Grade Level: 7th Grade

Purpose: This curriculum is designed to communicate:

- Basic anatomy and life cycles of insects.
- How an organism’s body structure contributes to their ability to survive and reproduce.
- How organisms’ interact and depend on one another and that energy moves through a food web.

Koa bugs in the classroom with student taking a closer look.

Rationale: Insects are by far the most numerous, most diverse, and could be viewed as the most ecologically important terrestrial creatures on the planet. They also provide a food source for many, are decomposers of organic materials, plant pollinators, and producers of important products like honey and silk. In addition, insects provide an opportunity for students to learn about biological processes inside the classroom. In Hawaii, *Coleotichus blackburniae*, or the Koa bug is an endemic species that can be brought into the classroom for students to learn about organisms’ structures and functions, and insect life cycle. This curriculum uses hands-on activities to promote interactive learning about Hawaii’s insects.

Hawaii Content and Performance Standards (HCPSIII) Addressed: 7.1 Scientific Investigation, 7.2 Nature of Science, 7.3 Organisms and the Environment, 7.4 Structure and Function in Organisms

Unit Concept Map
Student recording information about structure and function, molting nymph in the classroom.

This unit was created and piloted by Steve Souder and Lily Edmon.
**Topic**
Scientific Inquiry

**Benchmark SC.7.1.1**
Design and safely conduct a scientific investigation to answer a question or test a hypothesis

**Sample Performance Assessment (SPA)**
The student: Identifies the dependent and independent variables, writes an experimental design, and safely conducts the experiment.

<table>
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<tr>
<th>Rubric</th>
<th>Advanced</th>
<th>Proficient</th>
<th>Partially Proficient</th>
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<tr>
<td></td>
<td>Consistently design and safely conduct a logical, systematic scientific investigation to answer a question and test a hypothesis</td>
<td>Usually design and safely conduct a scientific investigation to answer a question or test a hypothesis</td>
<td>Sometimes design and safely conduct a scientific investigation to answer a question or test a hypothesis</td>
<td>Rarely design and safely conduct a scientific investigation to answer a question or test a hypothesis</td>
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<td></td>
<td>90-100 A</td>
<td>80-89 B</td>
<td>70-79 C</td>
<td>60-69 D</td>
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**Objective:** Students will brainstorm and investigate potential questions or tests of hypothesis from what they observe about the life cycle of Koa bugs.

**Background knowledge:** Students will make daily observations of koa bug taking notes on the changes in morphology and record mortalities and egg masses. The students will be provided with a reading assignment “What is a Koa Bug” to supplement their knowledge.

**Requirements:** Students will maintain individual logs recording what they observe about the koa bugs. Students will write a scientific paper based on the data collected. The paper will be formatted in the following order: introduction, materials and methods, results, discussion, and conclusion.
**Topic**  
Interdependence

**Benchmark SC.7.3.2**  
Explain the interaction and dependence of organisms on one another

**Sample Performance Assessment (SPA)**  
The student: Explains how organisms in a biological community interact (e.g., predator/prey, producer/consumer, parasitism, mutualism, competition, cooperation, niche).

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<tr>
<td>Evaluate and explain how organisms interact with and depend on one another</td>
<td>90-100 A</td>
<td>80-89 B</td>
<td>70-79 C</td>
<td>60-69 D</td>
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**Objective:** To analyze and demonstrate how different insects interact and even depend on one another in an ecosystem.

**Background knowledge:** Students will be able to identify ecological interactions based on the relationship organism have with one another. This will be presented first as a slide show, then as a series of foldable notes and worksheets.

**Requirements:** Students will be given foam balls, chenille strips, glue, wire meshing, yarn, straws, clear plastic, construction paper, toothpicks, glitter, coloring markers, pens, etc. Out of these supplies they will construct an insect of their design. They will need to make sure the insect has all body parts (anatomically correct), and is colored and sized appropriately. Along with their project, they will turn in a structure/function worksheet along with the insect’s niche and habitat. At the end of the project, they will be required to present their bugs to the rest of the class and explain its unique common and scientific name, features, niche, ecological interactions, and habitat.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Interdependence</th>
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<tbody>
<tr>
<td>Benchmark SC.7.3.3</td>
<td>Explain how biotic and abiotic factors affect the carrying capacity and sustainability of an ecosystem</td>
</tr>
<tr>
<td>Sample Performance Assessment (SPA)</td>
<td>The student: Identifies and describes how biotic and abiotic factors (e.g., available resources, disease, competition, predation, climate, habitat) affect the health and carrying capacity of an ecosystem.</td>
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**Rubric**

<table>
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<tr>
<th>Advanced</th>
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<td>Analyze and explain the biotic and abiotic factors that affect the carrying capacity and sustainability of an ecosystem based on evidence</td>
<td>Explain how biotic and abiotic factors affect the carrying capacity and sustainability of an ecosystem</td>
<td>Describe that biotic or abiotic factors affect the carrying capacity and sustainability of an ecosystem</td>
<td>Recognize that biotic and abiotic factors affect the carrying capacity and sustainability of an ecosystem</td>
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</table>

**Objective:** To analyze and demonstrate how the presence or absence of food, shelter, water, or space can limit the carrying capacity of an organism’s population.

**Background knowledge:** Students will be able to identify abiotic and biotic factors. Also, the relationships organisms have with one another will also have an affect on the carrying capacity of each organism. This will be presented first as a in class worksheet activity, then as a fun outdoor activity demonstrating population dynamics of koa bugs.

**Requirements:** Students will calculate the potential population of Koa bug based on the data collected from student’s observations without limiting factors and create graphs from “Koa bugs on the run” outdoor activity. Students will calculate mean, median, maximum, minimum, and range of Koa bug population.
**Topic**: Classification

**Benchmark SC.7.4.4**: Classify organisms according to their degree of relatedness

**Sample Performance Assessment (SPA)**

The student: Analyzes the degree of relatedness among selected organisms by comparing the similarities and differences found in internal and external anatomical features.

**Rubric**

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<th>Proficient</th>
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<td>Classify organisms according to their degree of relatedness and justify the classification</td>
<td>Classify organisms according to their degree of relatedness</td>
<td>Identify ways to classify organisms according to their degree of relatedness</td>
<td>Recognize that organisms can be classified</td>
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**Objective**: To analyze and demonstrate how insects are related based on the features they possess.

**Background knowledge**: Students will be able to identify insect families based on the structures and functions they possess. This will be presented as a hands-on in-class activity which challenges students to group unknown insects into like groups.

**Requirements**: Students will have to actively participate in the activity, identify the particular features that allowed them to make decisions about Family groups, and follow up with a in class discussion.
Build-a-Bug

Model Rubric

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<td>Analyze and compare how organisms’ body structures contribute to their ability to survive and reproduce and support conclusions with evidence.</td>
<td>90-100 A</td>
<td>Analyze how organisms’ body structures contribute to their ability to survive and reproduce.</td>
<td>70-80 C</td>
<td>Recognize that an organism’s body structure contributes to their ability to survive and reproduce.</td>
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<td>The student: Analyzes how body structures of different insects contribute to their survival and reproduction.</td>
<td>90-80 B</td>
<td>Describe how an organisms’ body structures contribute to their ability to survive and reproduce.</td>
<td>70-80 C</td>
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Objective: To analyze and demonstrate how different insect structures help them to fit into different niches.

Background knowledge: Students will be able to identify structural characteristics based on observation, and identify their functions based on the morphology. This will be presented first as a slide show, then as a series of foldable notes.

