The Smart Organism:
Reinforcing NC Biology Curriculum for Ecology and Human Impacts

Science Dudes Publishing
Leaf-cutter ants carry leaves from the canopy to their nests where they chew them to a pulp and then allow them to decay. The fungus that grows on the decomposed leaves is the ants’ food.

(Sunshine Pics/ Shutterstock)
Interactions Among Organisms

What characterizes interactions between organisms?

Life is not isolated. Organisms impact each other in a variety of ways. These interactions occur between all types of organisms.

Types of Interactions

- Competition
- Predation
- Mutualism
- Parasitism
- Commensalism

Carp (Cyprinus carpio) competing for food at the pond of the Royal Palace Agdal of Marrakech in Morocco.

Credit: Luc Viatour / www.Lucnix.be
Niche vs. Habitat

Every species has its own **tolerance**, or a range of conditions under which it can grow and reproduce. A species’ tolerance determines its **habitat**, the place where it lives.

A **niche** consists of all the physical and biological conditions in which a species lives and the way the species obtains what it needs to survive and reproduce. An organism’s niche is the role it plays in the environment, and it includes any relationships it may have with others within its species or with other species.

An organism’s niche must contain all of the resources an organism needs to survive. A resource is any necessity of life, such as water, nutrients, light, food, or space.

Source: *Samantha Toda, EduBlogs.org*

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Resource Partitioning

Similar Species Compete for Limiting Resources

There are only a limited number of ways of "making a living" within ecological communities. For example, on a coral reef, there are hard-skeleton corals that gain food from capturing planktonic animals in their tentacles and, in exchange for providing a suitable habitat and nutrients, gain extra sources of energy from sugar-synthesizing symbiotic algae. Within groups of species that make a living in a similar way, species compete for the same resources. These resources, which include nutrients and habitat, are the raw materials needed by organisms to grow, live, and reproduce. However, resources are not unlimited, and individuals from different species commonly compete for resources (interspecific competition).

Complete Competitors Cannot Coexist

Classic experiments and mathematical models show that two species cannot coexist on the same **limiting resource** if they use it in the same way: The superior competitor will always win out. If ecologically similar species (like corals on a reef or plants in a field) compete with one another for limiting resources, what stops the best competitor from out-competing all the others? The answer may lie in species "doing their own thing" — specializing in their use of resources and thereby limiting their competition with others.
Dividing the Resource Pie

Species can divide up a limiting resource, such as food, water, or habitat (in other words the resource "pie"), by using different slices or even using the same "slice" but in different places (i.e., they are dining in different restaurants, to take the analogy one step further) or at different times ("do you have a table free at eight o'clock?"). This division of the “resource pie” is known as **resource partitioning**.


Figure 1: Resource partitioning among bumble bees (Bombus spp.)

Species have proboscises of different lengths, enabling them to specialize in the exploitation of plants with different length corollas. Species with similar length proboscises occur at different altitudes (Pyke 1982).

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**Review 1.1 Reading Review**

**Question 1 of 4**

In what type of interaction do two different types of organisms both benefit?

- A. Predation
- B. Mutualism (Correct)
- C. Parasitism
- D. Commensalism
Task:

1. Choose any three different types of relationships between two different species of organisms (competition, predation, mutualism, parasitism or commensalism. You may research this information on the following websites:
   a. The Nature Education Knowledge Project
   b. Marietta College Biology Department
   c. Marine Bio Conservation Society

2. Sketch a very simple picture of the interaction using the interactive widget titled: “What’s Our Relationship?”

3. Label each relationship with either +, -, or 0 to indicate how each organism is affected by the interaction.
   
   +, the organism benefits
   - , it is harmed
   0, there has been no effect

   Example: A mutualistic relationship (+,+)

4. Add a cool fact!

5. Email your awesome sketch to your instructor.

Click the star to go further!
Section 2

Food Webs

How does energy move within and between ecosystems?

The Sun is the major source of energy for life on Earth. Plants and other photosynthetic organisms are able to use the Sun’s energy, along with inorganic substances like carbon dioxide and water, in order to create sugars. The plant then uses these sugars to power its own biological reactions. In turn, herbivores eat the plants, then carnivores eat the herbivores. Energy passes from organism to organism as one feeds off another. Decomposers break dead organisms back down into inorganic nutrients, and the cycle continues!

Source: EduBlogs

A simple six-member food web for a representative desert grassland. © 2012 Nature Education Adapted from Cain et al. 2008. All rights reserved.

