Summer: Getting the Bugs Out

High School Lesson Plan

Topic
Biodiversity

Grade Levels
9-12

Overview
QUEST *Summer* provides a glimpse into the world of wildlife that surrounds us but that we often do not notice. This QUEST episode illustrates the vast biodiversity found in a small area of Vermont in the summer – the time of the richest variety of wildlife in that region. With a fascinating focus on insects, this episode depicts the broad range of amazing ways in which insects have adapted to their environment – and how the world around them, in turn, has developed mechanisms for harnessing the insects' energy. This teaching unit will help students recognize not only that insects are fundamental to both terrestrial and aquatic food webs, but that insects also play a vital role in the plant world by helping to pollinate flowers.

Introduction
In this teaching unit, students will explore their understanding of biodiversity through a closer examination of insects. They will list the types of insects with which they are familiar and sort them according to their own classification system. In addition, they will research the broad variety of insects that exist, as well as how they are classified by science. Students will also compare various strategies used by individual insect families, discovering how natural selection has provided numerous structures and behaviors to meet similar goals. Finally, students will create their own field guide to insects in their local area.

Time Allotment
Five 45-minute class periods.

Accessing Prior Knowledge
Students should already be familiar with the standard scientific classification system. In the activities that follow, they will refresh their understanding and apply it to insects. Some background on the concept of natural selection will be helpful when students begin to examine specific insects to determine the variety of strategies (forms) they have adopted to successfully accomplish similar functions. Students will also benefit from having prior exposure to genetic variations – both how they occur and how they express themselves as new forms or behaviors in organisms.

Concepts to Clarify
Some high school students, when questioned, still have difficulty with the classification of life. They may have

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trouble even delineating living versus nonliving things. For example, students may use only movement or growth as a factor to determine whether something is living. Additionally, they may not have clear criteria for delineating the differences between plants and animals – using, for example, factors such as reproduction and/or respiration to determine whether a living organism is an animal. Another concern is that students may not have a clear picture of food webs. They may most frequently think of mammals as consumers, connecting only larger animals to the category of *predators*.

CONNECTIONS TO THE STANDARDS

National Science Education Standards	Benchmarks for Science Literacy	Maine Learning Results	New Hampshire Curriculum Framework	Vermont Learning Standards
Life Science: Biological Evolution (9-12) C 3a: Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.	**The Living Environment: Evolution of Life** (9-12) 5F 3: Natural selection provides the following mechanism for evolution: Some variation in the heritable characteristics exists within every species, some of these characteristics give individuals an advantage over others in surviving and reproducing, and the advantages offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.	**Science and Technology: Classifying Life Forms** (9-12) A 2: Describe the similarities and differences among organisms within each level of the taxonomic system for classifying organisms (kingdom through species). D 2: Explain how mutations can be caused by gene mutations or chromosomal alteration, and describe the possible results of such mutations on individuals or populations.	**Life Science** Curriculum Standard 3d: Students will demonstrate an increasing ability to recognize patterns and products of evolution, including genetic variation, specialization, adaptation, and natural selection. By the end of 10th grade, students will be able to: – Identify and describe similarities and differences among organisms of different, but closely related, taxa (groups), e.g., conifers, rodents, big cats, etc. – Relate different kinds of animals and plants to their habitat by observing their physical characteristics.	**The Living World: Organisms, Evolution and Interdependence** (9-12) 7.13.bbb: Demonstrate understanding of how biological organisms are classified into a hierarchy of groups and subgroups based upon similarities that reflect their evolutionary relationships (e.g., plants, animals, microorganisms). 7.13.ddd: Explain and justify how natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms.

Materials Needed

- TV with VCR
- QUEST *Summer: Getting the Bugs Out* video
- Computers with Internet access for student or teacher use (to download articles)
- Chart paper and markers
- Index Cards
- Background on the species of one order of insect found in your area
- Insect field guide(s) and resource Web sites for use in student research
- 1 copy per student of each of the following reproducible handouts:
  - Student Handout 1: Study of Insects
  - Student Handout 2: QUEST *Summer: Getting the Bugs Out* Video Viewing Guide
  - Student Handout 3: Insect Form and Function
  - Student Handout 4: Modeling Natural Selection
  - Student Handout 5: *QUEST* at Home: Creating Your Own BioBlitz
- For each team (to accompany Student Handout 4):
  - 2 paper cups, 2 paper plates, 20 beans of each of 4 types of beans

1. Introducing the Concepts

The first activity will help students begin to think about insects they are accustomed to seeing in their everyday lives. Working in teams, students will create their own classification systems based on common names and selected characteristics of a specific insect. They will then learn the scientific name of the species and research its habitat and anatomy.