Requirements: Students will be given foam balls, chenille strips, glue, wire messIng, yarn, straws, clear plastic, construction paper, toothpicks, glitter, coloring markers, pens, etc. Out of these supplies they will construct an insect of their design. They will need to make sure the insect has all body parts (anatomically correct), and is colored and sized appropriately. Along with their project, they will turn in a structure/function worksheet along with the insect’s niche and habitat. At the end of the project, they will be required to present their bugs to the rest of the class and explain its unique common and scientific name, features, niche, ecological interactions, and habitat.
Koa Bug Investigation

Supplemental information on this investigation can be found in the Koa Bug Images file (PDF).

**Concepts**
Analyze how an organisms’ body structure contribute to their ability to survive and reproduce. (Benchmark SC.7.5.4)
Explain the interaction and dependence of organisms on one another. (Benchmark SC.7.3.2)
Explain how energy moves through food webs. (Benchmark SC.7.3.1)
Design and safely conduct a scientific investigation to answer a question or test a hypothesis. (Benchmark SC.7.1.1)

**Overview**
Students are introduced to the endemic Koa bug (*Coleotichus blackburniae*), Hawaii’s largest true bug, and they will investigate their structure and function, life cycles, and the dependence of organisms on one another. Students will build suitable habitat for the insects and make daily observations of their change, eventually identifying males from females and understanding the insect’s life cycle. In addition, information gathered from this investigation will be utilized in a future lesson on “populations”.

**Purpose**
To have students identify adaptive strategies of insects and why these features are important to insect survival. The students will understand that an organism is a living thing and that energy moves through a food web. Furthermore, they will gain an understanding of organism interactions and that each is dependent on one another. The observations they make will allow them to understand what an organism does, how it responds to its environment, and report the observable biological changes that have occurred. Students should also be challenged to design an experiment.

**Materials**
- Koa bugs (collected from the field) *Images PDF*
- Seed pods w/ stems (Formosa koa, native Koa and Koaia, A’ali’i) *Images PDF*
- 4" Clear Tubes, Plastic, with Stoppers (at least ten per investigation) *Images PDF*
- 32 oz Translucent Plastic Cups with covers (5-7 Koa bugs per cup) *Images PDF*
- Insect netting (1 yard)
- Glue
- Petri dishes or small plastic container (50mm x 9mm circular)
- White paper towels no print (2 rolls)
- Water squirt bottle
- Magnifying glasses (At least one per group)
- Optional: Digital microscope with laptop
- Optional: Large Insect Cage (This needs to be built or bought) *Images PDF*

**Background Information/Preparation**
This investigation is a **logistical challenge** and should only be attempted if you are willing to deal with **daily maintenance and care of an organism**. **Remember the Koa bug is a living organism and should be treated with respect and care!** Furthermore, it is recommended that this investigation be done during the months of April through October, when climate conditions are warmer and more conducive to insect development. Temperature is very important to insects and warmer temperatures will increase development, shorten the life cycle, and improve survivability. If you have signed the waiver and agree to accept this responsibility, here is how you find them.

**Finding the Koa bug**

First, Koa bugs may be hard to find unless you know where to locate them. The best places to find them are in parking lots believe it or not! But it’s not that simple, these parking lots need to be landscaped with Formosa Koa (*Acacia confusa*). Formosa Koa has been used extensively in Hawaii as a landscape tree and is often found in the parking lots of malls, businesses, schools, and homes. If you are on the Big Island of Hawaii, a few potential locations to find them are Waikoloa Elementary (Very likely, always find them here), North Hawaii Education Resource Center Area in Honokaa (possible, seen them here), Parking lot near the corner of Kuawa and Kalanikoa Street in Hilo (Very likely, see them here often), K-Mart parking lot in Kailua-Kona (reported to be seen here), and Prince Kuhio Plaza in Hilo (never seen them here, because the trees are very tall).

These results are based on my own experience. The Formosa Koa trees continuously produce seed pods so it is a good food source for your classroom Koa bugs. If you are going to do short term studies you may also used the native Koa, Ko’aia, or A’ali’i plant seed pods. Avoid using the A’ali’i if possible, because the koa bugs blend in very well with this food source and are hard to see and remove when changing the plant material.

**Collecting the Koa bug**

Once you have identified a location where they are present, you will need to collect them. It may take a little time before you get an “eye’ for them, but try and focus your attention around the seed pods of the plants and you will eventually find a Koa bug. The adults are a bit more cryptic with its green coloration (photo at end), but they can be spotted. Collecting the nymphs (black and red, see photo at end) is relatively easy because they do not fly, however, as a defense, they drop and they also have a defensive spray (I’ll talk about this a bit more when I cover the adults). It is best to use a large container or bag to collect the nymphs. Hold the container under the nymph and either, remove the plant part they are on, or gently direct them into your container. Often times they will drop and collect themselves for you if you place the container under them.

Koa bugs are somewhat gregarious so you may find nymphs that are still in their 1*st*, 2*nd*, or 3*rd* instars clustered together. They tend to be more separated as they get older.

A total of 20-25 should be enough for your classroom. Try and collect nymphs that are similar in size, because they are more likely to be similar in age.

The adults are a bit more difficult to capture because they are good flyers and are harder to see. Use an insect net or individual collection vials for these guys. Be cautious when capturing adults, if one should spray, the other adults in the immediate area will sense this and flee, so be patient when trying to catch them. Age of adults can somewhat be determined, if the adult has very bright red iridescence in its coloration it could be a new emergent. The red coloration diminishes as adult’s progress in age. Collect about 15-20 adults and that should be more than enough for your classroom.
Seed Pods
The seed pods should be green to maroon in color (Images PDF) and have developed seeds within the pod. I like to use the “pinch” method to select my seeds. Place a pod between your thumb and index finger and find a seed, gently “pinch” the seed, if you do not feel the presence of a seed or if it feels like there is “no space” between your fingers the seed pod is too young. If you can feel a seed or feel as though there is “something” between your fingers this pod can be used. The Koa bug sucks nutrients out of the seeds, if there is nothing in the seeds the Koa bugs can’t feed. When collecting the pods, cut the plant at least 4 inches away from the pods which will enable you to place them in the clear water tubes.

Classroom Environment
In your classroom, select a spot where they may receive a few hours of sunlight (not necessarily direct sunlight) and ensure that they are not in the breeze of the air conditioner. They should also be taken home on the weekends to avoid subjecting them to long periods of darkness.

Instruct your students to be respectful of this living organism.

Maintenance
Seed pods collected from plants should have a portion of the stem on it (at least 4 inches) to be placed into the water tube. These pods should be changed every three days to ensure Koa bug survival. For example, if new pods are changed on Monday, they should be changed again on Thursday. When changing pods, be careful of the insects. Some of them may not want to let go. Be patient. Cut circles out of the white paper towels to fit bottom of container, this absorbs insect frass (frass is poop for insects) and towels should be changed every week.

Note: The pods may need to be changed every three days but the water in the tubes needs to be accessible to the cuttings, so pay close attention to water levels in the tube, the pods are no good if the cutting dies from lack of water. The water squirt bottle is a good way to refill the tubes.

Supplemental Material
Additional information needed to care for Koa bugs can be found in the “What is a Koa Bug?” reading.

Motivation
Students may have some abjection to studying “BUGS!?” but this will quickly change once they get to observe them up close and personal. In my experience, students forget about their fears and move into curiosity, then enthusiasm about this project. It is important for them to understand that they are going to be responsible for their care and this helps with the handling and care of the Koa bugs.

Safety
This investigation has no real dangers except for the occasional spraying by the Koa bugs. If anyone is sprayed wash hands immediately, but the area of the skin which was sprayed will turn brown for a few days. The safety of the Koa bugs should be a concern for all. No inappropriate behavior around the insect area. Make sure students are aware of their surroundings. No book bags on the bugs!