Click HERE to play the Chain Reaction Game and learn more about the steps of the food chain.
Interactive 1.2 Food Web

- **Primary Producer** (Autotroph)
- **Primary Consumer** (Herbivore)
- **Secondary Consumer** (Carnivore)
- **Tertiary Consumer** (Top Carnivore)
- **Decomposer**
Organisms do not generally show only one chain of feeding relationships because they use multiple sources of food. More this reason, feeding behavior involves a complex, interconnected web of organisms.

Here is a sample food web that also provides population numbers of each species shown:

**Checkpoint:**

1. How does population size change with each trophic level?
2. What are some reasons behind this change?

Food webs often contain connections that aren’t always clear to ecologists. Due to these intricate and delicate connections, should one species decline, other portions of the web may be affected.

Read “The Domino Effect of Extinction” and respond to the following questions:

1. What adaptation do the acacia trees use to defend against large herbivores, like giraffe and elephants?
2. How did the acacia trees respond to a reduction in herbivore populations?
3. Describe the relationship between the African acacia tree and the various native ant species.
4. Imagine that your school is an ecosystem (in many ways it is). Choose one component of school (custodial staff, resource officers, the lunch lady, etc.). If you were to remove this component from the school, what other parts of your “ecosystem” would be affected. Discuss both the short-term and long-term consequences. Would your school be able to adapt? If so, how?
5. Review the components which are important to the function of your school ecosystem. Which component’s absence would cause the greatest impact on your school ecosystem? Develop an argument supporting your claim. Consider counter-claims in your response.
Section 3

Nutrient Cycles

How are the Earth’s materials redistributed within ecosystems?

Inorganic nutrients are necessary to sustaining life and building living tissues. Carbon forms the foundation of sugars and starches. Sulfur is a component of proteins. Phosphorus and nitrogen help build DNA molecules. Without these substances, living things as we know them would not exist. These limiting nutrients cycle through the environment, between organisms, then back to the environment again by way of decomposers.

Agaricus bisporus

Source: www.eol.com
Click each link found below to review all of the animations. Be sure to turn on the volume of your computer, so that you can listen to the information as it is being shared with you.

**Interactive Nitrogen Cycle**
Source: University of Alberta and Bio-DiTRL
This media asset was adapted from the University of Alberta.

**Interactive Water Cycle**
Source: National Ocean Service | National Oceanic and Atmospheric Administration | Department of Commerce | USA.gov

**Interactive Carbon Cycle**
Source: Windows to the Universe, from the National Earth Science Teachers Association (NESTA)

**Sulfur Cycle Animation**

**Phosphorus Cycle Animation**

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**Think About It!**

From the animations you just watched, answer the following questions:

1. How does mutualism play a role in the nitrogen cycle?
2. How would the amount of groundwater available in an area be affected by urban development?
3. How do humans influence the amount of carbon in the atmosphere?
4. What do humans do to influence the development of acid rain?
5. Predict what may occur as a result of too much phosphorus being added to an aquatic ecosystem. Where might this overabundance of phosphorus come from?

Now get with a partner in your class, and share your ideas.

- *Did they provide any new responses that you had not thought of yet?*
- *What did you think of that they hadn’t?*

Work together to discuss: A farmer only plans to grow corn on her plot of land over the next ten years. In less than a page of written work, develop an argument which includes at least three reasons why she should rethink her plan based on its environmental impact. Support your argument with at least two resources. Cite all resources used.
Nature is a closed system, meaning nutrients do not generally leave. The matter that is here on Earth will not be lost nor gained. As Antoine Lavoisier states in the principle of conservation of matter, matter is neither created nor destroyed, but rather may be transformed. That banana you ate with your breakfast this morning doesn’t disappear after you eat it. While it definitely might change form, some of the banana will be used by your body to build tissues while the rest will be waste.

The image to the right shows the flow of carbon in a closed ecosystem. That carbon may be in the form of carbohydrates, parts of cell structures, or carbon dioxide in the air. While the image perhaps over-simplifies this carbon flow it is valuable to note that all of the carbon that enters a given stage in the cycle will eventually move on to another stage.

How much carbon did the bunny release through respiration? (Use the interactive calculator, as needed.)

In one paragraph, describe the flow of carbon shown in the diagram. Your description should accurately incorporate vocabulary from the chapter.
Many species of amphibians, like this red-eyed tree frog (scientific name: *Agalychnis callidryas*), are endangered or threatened. Human activities, like habitat destruction and the introduction of nonnative species, have accelerated the loss of amphibian species. Want to know more? [http://www.edgeofexistence.org/amphibian_conservation/amphibian_threats.php](http://www.edgeofexistence.org/amphibian_conservation/amphibian_threats.php)
Section 1

Impacts on Ecosystems

In what ways have humans impacted the world’s ecosystems?