Activity 1

Step 1

This lesson is best done with students working in cooperative groups. Divide the class into teams. Have students first brainstorm individually to create their own lists of insects in their area. Then have them expand their lists by comparing notes with their teammates.

Next, create a master class list of insects, recording the information on chart paper. (**Note:** In most instances, students will know these insects only by their common names. They will be exploring in depth one species and its order in Step 5. Therefore, be sure that the master class list contains a subgroup of insect names from which students will be selecting one species to study later in the activity.)

Step 2

Give each team of students a stack of index cards. Following the brainstormed master class list, students should write the common name of one insect on each individual card. When this is done, direct teams to sort their cards into a classification system of their own design. Next, have teams share their classification systems with the rest of the class.

Step 3

Have a discussion about the strategies students used to sort their insect cards. On a new piece of chart paper, create a list of all of the types of characteristics students used to classify the insects. On another piece of chart paper, list the problems that teams had with creating and defining their classification systems. During the discussion, try to ascertain whether any teams found that the same insect had more than one common name. Be sure to point out to students that although all of their systems are viable, there are problems inherent in having more than one classification system.

Step 4

Review the scientific classification system with the class. Discuss the criteria scientists use to sort organisms. Note that the tree of life delineated by the standard classification system is in a state of continual flux. Explain to students that more species are always being identified, and new connections between species are always being found. Point out that these connections are often found through DNA analysis or the discovery of new fossils. Ask students how they think scientists specifically determine such connections between species.

Step 5

Choose one species from the class master list. Give students the scientific names for this species to add to their appropriate index cards, including Class, Order, Family, Genus, and Species names. Identify with students any of the other species that might be from the same order of insects (e.g., all of the flies are members of *Diptera*, all of the beetles are members of *Coleoptera*, etc.). Discuss the physiological connections that are evident among members of the order to which your selected species belongs.

Direct student teams to outline the steps they think might have led to two species differentiating from their parent species and from each other. Discuss students' ideas about speciation. Lead students to see the connections among DNA mutations, heritable physiological characteristics, natural selection, and the creation of new species.

Step 6

Because DNA decoding cannot be done for every insect and is a relatively new process, physiological delineations are still most commonly referred to when classifying insects. To prepare students for their homework, briefly review the anatomy of insects. Also, at this time, assign each team a set of the insects from the class master list.

Now direct each team to re-sort their cards so that they have a subgroup containing the names of the insects in the set you have just assigned. Have them divide this subgroup of cards amongst themselves, making sure that each student has at least one card with an insect's common name on it. Next, distribute copies of Student Handout 1 (Study of Insects). Tell students that they must complete the handout as homework. They are individually required to find and record *at least* the following information: the selected species' scientific name, the defining characteristics of its order and genus, and its habitat. In addition, each student must draw a picture of his or her particular species.

2. Exploring the Concepts

In the next activity, students will watch the QUEST *Summer: Getting the Bugs Out* video. As they view the film, they will be recording information about the many different anatomical features of various insects that perform similar functions, from eating to defense. Students will then complete their species cards. During the course of the activity, they will explore the concept of *diversity of species*, recognizing that a variety of related organisms have different forms to do the same function.

Activity 2

Step 1

Distribute copies of Student Handout 2 (QUEST *Summer: Getting the Bugs Out* Viewing Guide). Review the handout with the class. Tell students that you will be showing them a film about insects. As they watch, they should take notes to fill in the chart on Student Handout 2. Remind students that they should be looking for information on the variety of forms that different insects have for doing certain tasks, from eating to protecting themselves. This might include, for example, all of the types of mouth parts that are mentioned in the film, or the variety of ways in which insects protect themselves.

Show the video QUEST *Summer* to the class. You may want to pause the film to allow students to take notes, or to point out any important segments. After the video, discuss what students have learned by having them share the facts they noted in their charts on the handout.

Step 2

Have students use their research notes from Student Handout 1 and the index cards they made in Activity 1 to make an identification card for each species they were assigned. When they have finished, have students regroup in their former teams and share their research information.

Step 3

Distribute one copy of Student Handout 3 (Insect Form and Function) to each team. Explain that student teams will be identifying, according to insect order, a list of physical characteristics for each order's eating, moving, and self-protection. Direct teams to begin with the subgroup of insects they were assigned in Activity 1. When they are done with their own team cards, they will trade with another team. They will copy the other team's research information onto their own team's set of insect cards; then they will make the appropriate notes on their Insect Form and Function handout. Direct student teams to circulate cards until they have seen all of the completed insect cards in the class. By the end of the activity, each team should have a completed handout as well as a complete set of insect cards that includes their classmates' research.