Activity
Day 1.
1. Break the classroom up into small groups and inform the class that they will be observing a “living organism” and should act accordingly. Pass out magnifying glasses and introduce the Koa bugs. The adults should be in pairs (male and female) in a petri dish and 2 nymphs in another petri dish. Allow the students to observe them while recording their observations on the “Koa Bug Observation” handout. This will get them to observe the structure and function of the insects as well as identify male from female. Let the bugs do their magic.

   **Note:** Petri dishes or containers should be taped closed to eliminate the students urge to open the container and any accidental openings.

2. Pass out the “What is a Koa Bug” reading for homework and instruct them that these Koa bugs will become part of their classroom and their care will be the responsibility of the students. For day 2, have students think about what the Koa bugs will need to survive in the classroom. For example, living container, food source, where to get food source, etc.

**Day 2+**

1. Allow the students to brainstorm their ideas and formulate all the needs of the Koa bug. Introduce the building materials and ask students if these materials can be used. Construct habitats and place adults and nymphs in separate containers (*Images PDF*).

2. Introduce the “Koa Bug Observation Worksheet” and have the class brainstorm about what they can learn from observations. Determine the potential questions that could be answered or hypothesis that could be tested using daily observations.

   **Note:** Guide your students questions based on the Koa bugs you collected. For example, if you collected adults that are laying eggs, you could have them determine the average number of eggs per egg mass and establish how long it takes for eggs to develop into nymphs. With nymphs, you can record time between molts and determine life span once they become adults.

3. The students will use the observation worksheet as their scientific log. They will use it to record behavior and biological changes they observe.

   **Note:** Important for students to record mortalities, moltings, number of eggs and clutches, and hatchings of new nymphs. The data collected can also be used with the “populations” lesson included with this curriculum.

4. Conduct a quick observations everyday until experiment is complete.

   **Note:** Take time out from class if anyone sees a Koa bug molting. This is a good time for students to see insect growth and is a good way to link nymphs with adults. Seeing is believing!

5. Students write up a scientific paper that includes an introduction, material and methods, results, and discussion or conclusion section.

**Going further/ Extension**

Use a calendar to chart the development of Koa bugs on a daily bases, have the students record and post this information for everyone to see. Students can be encouraged to write reflections in journals or create a newsletter for other students to read. This will keep and accurate record of events and also inform students in other classrooms about what is going on in yours.
If you are going to study ecosystems or have already covered this, you can link the information about the life of koa bugs to identify potential ecosystem habitats. Where do Koa bugs live in the wild? Identify the food source and you may find the consumer.

**Concept Discovery**
Students will be able to describe the sequence of changes experienced by the Koa bug and understand the structure and functions found on them.

**Assessment**
**Koa Bug Images and Supplemental Information**

This file should be used in conjunction with the Koa bug investigation file.

**Images**

- Nymph and Adult
- 1st instars
- Female
- Male

- 4 inch water tube
- 32oz deli container

Container with cover, koa bugs, water tube, and koa cuttings with seed pods.
Cover should be cut to allow ventilation and reduce condensation. Insect netting should be glued from the top as close to the cut as possible to reduce Koa bugs getting caught in the gap.

Large insect cage constructed of insect netting, wood, glass, hook lock, cloth, and foam. This cage is approximately 12 (length) x 6 (width) x 12 (height) inches. The netting for ventilation, the glass to make observations, wood provides support, cloth to access cage without opening the door (a sleeve from a long sleeve shirt tied in a knot works great), hook lock to secure door, and foam to seal the door shut. Pet stores also sell various plastic insect cages for reasonable prices.
Formosa Koa (Photo form www.hear.org)

Native *Acacia koa* with older pods. Thicker leaves (Photo from www.hear.org)
Native A’ali’i (*Dodonaea viscosa*)

Native *Acacia koaia* with flowers. It has narrow leaves. (Photo from www.hear.org)
New egg mass day 1

Egg Mass day 5

Egg Mass Day 8

Hatching day 10

Couple of hours after emergence
Koa Bug
(Coleotichicus blackburniae)

Lily Edmon
Waimea Middle School
Steve Souder
GK-12 PRISM Fellow
Koa Bug Egg Clutch
Developing Eggs
Ready to emerge!
Nymphs!!!
1 Hour Later
5th Instar Nymph
Adult in Formosa Koa
Adult Feeding
What is a Koa Bug?

Koa bugs are structured like all other insects: six legs, three body parts (head, thorax, and abdomen), and two antennae. The koa bug is the largest endemic true bug found in the Hawaiian Islands. Endemic species are native to or confined to a certain region. A true bug is one that has no mouth parts for biting, cutting, or chewing food. Instead, they possess a tube like beak for sucking fluids called a proboscis. In nature, the koa bug uses its proboscis to suck nutrients out of seeds from several Koa plants (Koa, Koai’a, Formosa Koa) and the native ‘A’ali’i. Anything native occurs naturally in an area, and has not been introduced by humans either intentionally or unintentionally. The koa bugs in your classroom are taken from populations found in the wild.

How Do Koa Bugs Grow?

Koa bugs start life in tiny eggs that hatch about 9 days after being laid. The eggs are about the size of tiny beads, slightly smaller than the “o” on this page. These eggs are laid in a tight cluster and are green at first, but eventually the tiny koa bugs begin to develop in the eggs. Their eyes and mouths become apparent and the eggs start to turn red. Newly hatched koa bugs are called nymphs, which is an immature bug. Nymphs
Insects grow by shedding their outer covering called the **exoskeleton**. The exoskeleton is the hard outer surface of the insect and it provides protection and support. The exoskeleton is not flexible so in order to increase in size, a new exoskeleton needs to be produced under the old. The old exoskeleton is split and the insect emerges from it while the new exoskeleton is still moist and flexible. The insect pumps itself up, increasing its size before the new exoskeleton hardens. The process of shedding the exoskeleton is called **molting**. Insects sometimes require several molts before emerging as adults. The koa bug requires 5 molts before taking its adult form. Each molt represents a nymphal stage called an **instar**. So, when the nymph emerges from the egg it is called a 1\textsuperscript{st} instar, once it molts and changes size it becomes a 2\textsuperscript{nd} instar. This continues until adulthood when molting ceases. Adult koa bugs are easily identified by their attractive iridescent colors. In the cages you will begin to see an accumulation of shed exoskeletons.
The nymphs of koa bugs are flightless and are red and black in color. The gradual maturing of koa bugs is called **incomplete metamorphosis**. Incomplete metamorphosis is when the immature young look much like the adults, but without wings. Koa bugs take about 38 days to move from 1\textsuperscript{st} instar to adults (25\textdegree Celsius). The koa bug hatches out in a ratio of 1:1 male to females. The life cycle from egg to egg takes ~77 days (11 weeks) at 25\textdegree Celsius.

![Nymph top, Nymph bottom, Emerging Adult]

Development of insects can be influenced by different things, one of which is temperature. It is important to understand that temperature determines the rate of development in insects. Development occurs slower at colder temperatures and faster at higher temperatures. Development does not occur at the upper and lower temperature thresholds, which varies from insect to insect.

**How do Koa Bugs Mate?**

Koa bugs begin mating about 30 days after molting to adulthood. Mating is easily recognized as the mating pair will be attached end to end at the rear of the abdomen. Determining males from females takes more effort and patience. The only means to identify males from females is to observe the reproductive parts. Females are determined by observing a flat triangle shaped reproductive part at the end of the abdomen, while
males have a single rectangular shaped reproductive part. Each can be seen in the photos below.

A few days after mating, females begin to lay clutches of eggs averaging about 25 eggs per clutch. A female will continue to mate and lay eggs about once every two weeks throughout her life. The eggs are either laid on seed pods or on a leaf directly adjacent to seed pods.

