Biological Interactions: An Ecological Context

How do the complex properties of life emerge from the interaction of biological systems?

Essential Understandings
4.A.5 Communities are composed of populations of organisms that interact in complex ways.
4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy.
4.B.3 Interactions between and within populations influence patterns of species distribution and abundance.
4.B.4 Distribution of local and global ecosystems changes over time.
4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem.

Major Connections:
1.A.1 Natural selection acts on phenotypic variations in populations.
2.A Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
2.D.1 All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.
2.C.2 Organisms respond to changes in their external environments.
3.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.

Textbook References
Summer Assignment plus Ch. 51-55

Laboratories
Energy Dynamics Activity for Lab Investigation 10
Animal Behavior Lab Investigation 12
4.A.5 Communities are composed of populations of organisms that interact in complex ways.

a. How are communities measured and described?

b. Mathematical or computer models are used to illustrate and investigate population interactions within, and environmental impacts on, a community.

b.1. Modeling to Visualize Population Cycles

A classic example of the predator-prey relationship in nature involves the Canada lynx and the snowshoe hare. The Canada lynx ranges across upper North America and preys almost exclusively on snowshoe hare. Starting in the mid 1800's, the Hudson's Bay Company tracked the number of lynx and hare pelts obtained by trappers (see the tables below from szukaitas.com). Assuming that these numbers provide a proportional estimate of the two populations over time, scientists have used this data to chart the predator-prey relationships between the lynx and hare.

Graph the pelt data using an application such as Microsoft Excel. Your graph should plot the numbers of pelts, clearly identifying which set of data is which and labeling the axes appropriately. The graph should also have your name included in the title. If you are not familiar with Excel or some other graphing program, consult a media specialist or manually graph.
Once you have completed your graph of the Hare-Lynx data, describe the pattern (if any) exhibited by that graph. Does there appear to be a cyclic pattern to the growth and decline of the populations? If so, is the cycle length consistent?

Are the growth/decline patterns of the two populations identical, or are they linked in some way?

What do you think the pattern of the graph suggests about the predator-prey relationship between the two populations?

b.2. In recent decades, scientists have revisited the common interpretation of the lynx-hare population data, i.e., that the population cycles were primarily attributable to the predator-prey relationship. While the predator-prey relationship undoubtedly contributes to the pattern, it has been proposed that other factors may be of equal or even greater importance. Conduct some research (either online or through other sources) and cite another factor that could significantly contribute to the observed population pattern. Be sure to list your sources.

b.3. Choose one of the following additional examples of how mathematical or computer models are used to illustrate and investigate population interactions and environmental impacts on a community. For the example you choose, find a problem similar to that for the hare-lynx problem above. *You must include a data table and an answer key. Include all proper citations/references.

- Symbiotic relationship
- Graphical representation of field data
- Introduction of species
- Global climate change models

c. Mathematical models and graphical representations are used to illustrate population growth patterns and interactions.

c.1. Based on your understanding of the lynx-hare populations and other work, what type of population growth would characterize the hare population without any predators?

c.2. Could the hare population sustain this type of growth indefinitely? Explain what factors might limit growth.

c.3. What type of population growth is the result of limiting factors? And, what are the terms used to describe the two major categories of growth limiting factors?

c.4. What kind of data can be used to study human populations and predict population growth? How are these data often illustrated to help predict human population growth trends?
4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy.

a. How is matter exchanged between organisms and their environment? And, how do these interactions differ from the movement of energy?

a.1. Diagram the exchange of carbon and nitrogen in an environment. Label the processes as well as all of the major the abiotic and biotic components.

b. What factors influence the different patterns of primary productivity found in different locations on earth?

c. / d. Organisms within food webs and food chains interact and are dependent on primary productivity.

The following is a food web for a meadow habitat that occupies 25.6 km². The primary producers’ biomass is uniformly distributed throughout the habitat and totals 1,500 kg/km².

Developers have approved a project that will permanently reduce the primary producers’ biomass by 50 percent and remove all rabbits and deer.