When the class has finished, have each team sort their cards according to the scientific classification system. Discuss the variations in insect anatomy, and help students recognize the anatomical variations amongst species (form) that accomplish the same task (function). Ask, for instance, "How many different forms of movement can be found in insects?" Clarify as needed.

Step 4

Lead a whole-class discussion about the charts completed by the teams. Once there are no more questions for clarification, distribute a new copy of Student Handout 3 to every student. Direct each student to create his or her own master chart of insect form and function, using the team's completed chart from Step 3 as a guide.

To assess their learning, first direct students to look back through the handouts and class lists generated in Activities 1 and 2. Lead a brief discussion about how students think insects have developed such a wide variety of physical forms. Then have each student theorize, in writing, how all of these physiological variations might have developed in insects. Have students turn this assignment in for your review. You will discuss their ideas in the next class.

3. Developing the Concepts

In the following activity, students will share information about the differences among the order, family, and genus of each species researched. They will reorder their cards to reflect this arrangement based on the scientific classification system. Then, student teams will work to create field guides to various local species.

Activity 3

Step 1

Direct students to regroup into their teams. Explain to them that they are going to do a simple modeling exercise in natural selection to help clarify their thinking. Tell them that they will begin by doing a Punnet square for a species characteristic. If they are unfamiliar with P-squares, you will need to provide them with an explanation. (**Note:** Refer to the Resources section at the end of this teacher guide for a Web site that provides a simple explanation of Punnet squares and how they work.)

Distribute copies of Student Handout 4 (Modeling Natural Selection). Review the scenario at the beginning of the handout, and briefly go through the series of questions. Direct students to get the paper cups and other supplies they need. Then have students work in their teams to complete the handout as directed. As teams are working, circulate to ask them questions about the steps listed on the handout and what they think these steps might mean in the natural world.

Step 2

When everyone has finished the modeling activity, discuss students' experiences. Help them identify the concept of *interrelationships* between species and their environment. Also point out how the success of a new species can usually be attributed to a favorable genetic mutation which allows a particular species an advantage in its environment. Encourage students to articulate that this kind of change in a species may, in turn, have an impact on the broader ecosystem, which might bring about further changes in other species' populations.

Also note with students that some variations may not be revealed as anatomical changes but as behavioral ones. For example, a particular species might shift its timing for reproductive activity, so that mating occurs earlier or later and offspring are therefore born earlier or later. Ask students to reflect back on the video. Draw a food web of some of the species mentioned in the video. Have students select one of the food chains within the food web. Then ask them to determine whether, if one of the species in the chain were to shift its reproductive cycle or migration cycle, this change would better protect the species from other species and more of the young would be able to survive. Point out to students that the video focuses on summer because that is when the populations of species are generally the highest, providing the broadest supply of food in their ecosystems. Help students see that if one species tries to arrive just when the population of another species upon which it feeds is peaking, the success of the predator species' population is usually assured.

4. Synthesizing and Applying the Concepts

In the next activity, students will diagram some of the factors that can cause genetic mutations. They will also explore the impact of these mutations on the related species' population, as well as the impact on other species in the ecosystem. Students will then complete a project in which they depict a designed change in a selected species.

Activity 4

Step 1

As a class, diagram the steps that occurred with the butterflies and honeysuckle in the previous activity. (These steps would include the occurrence of a genetic mutation, its expression as an anatomical variation in feeding, and its impact on species migration to match food supply.)

Step 2

Have students work in teams for the next part of this activity. Tell them that they will be forming a more generalized diagram to show genetic variation. First, ask each team to identify two ways in which genetic variations might occur. Then ask them to identify two more ways in which genetic variations can be expressed in organisms. Finally, ask them to identify two more impacts that might occur within the species' ecosystem. Discuss their ideas.

Tell students that in their teams, they will be creating a presentation entitled *Changing Populations*. They will select an environment and a species within that environment. They will then design an expressed changed form or behavior in the species. Next, they will depict how the change will allow the species an advantage in terms of survival. Finally, they will describe the resulting effect on two other species in the ecosystem. Their presentations can be done in the form of a poster, a PowerPoint demonstration, a cartoon, or a paper. Assign a due date for the teams' projects.

Step 3

When teams have completed their projects, have them present their ideas to the rest of the class.