**Coleotichus blackburniae**

All living organism are organized under a classification system. The animal kingdom is divided into major groups called phyla. Each phylum is divided into classes. Each class is divided into orders. Each order is divided into families. Each family is divided into genera, and each genus into species. A species is a basic category or a kind of animal. There are many definitions for species!

The koa bug is in the kingdom Animalia, phylum Arthropoda, the class Insecta, the order Hemiptera, the family Scutelleridae, the genus *Coleotichus*, and the species *blackburniae*. The common name is koa bug and the scientific name is *Coleotichus blackburniae*. A relative of the koa bug found in Hawaii is the southern green stink bug, *Nezara viridula* (Hemiptera: Pentatomidae).

Insect introductions have negatively impacted the population of koa bugs in Hawaii over the last few decades. Yet, the koa bug is still found on all of the major islands and in various climate areas.
Name _____________________
Period_______Date__________

**Koa Bug Observation Sheet**

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<tr>
<th>Date</th>
<th>Observations</th>
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Build-a-Bug Investigation

Concept
Organisms reproduce in different ways. Living things reproduce to make more organisms like themselves. Traits are passed down from parent to offspring. Non-living and living things interact to create an ecosystem. Analyze how organisms’ body structures contribute to their ability to survive and reproduce. (Benchmark SC.7.5.4) Explain the interaction and dependence of organisms on one another. (Benchmark SC.7.3.20) Classify organisms according to their degree of relatedness. (Benchmark SC.7.4.4) Explain how energy moves through food webs. (Benchmark SC.7..3.1)

Purpose
The purpose of this investigation is to engage student learning by providing them with “hands-on” activities that build student scientific inquiry and investigation. In a sense, the students become scientist, and the lessons within this investigation focus on student observations and inquiry to answer questions about the world around them.

Day one
Field Trip: Students will make a trip to a local park or area and use various forms of insect gathering devices to collect insects.

Day two
PowerPoint (10 min): Students learn about basic insect anatomy and identify non-insects (spiders, centipedes, pseudo-scorpions). Hands-on in-class activity (30 min): Students identify adaptive strategies of insects and why these features are important to insect survival. Discuss advantages and disadvantages of these structures (10 min).

Day three
PowerPoint (10min): Students learn about different insect mouth types and their function. Hands-on in-class activity (30-40): Students will use the collected insects from day 1 or insects collected from the previous year in a classification exercise. Students place like characteristics together and also use reference materials to identify the Order of the insect. This exercise also reinforces structure and function and insect anatomy.

Day four
PowerPoint (15-20 min): Students are familiarized with ecological terms for organism interactions and discuss these interactions using real world examples.
Introduce Build-a-Bug Project: Begin to develop ideas and discussion about potential insect structures and functions. Students work on an in-class worksheet (20-30 min) on niche and niche description, abiotic and biotic factors, and initial drawing of insect.

**Day five**

PowerPoint (10-15 min): Introduce students to incomplete and complete metamorphosis of insects.
Introduce the building materials and expectations.

**Day six and seven**

Allow students to work on their project: They should decide on a life cycle, develop at least two ecological interactions, and identify abiotic and biotic factors.

**Day eight**

Presentations of individual or joint projects.
Background for Insect Investigation

Insects

Insects are found everywhere on terrestrial Earth except for the coldest polar regions of the North and South Pole. Insects are by far the most numerous, most diverse, and could be viewed as the most ecologically important terrestrial creatures on the planet. They can be found in your home, under the ground, on vegetation, under water, and are even found thousands of feet in the air.

The key ecological functions they provide range from, providing a food source for many, decomposers and recyclers of organic materials, plant pollinators, and produce important products like honey and silk. Humans see insects as both beneficial and detrimental. Insects cause worldwide damage to crops (cotton, corn), livestock (cattle), and are vectors for disease (malaria). However, insects are also used to reduce invasive or pest species (biological control), solve crimes (forensics), and used extensively in scientific research (genetics).

The number of insects worldwide surpasses the total number of species of plants and other animals combined. Over one million insects have been identified worldwide and the number keeps increasing. Seventy two percent of all animals are insects. It is unknown what the total number of insect is and how many different types of them there are. Some colonies of insects have populations in the millions.

Anatomy & Life Cycle

Key features that distinguish insects include a hard outer layer called an **exoskeleton**, three body regions (head, thorax, and abdomen), two antennae, and six jointed legs. Insects have different stages of development and molt (shed outer exoskeleton) as they grow, sometimes the immature forms called nymphs may resemble the adult. This is called **incomplete metamorphosis**. If the juvenile stage is completely distinct in appearance (larvae) and habits it is called **complete metamorphosis**. This life cycle also includes a pupae or cocoon stage. Insects have passive respiration which takes air into the body through a series of tubes called tracheae. Insects do not have blood rather it is called hemolymph.

All insects have three main body regions: the head, the thorax, and the abdomen.

The Head
The head is the first body part of an insect and the main parts on the head are the eyes (simple and compound), two antennae, and the mouthparts.

The Thorax
The thorax is the second body part or the middle section of the insect. The wings and legs are connected to this portion. The thorax is covered by a pronotum and is divided into three segments, the prothorax, metathorax, and mesothorax. Each segment has a pair of legs and the metathorax and mesothorax have wings on the top of the insect.
The pronotums shape and features are sometimes used to identify insects. The legs of different insects are adapted to do different things. The legs of some insects are adapted for swimming, burrowing, jumping, or grasping. The wings (if present) come in various shapes and design.

The Abdomen
The abdomen contains the digestive and reproductive organs. The main structures on the abdomen include the **spiracles**, **ovipositor**, and **prolegs** (larvae only, found on caterpillars and some sawflies). The abdomen spiracles are tiny openings for passive breathing. The ovipositor is used for egg laying by females. On some insects, there is a large round disc on the first called a **tymanum** and is the insect’s ear.

![Abdomen Diagram](http://www.sidney.ars.usda.gov/grasshopper/ID_Tools/F_Guide/images/fig1.jpg)

Classification
Understanding the taxonomic classification of any organism is important for identification. Students can draw connections when classifying insect Order and Family, because these divisions can be used to link insect structure and function and they share similar characteristics. The levels of classification are:

**Kingdom**: Animalia

**Phylum**: Arthropoda – these include the arthropods, also with exoskeletons and jointed feet. (insects, spiders, crabs, among others)

**Class**: Insecta – Three body parts (head, thorax, abdomen), six legs, two antennae.

**Order**: the number of Orders varies depending on what you reference. However, somewhere around 30 Orders have been identified. Among the most recognized are Hemiptera (true bugs), Coleoptera (beetles), Lepidoptera (butterflies and moths), Diptera (flies), Hymenoptera (ants, bees, and wasps), Orthoptera (grasshoppers and crickets) and Odonata (dragonflies).
**Family**: An important level of insects where entomologists further group insects by structure and function. For example, the hawk moths belong to the Order Lepidoptera, Family Sphingidae.

**Genus**: a further classification level where very similar characteristics are identified

**Species**: a reproductively distinct group

**Scientific Name (binomial nomenclature): Genus and species**
The scientific name for a species is either in Latin or Greek and is two part. It is a universal way of describing organisms to avoid misunderstandings which can arise when using the common name of a species.
Example: *Tyrannosaurus rex*, translated into English tyrant (tyrannos) + lizard (saurus) king (rex).
Tell me what you know about insects

What is an Insect? (Think about body parts and features)

How many different kinds of insects are there in the world? Hundreds? Thousands? Millions?

Why are insects important? What kind of “jobs” do they have?