An important concept in biology is the interaction between organisms and the environment. Each impacts the other. For instance, the environment adds “selection pressures” to living things. Organisms must struggle for existence because of the limited resources the environment provides. It is also true that living things change the environment they live in. They use energy and matter, changing the availability or usability of resources.


Some Ways Humans Effect Ecosystems

- population growth
- pollution
- fossil fuels
- global climate change
- habitat destruction
- utilization of water resources
- introduction of nonnative species
Human population growth

An important aspect to the impacts humans have on the world’s ecosystems is human population size. More humans equals more human-caused effects. Some of these are:

- increased demand for limited resources
- increased waste products and pollution
- increased habitat loss (perhaps the most devastating one)

The current estimated world population exceeds 7 billion people with a population growth rate of approximately 1.3%. This means that the world’s population will double to over 12 billion within the next 54 years!

Check out the World Population Clock. Think about what you see here as you read about human impacts on ecosystems.

How many people can the world support? Check out what LiveScience.com says about this question.

Watch this video on The Demographic Transition Model

It will be helpful at this point to have a class discussion of the demographic transition model.

What are some similarities and differences between the impacts that developing nations vs. the impacts that developed nations have on the world’s ecosystems?

Pollution: Pesticides and Bioaccumulation

Read Pollution and Bioaccumulation of Pesticides and respond to the following questions:

1. Consider the author’s point of view on the topic of the bioaccumulation of DDT. What is his intent in writing this article? Provide evidence (a “direct quote” or description of tone) with your response.

2. What did you learn about DDT? List at least three concepts with which you were unfamiliar before reading the article.

Use of fossil fuels

“Fossil energy sources, including oil, coal and natural gas, are non-renewable resources that formed when prehistoric plants and animals died and were gradually buried by layers of rock. Over millions of years, different types of fossil fuels formed depending on what combination of organic matter was present, how long it was buried and what temperature and pressure conditions existed as time passed.

Today, fossil fuel industries drill or mine for these energy sources, burn them to produce electricity, or refine them for use as fuel for heating or transportation. Over the past 20 years, nearly three-fourths of human-caused emissions came from the burning of fossil fuels.” - Source: US DOE energy.gov
Invasive Species

Read the following article “Invasive Species” from the Encyclopedia of Earth - Mark McGinley (Lead Author)

After reading the subsection “Invasive Species” and viewing the links and image about Burmese pythons above, consider what ways humans might be able to control these pythons.

Think About It!  Threats to Wildlife

Source: World Wildlife Fund-WWF

Choose one of the threats that the WWF presents as a concern for the world’s wildlife. For this threat, complete the following steps:

I. Define the threat to wildlife. You may use a direct quote from the website or write your own definition.

II. Identify the root causes of the threat. Write a list of the human activities that have lead to this becoming a threat.

III. What does the WWF suggest as some possible solutions or steps that should be taken to mediate the current situation?

Kudzu was introduced as a ground cover plant for landscaping. It did the job so well, it overgrows everything!
Section 2

North Carolina Environmental Concerns

What are some of the biggest environmental challenges our state currently faces?

Gallery 2.3 Some challenges facing North Carolina

Mount Mitchell is the tallest peak in Eastern North America at an elevation of 2,037 m (6,683 ft).

North Carolina Environmental Concerns
air pollution: acid rain in western NC
coastal development: beach erosion
urban development: groundwater use
economic development: hog farms
invasive species: kudzu
Acid Rain in the NC Mountains.

Some documented effects of acid precipitation include: runoff effects to fish and amphibian species; and forests, including the invasion of the hemlock woolly adelgid, which has affected Mount Mitchell’s trees.

Interactive 2.1 Field pH Measurements from 2004

Beach Erosion and Coastal Management

http://www.learnnc.org/lp/editions/nchist-recent/6374

Urban Development in the NC Piedmont

“Development doesn’t cause flooding but can make flooding worse. Although flooding is a natural occurrence, man-made changes to the land can also be a factor. In cities and suburbs, pavement and rooftops prevent some rainfall from being absorbed by the soil. This can increase the amount of runoff flowing into low-lying areas or the storm drain system. And eventually, that excess runoff flows into our creeks.

While flooding cannot always be prevented, the risks can sometimes be reduced. Storm Water Services:

• installs and maintains storm drain pipes to reduce street and house flooding
• removes blockages from stream channels
• updates floodplain maps to show risk along major creeks
• regulates construction in floodplains
• maintains a flood notification system for local emergency responders.”