5. Extending the Concepts

QUEST at Home

Step 1

Distribute copies of Student Handout 5 (*QUEST* at Home: Creating Your Own BioBlitz). Describe the process for students who are interested in doing mini-BioBlitzes with their families and friends. Agree upon a time period for students and their families to complete their inventories. (**Note:** To keep things relatively uncomplicated, you may want to limit students' surveys to just animals, just plants, just insects, or just birds.)

Step 2

Plan for a method for students to post their data in the classroom when their projects are done. Also consider how to help them investigate any unidentified species. Finally, plan to create a master list for their species inventories.

Community Connections

Many communities have local parks. There may also be state or national parks in your community. Parks may be managed by a governmental organization, a conservation organization, a town recreation department, or a town conservation commission. The staff of these organizations may conduct annual inventories as a tool for managing the lands. Ask a park ranger or town official to visit your class and discuss your area resources, the wildlife that lives in your region, and how species populations are inventoried and tracked.

Country extension officers are part of a national program of the U.S. Department of Agriculture. They have offices in each county and assist landowners with problems involving pest control, gardening, and landscaping. These officials often have a great deal of information about the wildlife in the area, including native plants.

Pest managers are professional exterminators. They know a great deal about the insects with which we are most familiar -- the ones that we usually do not want around. Ask one of these professionals to come into your class and discuss the variety of species they deal with, why these insects are considered pests, and how people can prevent them from invading their homes.

Beekeepers are usually farmers who use the bees to pollinate their orchards and gardens. They also make honey from the bees. These individuals know a great deal about the life cycle of the honey bee, the pollination needs of various plants, and the process of making honey. If possible, visit a local beekeeper, or ask one to come to your school.

Career Opportunities

Field Biologist or Ecologist: These individuals conduct research in natural systems. They investigate a particular species, a community of species, or the interactions within an entire ecosystem. They often work for state or national fish and wildlife departments or parks.

Horticulturalist: Specializing in growing plants, horticulturists work in greenhouses or nurseries. They must have a full understanding of the insect pests and diseases that affect plant growth.

Beekeeper: Beekeepers maintain beehives both for the production of honey and the fertilization of crops. In many regions, beekeepers actually keep the beehives on a tractor trailer truck and move them between orchards or blueberry fields.

Illustrator: Many researchers and publishers require illustrations of species for their reports, books or journals. A good illustrator can carefully depict variations in species for field guides or journal articles. Those with more fanciful skills may be able to illustrate children's books.

Resources

Virtual Exhibit on Canada's Insects
http://collections.ic.gc.ca/biodiversity/index.html
This site supplies background on a variety of insects and has a searchable database of species, with illustrations.

Tree of Life Web Project
http://tolweb.org/tree/phylogeny.html
This site illustrates the relationship among order, family, and genus of insects. It also indicates the orders that have become extinct. Additional information is provided on insects' anatomical characteristics for students who are already somewhat familiar with insect anatomy. There is also a link to other Web resources.

Department of Entomology, University of Illinois
http://www.life.uiuc.edu/entomology/illustrations.html
This site includes illustrations of the orders of insects and offers links, by order, to the Tree of Life site.

Kendall Bioresearch Services (UK)
http://www.kendall-bioresearch.co.uk/class.htm
This site provides a good description of insect orders and simple diagrams of insect anatomy.

PBS: Alien Empire
http://www.pbs.org/wnet/nature/alienempire/index.html
This Web site, for the Nature program, contains an episode on insects.

Animal Diversity
http://animaldiversity.ummz.umich.edu/site/accounts/information/Insecta.html
This site, from the University of Michigan, has information and pictures.

Baby Steps Through Punnett Squares
http://www.borg.com/~lubehawk/psquare.htm
An explanation of Punnet squares, with opportunities for practice, is located at this site.

Study of Insects

Insect's Common Name(s):	
Insect's Scientific Name:	
Insect's Family:	
(A) ORDER:	(B) Order – Physical Characteristics:
(A) GENUS:	(B) Genus – Physical Characteristics:
(A) SPECIES:	(B) Species – Physical Characteristics:
Habitat:	

Picture:

QUEST *Summer: Getting the Bugs Out*
Viewing Guide

FUNCTION *What are the many ways in which insects:*	**FORM**
Eat	
Move	
Reproduce	
Protect themselves	

Insect Form and Function

Insect (Order/Genus)	Body Structures for Eating	Body Structures for Moving	Body Structures for Protecting

Modeling Natural Selection

Part 1: Punnet Squares

Punnet squares are used to determine how heredity of a given characteristic can vary from generation to generation. For instance, imagine that a new trait has developed in a variety of butterfly. This new trait allows the butterfly to have a longer proboscis to insert into flowers and gather nectar. In the habitat in which this butterfly lives, a new variety of honeysuckle has begun to grow that has a deep tubular shape. The butterflies that inherit and express the longer proboscis are able to get the nectar from the honeysuckle, and in turn are able to pollinate the honeysuckle flowers more effectively. Both the butterfly and the honeysuckle have gained an advantage in survival from this new trait which has been expressed in the structure of the butterfly.