Where do insects live? (Name all the places you can find insects)

How do insects grow?

Are insects good? Bad? Or Both?

What is endemic? Native? and Introduced?

What would the world be like without Insects?

What kind of strategies do insects use to survive and thrive? (think about insect structures or interactions)

What do you want to know about insects?
Assessment of observations

Can you answer some of these questions from observing this insect?

How does it grow?  Yes  or  No

Where is it found?  Yes  or  No

What does it eat or who eats it?  Yes  or  No

Where did it come from?  Yes  or  No

What kind of lifecycle does it have?  Yes  or  No

How does it reproduce? How many generations are there in a year?  Yes  or  No

How long do they live?  Yes  or  No

Is it a pest or beneficial?  Yes  or  No

Is it endangered or threatened?  Yes  or  No

Do humans affect this organism?  Yes  or  No

What was the most interesting thing you learned about your insect?
Build-a-Bug Investigation

Day 1

Insect Collection/Bug Hunt

Concept
Analyze how organisms’ body structures contribute to their ability to survive and reproduce. (Benchmark SC.7.5.4)
Classify organisms according to their degree of relatedness. (Benchmark SC.7.4.4)

Overview
This is an outdoor activity that allows students to investigate their surrounding and problem solve ways to capture insects. Students should be dressed appropriately for the outdoors. Ideally the field trip should take place in a park where there is a body of water and lots of vegetation. This will increase the likelihood of gathering insects as well as allow students to see variation in habitat occupied by insects.

Note: This exercise can be supplemented by students capturing insects at home or at school prior to the field trip. This may be necessary to accumulate the needed amount of insects for the classification exercise. Consider extra credit for those who participate.

Purpose
The insects collected will be used in subsequent lessons where they will investigate structure and function as well as taxonomic classification.

Materials
- Insect nets (fine mesh fishing nets can be used as a substitute) *Images at end of lesson*
- Killing Jar (Large glass jar with cover, may need more than one). Place alcohol soaked cotton balls in the bottom along with crumpled pieces of tissue paper for insects to hide in. Leave insects overnight. Label the jar to identify it as noxious.
- Tupperware containers or any covered container to hold insects before going into killing jar.
- Umbrella, preferably white of light colored. (Turn is upside down and it can be used under trees or shrubs that are shaken or beaten, catches falling insects)
- Aspirators (can be constructed out of old film canisters, nylon, and rubber tubing or flex straws) *Image at end of lesson*
- Hand troll or small rake (to move loose piles of dirt or gravel)
- Small fish nets (for water insect capture)
- Tweezers or forceps to grab insects.

Background Information/Preparation
The collection of insects should be conducted well in advance of the field trip. This will help students get proficient at catching insects as well as meet the necessary number of insect samples needed for subsequent lessons. Instruct your students to be motivated and encourage them to collect insects at home or at school. Insects collected in advance
should be placed in the freezer. Bait traps, light traps, and pitfall traps (*Diagram at end of lesson*) could be placed ahead of time in designated areas. Light traps are just a catchment container under any outdoor light. Bait traps are design like pitfall traps with the addition of meat, fruit, peanut butter, or sugar in them. Each will attract different insects.

**Motivation**
Come on! It’s an outdoor activity!

**Safety**
No inappropriate behavior (tackling, pushing, etc.). Running may be required but students should be reminded to be aware of their surroundings. Insects do **bite** and **sting**! **Therefore, students with allergies to insects and their kin (bees, centipedes, and spiders) should be identified and precautionary measures should be taken.** Students should avoid these critters!

**Activity**
1. Very simple, catch some insects and place them in the container. Students should form small groups and target different areas for collections. Ensure students have equal time catching insects.
   **Note:** Instruct students to capture insects on sight or by running the net through vegetation where insects may be more cryptic and camouflaged. Also, disturbing the ground or around plants may flush insects from their hiding place.
2. Collect all the insects in a large container or bag and place them in the freezer for preservation.
   **Note:** Proper pinning of winged insects like butterflies and moths, may not be done if insects are place in the freezer first.
3. Pinning insects could also be untaken.

**Going further/Extension**
Students should be encouraged to discuss the different levels of difficulty in capturing insects and draw some conclusions as to why that is. Are flying insects easy to capture? Where some of the insects hard to see? Also, students can discuss where certain insects where captured. In the air, on a plant, under the ground, over water, and discuss a possible link between structure and environment. Students could have a competition to determine which technique catches the most insects or what bait is best.

**Concept Discovery**

**Assessment**
Students will be assessed by active participation and responsible behavior.
Aquarium fish nets [www.online-garden-centre.com](http://www.online-garden-centre.com)

Build-a-Bug Investigation

Day 2

Introduction to Key Features of Insects/What do I do?

Concept
Analyze how organisms’ body structures contribute to their ability to survive and reproduce. (Benchmark SC.7.5.4)

Overview
The students will be introduced to key features of insects and attain a basic knowledge of insect body form. Students will also be able to identify insects from non insects (spiders, centipedes). Students will also understand that insect body forms develop under different strategies, which enhance their ability to reproduce and survive. Furthermore, students will compare and contrast individuals and place them in “like” groups based on similar characteristics and structure. Student will specify the reasons for classification based on their observations and discuss their results with other groups.

Purpose
To have students identify adaptive strategies of insects and why these features are important to insect survival.

Materials
- Five sets of insect images that demonstrate camouflage, defense, warning coloration, burrowers, flyers, and aquatic insects
- Include classification cards for organization (Camouflage, Flying, etc.)

Background Information/ Preparation
Teacher will begin the class by introducing the common features of insects and distinguish non-insects (spiders and centipedes). Insects have two antennae, six legs (three on each side of thorax), and three body parts (head, thorax, and abdomen). Teacher will need to become familiar with each insect card and know the particular features of the insect.

Motivation
In everyday life we often times change our appearance/structure in order to accomplish some task. The change in appearance/structure allows us to gain an advantage in what we want to accomplish. If we are going hunting, we were camouflage or bright colors to conceal ourselves or warn others of our presence. Also, think of the medieval knights of old who wore armor to protect themselves. The armor serves as protection, but limits mobility. Organisms have evolved different strategies to enhance their survival. Insects provide an excellent example.

Safety
No eating insect images
Activity
1. Pass out a collection of images to each group of students and have them make observations. Next, have them begin to group insect that they think share the same strategies. Walk around the room to monitor and ask questions to help those having trouble making observations. Also ask students why they have chosen their group of insects. Allow students to classify the structures on their own first, before introducing the category cards. The exercise may work better for a classroom of advanced students that may not need as much guidance and the category cards supplement their findings.

   Note: No Right Answer, some of the students may get hung up on getting the right answer rather than using their own observations to do that. I encourage the students to choose their own categories but challenge them to explain why they chose the way they did.

2. Once they have determined their insect groups. Students will share their decision to each other and discuss the characteristics they have in common. Important to mention that: insects may be in more than one group. The student’s discussion as to why they have chosen to place something in a particular group may need to be facilitated by the teacher who may also have to redirect or guide misconceptions or errors in structure and function.

Going further/Extension
Have students write down a reflection in their journal about what they learned. For example, I learned that insects with bright colors might be poisonous or distasteful to predators. Insects that burrow have short powerful legs. Another extension would be to record the advantages and disadvantages of each structure. You could also expand structure to other organisms. For example, Dragonflies are primarily flyers, what other organisms are primarily flyers? Birds and Bats.