Check out more information from Storm Water Services in Charlotte-Mecklenburg

http://charmeck.org/stormwater/basics/Pages/default.aspx
If you are not familiar with the term "impervious surface," this picture will help explain it. As cities grow and more development occurs, the natural landscape is replaced by roads, buildings, housing developments, and parking lots. Rainfall cannot move through these materials so they are called “impervious” structures.

Here are some further readings about specific challenges in NC.

Hog Farms: Economics vs. Environment

Reference: NC in the Global Economy: Hog Farming

Food & Water Watch: Factory Farmed Hogs in NC

Kudzu: NC Control of an Invasive Species

Reference: Biological Control of Kudzu

Learnnc.org
http://www.learnnc.org/lp/editions/nchist-recent/6174

Interactive 2.2 Scientific Calculator

Use this calculator to answer the following questions about human impacts on the ecosystem.
Section 3

Conservation and Stewardship

How can humans mediate their impact? What can you do?

I. Choose one of the impacts humans have on the ecosystem which was highlighted in Chapter 2, Section 1.
   A. Sketch a “multi-flow” thinking map to describe the human causes for your impact and the effects that result from the human impact.
   B. Write a summary paragraph (4-5 well-written sentences) that links cause and effect. Remember to include supporting evidence from text-based sources.

Note: there is an example image of a multi-flow thinking map on the following page.

II. Choose one of the North Carolina environmental concerns that was discussed in Chapter 2, Section 2. Each one of these concerns has economic and environmental issues associated with it.
   A. Identify several issues related to the concern you have chosen. Define the issue as “environmental” or “economic”.
   B. Write a statement (1-2 sentences) to support your definition for each issue. Remember to include supporting evidence from text-based sources.

III. Define, in your own words, the terms “conservation” and “stewardship”.
   A. List ways you can mediate your own impact on the ecosystem.
   B. Are there any of the items on the list you can start doing immediately? Are there any items on the list that you could encourage others to use, too?
   Write a short personal mission statement that you would follow to model...
Some organism photos are presented courtesy of the Encyclopedia of Life (http://eol.org).
NC Essential Standards and Unpacked Content

Link to: Essential Standards: Biology ● Unpacked Content

This iBook correlates to the following NC Essential Standards:

Ecosystems

Bio.2.1 Analyze the interdependence of living organisms within their environments.

- Bio.2.1.1 Analyze the flow of energy and cycling of matter (such as water, carbon, nitrogen and oxygen) through ecosystems relating the significance of each to maintaining the health and sustainability of an ecosystem.

- Bio.2.1.2 Analyze the survival and reproductive success of organisms in terms of behavioral, structural, and reproductive adaptations.

- Bio 2.1.3 Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within ecosystems.

- Bio.2.1.4 Explain why ecosystems can be relatively stable over hundreds or thousands of years, even though populations may fluctuate (emphasizing availability of food, availability of shelter, number of predators and disease).

Bio.2.2 Understand the impact of human activities on the environment (one generation affects the next).

- Bio.2.2.1 Infer how human activities (including population growth, pollution, global warming, burning of fossil fuels, habitat destruction and introduction of nonnative species) may impact the environment.

- Bio.2.2.2 Explain how the use, protection and conservation of natural resources by humans impact the environment from one generation to the next.
Unpacked Content - What does this standard mean the student should know, understand, and be able to do?

Bio.2.1.1

• Deconstruct the carbon cycle as it relates to photosynthesis, cellular respiration, decomposition and climate change.

• Summarize the nitrogen cycle (including the role of nitrogen fixing bacteria) and its importance to synthesis of proteins and DNA.

• Identify factors that influence climate such as:
  • greenhouse effect (relate to carbon cycle and human impact on atmospheric CO2)
  • natural environmental processes (relate to volcanic eruption and other geological processes)

• Explain the recycling of matter within ecosystems and the tendency toward a more disorganized state.

• Analyze energy pyramids for direction and efficiency of energy transfer.
  • Living systems require a continuous input of energy to maintain organization. The input of radiant energy which is converted to chemical energy allows organisms to carry out life processes.
  • Within ecosystems energy flows from the radiant energy of the sun through producers and consumers as chemical energy that is ultimately transformed into heat energy. Continual refueling of radiant energy is required by ecosystems.

Bio 2.1.2

• Analyze how various organisms accomplish the following life functions through adaptations within particular environments (example: water or land) and that these adaptations have evolved to ensure survival and reproductive success.