This trait is dominant. The **dominant** trait will be expressed when a butterfly carrying this trait mates with another butterfly with a traditional proboscis. The longer proboscis will become the one expressed in the next generation. In the Punnet square below, the new trait is represented by **B**. The traditional proboscis is a **recessive** characteristic; it is represented by **b**.

Directions: Complete the Punnet square below for one parent with a long proboscis and one with a traditional proboscis.

	B	**b**
b		
b		

1. How many offspring will have a have the longer proboscis? _____

_____

Now complete the Punnet square below for two parents with the recessive gene for the shorter proboscis, but also both with the dominant longer proboscis gene: **Bb x Bb**.

	B	**b**
b		
b		

2. How many offspring will have the longer proboscis? _____

_____

Part 2: Demonstration

Directions: For each team, take two paper cups and two paper plates. Next, count out 20 of ***each of the four types of beans***. One type of bean will represent short-proboscis butterflies, one type of bean will represent long-proboscis butterflies, another type deep-tube honeysuckle and the last type shallow-tube honeysuckle. The cups will be populations of the different types of butterflies; the paper plates will be populations of the different types of honeysuckle. All live within the same ecosystem. Label the cups and plates accordingly.

1. Set up an ecosystem where the predominant butterfly has a short proboscis and the honeysuckle is short-tubed.

a. Place 15 beans representing short-proboscis butterflies and 5 beans representing long-proboscis butterflies in one cup.

b. On one paper plate, place 15 beans representing shallow-tubed honeysuckle and 5 beans representing deep-tubed honeysuckle.

In this environment, each butterfly needs one of the appropriate honeysuckles to survive. Since there is a match, each of this generation survives. Since they can mate, the 5 long-proboscis butterflies will mate with 5 short-proboscis butterflies. According to the Punnet square above, how many offspring will have the long proboscis? Multiply the number of pairs (5) by the number of offspring by the number that inherit the long proboscis.

2. Place the appropriate number of offspring in the second cup. The remaining 10 short-proboscis butterflies will interbreed in 5 pairs. Each of these pairs has 4 offspring with the short proboscis. The results are a total of 20 short-proboscis butterflies. You should now have 20 beans representing short-proboscis butterflies and 15 beans representing long-proboscis butterflies in the second cup.

3. If this pattern continues and the food supply stays the same, what will happen to the populations? Which type of butterfly will be dominant?

4. Now the butterflies have expanded their range into an environment where the deep-tube flower is predominant. Place 15 beans representing the deep-tube flowers on the second paper plate, along with 5 beans representing the shallow-tube flowers. Determine the next generation by going through the same process, using the second generation of butterflies and the changed food supply.

5, Identify which butterflies survive based on the food supply.

6. Identify the mating pairs and numbers of each population type.

7. How has the population changed? Which variety of butterfly is predominant?

Creating Your Own BioBlitz

You're on a Quest!

Do a BioBlitz in your own backyard or neighborhood! Involve your family and friends in this activity. This is a chance for you to go out into your own area and do an inventory of the wildlife species that can be found.

1. Begin by drawing a map of the area you plan to survey. Sketch it roughly to scale.

2. Determine **when** you will be able to go out to take the survey, and **how much area** you can cover in the time you have been allotted. Sketch out the way you will walk through your area. You can do this by forming a grid to cover the space or by just walking a trail.

3. Look in your local library for field guides. Review the species that you think may be in your area. The local parks department, recreation department, or agricultural extension agent may have a local species list. You may also be able to find them listed on the Internet by the parks department for your state.

4. Begin the survey. Take your map and field guides, if possible. Write down all of the species you see.

If you are unsure about the identification of any species, take a picture of it, or sketch it carefully. Be sure to record any markings or distinguishing features. Also, mark on the map where you found it. Then take the picture of the "unknown" species to your local agricultural extension agent, park naturalist, or high-school biology teacher. These professionals can help you with your identification.

5. Share your master list with the local conservation commission, park ranger, land trust or county extension agent. Plan for a later time to survey the area again to see how things have changed through the seasons. See how many species you can add to your list!

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