Concept Discovery
Students will use their own observations about their insect characteristics to group them into adapted strategies for survival.
Insect camouflage

Insect Warning Colors
Burrowing Insects

Defensive Insects

Large antennae
Aquatic insects
Flying insects
Membracid, fulgorid, peanut head, shield bug

Ant mimic, thorn mimic,
Camouflage
Aquatic
Flyers
Burrowers
Warning Colors
Defensive
Long Antennae
Armored
# Mimic

<table>
<thead>
<tr>
<th>Structure</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defensive</td>
<td>Protection from predators</td>
<td>Loss of mobility, expensive</td>
</tr>
<tr>
<td>Armored</td>
<td>Good Protection</td>
<td>Slow moving</td>
</tr>
<tr>
<td>Aquatic</td>
<td>Good swimmers, evade terrestrial predators</td>
<td>Restricted to water, habitat loss</td>
</tr>
<tr>
<td>Flyers</td>
<td>Fast, easy escape from predators, move to prey</td>
<td>Fragile, less protection</td>
</tr>
<tr>
<td>Camouflage</td>
<td>Hide from predators or prey</td>
<td>Limited to certain habitat</td>
</tr>
<tr>
<td>Burrowers</td>
<td>Escape predators</td>
<td>Slow</td>
</tr>
<tr>
<td>Warning Colors</td>
<td>Lets predators know you are poisonous or bad tasting</td>
<td>Easy to see</td>
</tr>
</tbody>
</table>
INSECT ANATOMY

Lily Edmon
Waimea Middle School

Steve Souder
GK-12 PRISM Fellow
The common features of all Insects include:

Three body parts: Head, Thorax, and Abdomen

Six Legs

Two Antennae

Two Eyes (simple or compound)
Non-Insect

http://www.mdc.mo.gov/kids/out-in/2006/08/2.htm
Non-Insect

Centipede

http://www.animalcorner.co.uk/insects/centipedes/centipede_anatomy.html
Am I an Insect?

http://habitatnews.nus.edu.sg/guidebooks/spiders/text/Myrmarachne_plantaleoides.htm

http://www.mexmission.com/images/typical/animals/centipede_from_apetlanta.jpg.html
Am I an Insect?

www.geocities.com/.../AntMimicJump.htm
http://www.thebestlinks.com/images/5/50/Pseudoscorpion.jpg
One more time!

www.pbase.com/cerumen/image/60617275

www.pbase.com/jamato8/image/60592124
Insect body parts

Fly

Grasshopper
Build-a-Bug Investigation

Day 3

Have you seen my “Family”? Version 1 w/o insects
Insect Classification Version 2 with insects

Concept
Structures of organisms provide a function which allows them to survive and reproduce. Organisms are classified in a hierarchal system.

Overview
The students will identify characteristics of insects, which enhance their ability to reproduce and survive. Furthermore, students will compare and contrast individuals and place them in categories based on similar characteristics and structure. Student will specify the reasons for classification based on their observations and discuss their results with other groups.

Purpose
To have students identify what characteristics can help classify insects and why these features are important to insect survival.

Materials (Version 1)
- Five sheets of chart paper or five boards.
- One copy of each insect image (provided at end of lesson)
- Copy of written clues (for teacher)
- Science journal (if none, just use plain paper)
- Copy of Insect Key (for teacher)
- Family labels (provided at end of lesson)
- 6 folders
- Insect field guides and books (recommended)

Materials (Version 2)
- Five 12 x 12 x ½ inch Styrofoam pieces for insect placement
- Collection of insect specimens from day 1 (preferably pinned insects)
- Tweezers or forceps (Only if non-pinned specimens)
- Receptacles to hold insects
- Labels of insect orders (provided at end of lesson)
- Magnifying glasses
- Insect field guides and books (recommended)

Background Information/Preparation
Version 1.
Teacher will need to become familiar with each insect image and need to know the family and common name. Write clues onto the chart paper or write on board. Cover the
clues somehow so students cannot see it until the exercise begins. Write the name of each insect family on a folder.

Version 2.
Organize the insects collected from day 1 into their Orders using field guide or insect book. Distribute the insects evenly into five groups trying to have a representative for each Order in every observing group. Insect should be pinned if teacher is familiar with the technique to help preserve the specimens. Familiarize yourself with the Linnaean classification system.

**Motivation**
Version 1.
A hurricane or any other natural disaster has displaced insect relative around the classroom. In order to restore order each insect must locate its family members. How do we get them back together?

Version 2.
Begin to pose questions about how students can classify themselves. Are there similarities and differences between them? How could you start to divide into smaller and smaller groups until you have an individual identified?
For example, 1. boys and girls, 2. boys short boys tall, 3. tall boy with brown hair, 4. tallboys with brown hair and blue eyes, 5. tallboy with brown hair and blue eyes with glasses, etc…

**Safety**
No running, horseplay, and please be patient.
Insect pins are extremely sharp and care should be taken when handling them. Only the ball of the pin should be handled.

**Activity**
Version 1
1. Pass out an image to every student and instruct him or her to keep the image to themselves. Have them make observations and write down three distinguishing characteristics about their insect. Walk around the room to monitor and ask questions to help those having trouble making observations.
2. Once they have written the information down, uncover the clues. Instruct the students that they will need to read the clues to find their insect family. Once they find their family name, they will need to find the folder with that name on the desks and go sit by it. Students will then get up and walk around, following the clues.
3. While students are walking around set up the family cards at the tables. Once all members are together, students will reveal their insects to each other and discuss the characteristics of their family out loud.
Version 2

1. Form your class into five groups. Pass out the Styrofoam pieces and reveal the insect specimens. Each group will work together to classify insects into different Orders. Have reference materials available.

   **Note:** It is a good idea to review the basic features of an insect (three body parts: head, thorax, and abdomen, two antennae, and six legs all attached to the thorax) and challenge students to identify anything that is not an insect. This will make the build-a-bug portion go smoother and address misconceptions students have when they begin building their insects.

2. Begin the exercise by telling students that they are going to be “scientist” and are going to classify the insects by similar structures and characteristics. They should be advised to also think about the structure and functions that they observe. Also, have them be prepared to discuss what type of food the organism may eat based on the mouth structure.

3. Pass out the Order labels at a time when students are either having difficulty making decisions or when they feel their classification is complete. This will reinforce what they should have already established or help guide them in the right direction.

4. Once all groups have completed their classification, engage each group to discuss a particular Order with the rest of the class and have them identify a distinguishing feature and its possible function. Also, have them discuss the potential food source based on the mouth structure. Teacher may have to facilitate this portion.

5. **Going further/Extension**

   Version 1.
   Redistribute cards and have students try again.

   Version 2.
   Every student should be familiar with grasshoppers and butterflies. Ask students if they know how these two organisms develop and use these to examples to introduce students to the life cycles of insects which will be covered on day 4. For example, Lepidoptera: complete metamorphosis, egg, caterpillar, cocoon, butterfly or moth. Orthoptera: incomplete metamorphosis, egg, nymph, adult.

**Concept Discovery**

Students will use their own observations about their insect characteristics to group them into Families or Orders. Also, they will be able to discuss these characteristics that help them survive.

