the series Biology: The Science of Life
Video Quiz

Directions: Answer the following either true or false.

1. True or False? Water is a product of aerobic respiration

2. True or False? Air is mostly oxygen gas.

3. True or False? Transpiration is a process that occurs in plants.

4. True or False? Humus in soil comes from eroded rock.

5. True or False? Nitrogen-fixing bacteria live in the roots of certain plants.
ECOSYSTEMS: THE ROLE OF ABIOTIC FACTORS
from the series Biology: The Science of Life
Crossword Puzzle

Across
9. Oxygen in used up in this energy releasing process.
10. This part of soil is made from decayed organic materials.

Down
1. This process occurs when water vapor becomes liquid water.
2. This is a term for a liquid that can dissolve things.
3. This process is said to have taken place if every member of a species has died out.
4. This process occurs when liquid water becomes water vapor.
5. Living things are mostly this material.
6. Nitrogen-fixing bacteria live in these structures found in the roots of legumes.
7. Most of air is this gas.
8. Besides carbon dioxide, water, and chlorophyll, plants need this to carry out photosynthesis.
The following are important words and names pertaining to *Ecosystems: The Role of Abiotic Factors*. Listen for these terms while viewing the program; pay close attention so you can include them in your writing assignments.

<table>
<thead>
<tr>
<th>Abiotic Factors</th>
<th>Decomposers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The non-living, physical aspects of an ecosystem such as air, water, soil, heat, and light.</td>
<td>Organisms such as fungi and bacteria that break down the complex chemical compounds made by living things into simple nutrients that are used by food producers.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aerobic Respiration</th>
<th>Dentrification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy releasing biochemical reactions that use oxygen.</td>
<td>The process by which bacteria cause nitrogen gas to be released back into the environment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air</th>
<th>Ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td>A mixture of gases; mostly nitrogen and oxygen.</td>
<td>The study of the relationships and interactions of living things with one another and with their physical environment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anaerobic Respiration</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy releasing biochemical reactions that do not need oxygen to occur.</td>
<td>The ability to do work. Light and heat are examples of energy. Energy has no mass (weight) and occupies no space.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Atom</th>
<th>Extinction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A tiny particle of matter.</td>
<td>The complete destruction of all the members of an ecological population—death of every member of a species.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biotic Factors</th>
<th>Food Chains</th>
</tr>
</thead>
<tbody>
<tr>
<td>The living things in an ecosystem.</td>
<td>Energy links between different organisms in an ecosystem based on feeding habits.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carbohydrates</th>
<th>Food Producers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical compounds containing carbon, hydrogen, and oxygen. Sugar is a carbohydrate. Carbohydrates store energy in their chemical bonds.</td>
<td>Organisms such as plants and algae that create energy-rich food through the process of photosynthesis.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carbon Cycle</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>The movement of carbon atoms through an ecosystem between living organisms as well as the non-living part of the environment.</td>
<td>The place in which an organism lives.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carbon Dioxide/Oxygen Cycle</th>
<th>Helium</th>
</tr>
</thead>
<tbody>
<tr>
<td>The recycling of carbon dioxide and oxygen between organisms and the air.</td>
<td>Trace element in air.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carbon Dioxide</th>
<th>Humus</th>
</tr>
</thead>
<tbody>
<tr>
<td>A chemical compound made from one atom of the element carbon and two atoms of the element oxygen. The chemical formula for carbon dioxide is CO2.</td>
<td>Soil material created by decay of organic material such as dead leaves.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cellular Respiration</th>
<th>Krypton</th>
</tr>
</thead>
<tbody>
<tr>
<td>The process of releasing energy stored in carbohydrates. Respiration produces carbon dioxide and water. Respiration usually requires oxygen in which case it is usually called aerobic respiration or aerobic cellular respiration.</td>
<td>Trace element in air.</td>
</tr>
</tbody>
</table>
ECOSYSTEMS: THE ROLE OF ABIOTIC FACTORS
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**Vocabulary Activity**
Directions: From the vocabulary list select the correct word to fill in the blanks.

1. Three oxygen atoms are needed to make one molecule of ____________.

2. _______________ is the process of creating nitrogen gas from nitrogen compounds.

3. ______________, ______________, and ______________ are trace elements in air.

4. ______________ releases energy by using oxygen.

5. Plants called ___________ play an important role in the nitrogen cycle.

---

**legume**- plants of the pea family that have nitrogen fixing bacteria living in their roots.

**lichens**- organisms usually composed of both fungi and algae cells living together symbiotically that erode rock into soil.

**matter**- the material of the universe: those things that occupy space and have weight.

**nitrogen**- an element needed in both DNA and protein molecules.

**nitrogen cycle**- the recycling of nitrogen be-tween living organisms and the air and soil.

**nitrogen-fixing bacteria**- bacteria that can convert nitrogen gas from the air into useable compounds.

**nutrient**- a simple chemical substance used to nourish living things; the useable part of food.

**ozone**- a molecule made from three atoms of oxygen.

**photosynthesis**- a chemical reaction in which carbon dioxide and water are combined in the presence of chlorophyll and sunlight to form energy-rich sugar.

**population**- a group of organisms of the same species living in the same ecosystem.

**solvent**- a liquid capable of dissolving other substances.

**species**- very similar organisms that can interbreed and produce fertile offspring.

**transpiration**- the natural loss of water from plants.

**water cycle**- the natural cycle of water purification.

**xenon**- a trace element in air.