Which of the following is the most likely result at the completion of the project?

(A) The biomass of coyotes will be 6 kg, and the biomass of hawks will be 0.5 kg.

(B) The biomass of coyotes will be dramatically reduced.

(C) The coyotes will switch prey preferences and outcompete the hawks.

(D) There will be 50 percent fewer voles and 90 percent fewer hawks.
For the grassland ecosystem depicted above, how much carbon (in g/m²) is released into the atmosphere as a result of the metabolic activity of herbivores? Give your answer to the nearest whole number.

e. Models allow the prediction of the impact of change in biotic and abiotic factors. Draw the shape of a growth curve for a population that has grown and then reached the carrying capacity (K) of its environment.

e.1. / e.2 Identify at least five density-dependent and three density-independent factors that contribute to the regulation of population size.

f. Human activities impact ecosystems on local, regional and global scales.

f.1.a Explain how human population growth has impacted habitats for other species.
Read the articles concerning Greenwich’s local coyote and/or deer populations. Examine how the human population influences the patterns of distribution and abundance of the coyote and deer populations including the role that communication plays in their interactions (e.g. avoidance responses and behavior). Draw conclusions about the specific impact of human population growth and the role of communication.

f.1.b. Identify the kind of data that would be required to support your investigation above and then analyze existing data from the state Department of Energy & Environmental protection to refine your conclusions. Reference your sources.

Extension: Today there is an abundance of wild turkeys in CT. This was not the case fifty-years ago. Why?

g. Many adaptations of organisms are related to obtaining and using energy and matter in a particular environment. Describe how the specific adaptations of particular organisms help them to obtain and use energy and matter at each major stage in the primary succession of a terrestrial ecosystem.
4.B.3 Interactions between and within populations influence patterns of species distribution and abundance.

a.1. Describe each of the five major types of relationships between species.

a.2. In addition to the predator/prey relationships you explored earlier, other interactions between populations can be modeled mathematically.

Conduct two searches: one to identify an existing mathematical model that may be used to help humans prepare for the upcoming influenza/flu season (epidemiological model); and, a second search to identify an existing mathematical model that may be used to help humans prevent the spread of Dutch elm disease.

a.3. Explain one example of how a feedback control system functions in a particular symbiotic relationship.

b. What is the principle of “emergent properties” and how does this relate to the ability of an ant population to efficiently locate and exploit remote food sources?

c. Using either the case of the invasive Kudzu or the loss of a particular keystone species such as the seastar *Pisaster ochraceus*, explain the effects on species distribution or abundance.

4.B.4 Distribution of local and global ecosystems changes over time.

a.1. Describe at least five human activities that have accelerated environmental change - locally and globally.

a.2. Explain the biological factors that influenced the outcome of the European colonization of the Americas.

b.1. Explain how activities such as continental drift and major meteor impacts have changed ecosystem distribution over time.

4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem.

a. Generally, which ecosystem would you predict to be most resilient to changes in the environment - an ecosystem with few component parts and little diversity or an ecosystem with relatively high biodiversity? Apply scientific concepts to justify your answer.

b. How do keystone species, producers, and other essential abiotic and biotic factors contribute to maintaining the health and diversity of an ecosystem?
The diagram above shows the progression of ecological events are in a particular ecosystem. Based on the diagram, which of the following best explains why the oak trees are later replaced by other trees?

(A) Eventually the other trees grow taller than the oak trees and form a dense canopy that shades the understory.
(B) Oak trees alter the pH of the soil, making the forest better suited for shrubs and other trees.
(C) Roots of shrubs proliferate in the soil of the forest and prevent the oak trees from obtaining water.
(D) Oak trees succumb to environmental pollutants more readily than do either the shrubs or the other trees.

How do the following topics connect to what you are learning in this unit?

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2.A Growth, reproduction and maintenance of the organization of living systems require free energy and matter.

2.D.1 All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.

2.C.2 Organisms respond to changes in their external environments.

3.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.