**Version 1.**

**Clues**

Board 1:
I have triangle shaped wings: go to board 2
I don’t have wings: go to board 5
I look hard and shiny: go to board 3
I have very long back legs: go to board 4
I have four unfolded wings with spots near the tips: go to board 5
I have a large triangular head: go to board 4

Board 2:
I have wings that look like a leaf: go to Family Tettigoniidae 4
I look soft and fuzzy: go to board 3
I have a triangle shape in the middle of my back: go to Family Cetoniidae

Board 3:
I have pincers at the tip of my abdomen: go to Family Labiduridae
I have a short thick abdomen that can be seen: go to Family Sphingidae
I have bright colors: got to board 2

Board 4:
I have 2 large eyes: go to board 5
I have very long antennae: go to board 2
I have a long narrow abdomen that is not covered by my wings: go to Family Libellulidae

Board 5:
I have large folded front legs: go to Family Mantidae
I have large compound eyes that give my head a round shape: go to board 4
I have short stout legs and thick abdomen: go to board 3

**Insect Key**

<table>
<thead>
<tr>
<th>Family</th>
<th>Common Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphingidae</td>
<td>Hawk Moths</td>
</tr>
<tr>
<td>Libellulidae</td>
<td>Dragonflies</td>
</tr>
<tr>
<td>Mantidae</td>
<td>Common Praying Mantids</td>
</tr>
<tr>
<td>Labiduridae</td>
<td>Striped Earwigs</td>
</tr>
<tr>
<td>Cetoniidae</td>
<td>Flower Chafers</td>
</tr>
<tr>
<td>Tettigoniidae</td>
<td>Katydids</td>
</tr>
<tr>
<td>Fulgoridae</td>
<td>Planthoppers</td>
</tr>
</tbody>
</table>
Sphingidae/Oleander hawk moth, Small elephant hawk moth, Lime Hawk moth
Cetoniidae/Tropical rose chafer, Red chafer beetle, Dicronorhinna derbyana
Tettogoniidae/Leaf Katydids
Mantidae/ praying mantis adult.
Libellulidae Dragonfly

Labiduridae/Striped earwigs
Sphingidae
Libellulidae
Mantidae
Labiduridae
Cetoniidae
Tettigoniidae
Fulgoridae
Version 2.

Diptera

Odonata

Lepidoptera

Hemiptera

Hemiptera (true bugs)
Hymenoptera

Coleoptera

Orthoptera
Insect Mouth Types

Steve Souder
Fellow PRISM GK-12
Chewing Mouth Parts

- Usually found on insects that are predators, aggressive, or feed on vegetation.
- Mouth parts seen here are called the mandibles

http://www.backyardnature.net/insmouth.htm
Sucking Mouth Parts

- The slender, tubular feeding and sucking organ of certain insects.
- True bugs use their mouthparts to extract fluids from plants and animals. Butterflies use it to extract nectar from flowers.

http://www.backyardnature.net/insmouth.htm
Sucking Mouth Parts

- The labium seen here is used to suck up fluids like a sponge.
- Most insects with this mouth part do not chew or bite, instead they vomit digestive enzymes on their food in order to lap it up.
- Don’t let flies touch your food!

http://www.backyardnature.net/insmouth.htm
Combination Mouth Parts

These insects have a combination of mouth parts that enable them to survive and thrive.

The carpenter bee seen here has both chewing parts (galea) to bore through wood and a glossa that acts like a tongue to ingest nectar from flowers.

http://www.backyardnature.net/insmouth.htm
Hymenoptera

- Sawfly
- Ant
- Brie
- Wasp

Coleoptera

- Ground Beetle
- Scarab Beetle
- Click Beetle

Orthoptera
Insect Mouth Structures

Images from www.backyardnature.net

Insect mouth Types from left to right top to bottom: Order Diptera Sucking (sponge like), Order Hymenoptera Chewing (two large mandibles), Order Hemiptera Sucking (Proboscis), Order Lepidoptera Sucking (Proboscis), Order Hymenoptera chewing and sucking, Order Coleoptera chewing (cutting vegetation).

Insect mouth parts come in a variety of form and have often been generalized as either a "sucker" or a "chewer."

One type called a **proboscis** is a tube like structure that can either be folded back or rolled up. Butterflies suck nectar out of flowers with a rolled up proboscis, assassin bugs used a folded back proboscis to suck nutrients out of prey.

MOUTH PARTS OF SELECTED INSECT ORDERS

Odonata (dragonflies): chewing
Hemiptera (true bugs): sucking
Coleoptera (beetles): chewing
Lepidoptera (butterflies & moths): sucking
Diptera (flies): sucking
Hymenoptera (wasps, bees): chewing, chewing-sucking
Orthoptera (grasshoppers & crickets) chewing
Build-a-Bug Investigation

Day 4-8

Building the Bug

Concept
Organisms reproduce in different ways.
Living things reproduce to make more organisms like themselves.
Traits are passed down from parent to offspring.
Non-living and living things interact to create an ecosystem.
Analyze how organisms’ body structures contribute to their ability to survive and reproduce. (Benchmark SC.7.5.4)
Explain the interaction and dependence of organisms on one another. (Benchmark SC.7.3.2)
Classify organisms according to their degree of relatedness. (Benchmark SC.7.4.4)
Explain how energy moves through food webs. (Benchmark SC.7.3.1)

Overview
Students demonstrate what they have learned through the design and construction of their own insects along with a “mini-ecosystem.” Students select the structures and functions of their model insects and identify the abiotic and biotic components found in their habitats. Students also explain at least two ecological interactions of their model insects and diagram all of the stages in their life cycles. Lastly, students write reports on each segment and present an oral report on their entire project and answer questions about what they presented. This multi-level assessment demonstrates student understanding of insect structure, reproduction and life stages, and the interactions insects have with other organisms and their environment.

Purpose
Final assessment Project.

Materials
- **Pipe cleaners** (different colors), **Styrofoam balls** (various sizes and shapes), **wire** (copper, tin, iron), **bamboo skewers**, **popsicle sticks**, **felt**, **construction paper** (various colors), **clay**, **paint** (various colors), **glitter**, **clear plastic** (various colors), **window screen**, **fake eyes** (various sizes), **toothpicks**, **q-tips**, **cloth balls** (various colors and sizes), **glue**, **scissors**, **cardboard**, **nylon stockings**, **plastic plants**, **beads**, **Celluclay**, and anything else that students can build with.
- Each student will need to obtain a cardboard box to create the habitat for their insect.
- Newspapers (use it as table cloths to help keep desktops clean)
- Paper towels (it gets messy)
Background Information/ Preparation
Students will brainstorm about potential habitats, structures and functions, adaptive strategies, interactions with other organisms, and niche for their insect. They will have to draw on the information they just learned to do this.

Motivation
This is a chance for students to use art and imagination to display the knowledge that they learned. This is the final project and culminates with oral presentations

Safety
No eating building materials.

Activity
1. Detail the expectations of the project. Students will build an anatomically correct insect and include 3 biotic and abiotic factors associated with their insect. They will also have to create a scientific and common name for their insect. They must develop two different ecological interactions and identify three adaptive structures and their functions. They will also have to diagram the insects complete life cycle.
   **Note:** Students can work together in groups of two when their insects are ecologically connected.
2. Instruct them in proper behavior and let them build away. Remind them that materials are to be conserved.
3. Provide them with a checklist of each expectation and once complete have them prepare for the oral presentation.
4. Oral presentation: Each student will have to explain each expectation about their insect and answer questions from other students and teacher about what they created.

Going further/Extension
Have students write down a reflection in their journal about what they learned about someone else’s insect.

Concept Discovery
Students will increase their ability to communicate information to others as well as have a strong understanding of what they learned. They can not talk about what they don’t know.

Assessment
Completion of all expectations and tasks. Good oral communication with eye contact.
Organism Interaction

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Waimea Middle School

Steve Souder
GK-12 PRISM Fellow
Competition

- **Competition** occurs when two or more individuals seek to utilize the same resource.
- Siafu or Driver Ants (Hymenoptera) of Africa out compete and consume everything that crosses its path, even cows!!!
Symbiosis is a close ecological relationship between the individuals of two or more species. Sometimes a symbiotic relationship benefits both species. Mutualism, commensalism, parasitism, cooperation. Bees (Hymenoptera) and Plants.
Mutualism

- **Mutualism** is an association between organisms of two different species in which each member benefits.
- Ants (Hymenoptera) protect the aphids (Aphididae) and the aphids provide honeydew for the ants

http://www.richsoil.com/antsandaphids/ants_aphids_sugar.jpg
Commensalism

- **Commensalism** is a symbiotic relationship between two organisms of different species in which one derives some benefit while the other is unaffected.