  • **Transport and Excretion** – how different organisms get what they need to cells; how they move waste from cells to organs of excretion. Focus is on maintaining balance in pH, salt, and water. Include plants - vascular and nonvascular.

  • **Respiration** – how different organisms take in and release gases (carbon dioxide or oxygen, water vapor); cellular respiration

  • **Nutrition** – feeding adaptations and how organisms get nutrition (autotrophic and heterotrophic) and how they break down and absorb foods.

  • **Reproduction, Growth and Development** – sexual versus asexual, eggs, seeds, spores, placental, types of fertilization.

  • Analyze behavioral adaptations that help accomplish basic life functions such as suckling, taxes/taxis, migration, estivation, and
hibernation, habituation, imprinting, classical conditioning (e.g. Pavlov’s dog–stimulus association), and trial and error learning.

Bio 2.1.3

• Identify and describe symbiotic relationships such as mutualism and parasitism. (middle school review)

• Exemplify various forms of communication and territorial defense including communication within social structure using pheromones (Examples: bees, ants, termites), courtship dances, territorial defense (Example: fighting fish).

• Explain patterns in predator /prey and competition relationships and how these patterns help maintain stability within an ecosystem with a focus on population dynamics.

Note: There is much debate about whether commensalistic relationships are just early mutualism. We may just not understand the benefits to each organism.

Bio 2.1.4

• Generalizing that although some populations have the capacity for exponential growth, there are limited resources that create specific carrying capacities and population sizes are in a dynamic equilibrium with these factors. (e.g. food availability, climate, water, territory).

• Interpret various types of population graphs – human population growth graphs indicating historical and potential changes, factors influencing birth rates and death rates, and effects of population size, density and resource use on the environment.

• Explain how disease can disrupt ecosystem balance. (Examples: AIDS, influenza, tuberculosis, Dutch Elm Disease, Pfiesteria, etc.)

Bio 2.2.1

• Summarize how humans modify ecosystems through population growth, technology, consumption of resources and production of waste.

• Interpret data regarding the historical and predicted impact on ecosystems and global climate.

• Explain factors that impact North Carolina ecosystems. (Examples: acid rain effects in mountains, beach erosion, urban development in the Piedmont leading to habitat destruction and water runoff, waste lagoons on hog farms, Kudzu as an invasive plant, etc.).

Bio 2.2.2

• Explain the impact of humans on natural resources (e.g. resource depletion, deforestation, pesticide use and bioaccumulation)

• Exemplify conservation methods and stewardship.
Carnivores

Organisms that eat meat.

Related Glossary Terms
Drag related terms here

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Chapter 1 - Food Webs
Commensalism

A symbiotic relationship in which one organism benefits while the other is unaffected.

Related Glossary Terms

Drag related terms here
Competition

The effect or result of a common demand by two or more organisms upon a limited supply of resources.

Related Glossary Terms

Drag related terms here

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Find Term

Chapter 1 - Interactions Among Organisms
Decomposers

Heterotrophs which convert dead organic matter into simpler inorganic materials.

Related Glossary Terms

Drag related terms here

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Find Term

Chapter 1 - Food Webs
Food web

Complex feeding relationships within a community; all interconnected food chains in a community.

Related Glossary Terms
Drag related terms here
Habitat

A place or environment in which a specified organism lives.

Related Glossary Terms
Drag related terms here

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Chapter 1 - Interactions Among Organisms
Herbivores

Organisms which eat plant matter.
Limiting resource

A substance necessary for organisms to survive and reproduce, and may limit population growth when absent.

Related Glossary Terms

Drag related terms here

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Chapter 1 - Interactions Among Organisms
Mutualism

A symbiotic relationship in which both organisms benefit.
Niche

An organism's role in an ecosystem; includes relationships with other organisms and feeding habits.

Related Glossary Terms

Drag related terms here

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Find Term

Chapter 1 - Interactions Among Organisms
Parasitism

A symbiotic relationship in which one organism benefits at the expense of another.

Related Glossary Terms
Drag related terms here

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Find Term

Chapter 1 - Interactions Among Organisms
Predation

A relationship in which one organism hunts, kills, and eats another.

Related Glossary Terms
Drag related terms here

Index
Find Term
Chapter 1 - Interactions Among Organisms
Resource partitioning

Division of the use of a resource by different species of organisms, so that both populations are not in direct competition.

Related Glossary Terms

Drag related terms here
Tolerance

A range of conditions under which a species can grow and reproduce.

Related Glossary Terms

Drag related terms here

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Chapter 1 - Interactions Among Organisms