- Pseudoscorpions hitching ride on a fly’s (Diptera) leg

[Image: www.discoverlife.org/nh/tx/Arachnida/Scorpionida/]
Parasitism

- **Parasitism** is a form of symbiosis in which one species benefits at the expense of another species; similar to predation, but acts more slowly than predators and may not always kill the host.

- Parasitized caterpillar (Lepidoptera), covered with wasp (Hymenoptera) pupae which have consumed all internal tissue except vital organs

http://entweb.clemson.edu/cuentres/cesheets/benefici/ce174.htm
Cooperation is the act of working or acting together.

Ants and bees colonies work together.

*Polyergus samurai* (left) raid and capture pupae of *Formica japonica* (right) and use them as workers when they emerge.

http://ant.edb.miyakyo-u.ac.jp/IMAGEE/00027.HTM

ant.edb.miyakyo-u.ac.jp/.../4445/4445j.html
Predator and Prey

- **Predation** describes an interaction where a **predator** species kills and eats other organisms, known as **prey**.
- Sometimes, predators themselves become prey.
- Praying mantis captures grasshopper.
- Anole captures and eats praying mantis.

www.bcps.org
www.answers.com/topic/carolina-anole-1
Think about these examples?

- Anemone and clown fish
- Deer, elk, and grass
- Dog and tick
- Plant seeds and humans
- Termites
- Hawk and rabbit
Insect Life Cycles

Lily Edmon
Waimea Middle School

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http://chs.cullmancats.net/ins.htm
http://bugs.osu.edu/~bugdoc/Shetlar/462/462InsectOrders/Orders04.htm
Benchmark

- Organism reproduce in different ways
- Young of organism look like their parents and pass on their traits
How do insects grow and reproduce?

- The life cycle of insects consist of a series of changes from egg to adult called metamorphosis.
- There are 2 distinct forms of metamorphosis:
  - Incomplete Metamorphosis
  - Complete Metamorphosis
Complete Metamorphosis

- Complete metamorphosis is characterized by the following stages: egg, larva (immature), pupa, and adult.

- The larval form is very different from the adult form and includes a pupa stage.

- Maggots are the larval stage of flies, caterpillars are the larval stage of moths and butterflies, and grubs are the larval stage of beetles.

http://www.ivyhall.district96.k12.il.us/4TH/KKHP/1insects/buginfo.html
Incomplete Metamorphosis

- Incomplete metamorphosis is characterized by the following stages: egg, nymph, and adult.

- These insects do not go through major changes. The young look like wingless adults or are only slightly different from their adult form.

- Aquatic nymphs are sometimes called naiads.

Can you name this life cycle?

Mosquito
Family Diptera

http://www.naturegrid.org.uk/biodiversity/invert/glossary.html
How about this one?

Grasshoppers
Family Orthoptera

http://www.naturegrid.org.uk/biodiversity/invert/glossary.html
This one?

Dragonflies
Family Odonata

http://www.ndsu.nodak.edu/entomology/topics/growth.htm
Flies
Family Diptera

Answers

complete
incomplete
incomplete
complete
Insect Metamorphosis

The life cycle of insects consist of a series of changes from egg to adult called metamorphosis. There are 2 distinct forms of metamorphosis: incomplete and complete metamorphosis.

Insects that go through incomplete metamorphosis are characterized by the following stages: eggs, nymphs, and adults. These insects do not go through major changes. The young look like wingless adults or are only slightly different from their adult stage. Aquatic nymphs are sometimes called naiads.

Insects that go through complete metamorphosis are characterized by the following stages: eggs, larvae, pupae, and adults. The larvae form is very different from the adult form. Maggots (flies), caterpillars (moths and butterflies), and grubs (beetles) are examples of the common names of some insect larvae.

Using a blank piece of paper, diagram your insect’s life cycle for your “Build a Bug” project like those seen at the top of the page. For those of you who want to go above and beyond and are really ambitious, go ahead and diagram the estimated number of eggs laid per clutch, and number of instars (no more than 5) in your diagram also. Use the diagrams on the following page to help you do that.
Incomplete metamorphosis

common clothes moth life cycle

Complete metamorphosis

Incomplete metamorphosis
# Insect Feature Chart

<table>
<thead>
<tr>
<th>Wings?</th>
<th>Antennae?</th>
<th>Body Shape</th>
<th>Coloration/Pattern</th>
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<tbody>
<tr>
<td>Predictions: Food/Habitat</td>
<td>Other Interesting Features</td>
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<table>
<thead>
<tr>
<th>Insect #1</th>
<th>Insect #2</th>
<th>Insect #3</th>
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<td>Insect #4</td>
<td>Insect #5</td>
<td>Insect #6</td>
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Populations

Day 1
Population without limiting factors

Concepts
All organisms need a source of energy to survive and to reproduce. Organisms within an ecosystem interact with each other. Non-living and living things can affect how an ecosystem functions. Students will explore some of the abiotic and biotic factors affect the carrying capacity and sustainability of an ecosystem. (Benchmark SC.7.3.3)

Overview
This exercise will challenge students to calculate the potential population of Koa bugs without any limiting factors from one pair of reproducing adults after one year. Students will become familiar with ecological terms such as limiting factors, population dynamics, and reproductive potential. This exercise will broaden students understanding of the world around them.

Purpose
Introduce students to the potential reproduction of a given organism without limiting factors. Students will understand that organism populations in the wild are a result of interactions by abiotic and biotic factors acting upon them.

Materials
The lesson was designed specifically to be used in conjunction with the “Koa bug investigation”.
- Prepared data collected from Koa bug investigation
- “What is a Koa bug” reading.
- Population Potential worksheet
- Koa bug stages of life worksheet

Note: Mock data from any living organism can be used as a substitute.
In class worksheets need to be made by teacher.

Background Information/ Preparation
Review what was observed with the Koa bug investigation and introduce the concepts of population, carrying capacity, reproductive potential, and limiting factors.

Population: All the organisms that constitute a specific group or occur in a specified habitat.
Biotic Reproductive Potential: The maximum reproductive capacity of an organism under ideal environmental conditions.
Limiting Factors: An environmental factor essential for life that is absent or depleted below the critical minimum, or that exceeds the maximum tolerable level for the species.
Carrying Capacity: The maximum number of individuals that a given environment can support without detrimental effects.
**Population Dynamics:** The total of processes that determine the size and composition of any population.

**Motivation**
All living organisms need food, shelter, water, and space to survive. Populations of organisms can increase when all these requirements are satisfied. However, when one or more of these become unavailable what happens to the population? What would happen if there was no limit to the requirements of an organism? Is this what we see in the wild?

**Activity**
- Provide each student with prepared data from your observations. Your data should provide a timeline to calculate population after one year. If you have incomplete portions of data, you can use the information from the worksheets provided.
- Using the materials provided, students work alone or in small groups to determine the population of a single mating pair. Students will be surprised at the results.
- Using the Koa bug, discuss with the class why Koa bugs are not crawling all over the place.

**Extension**
What would the population be of a single pair of humans after one year? Is it the same as Koa bugs? Inquire about the current human population trends? Students can discuss the threats that our ever increasing population may have on us and to the organisms around us.

**Concept Discovery**
Students will discover that life is complex. They will understand that abiotic and biotic factors in an environment can limit a population. Students will understand that humans impact the environment and that our actions have consequences that need to be addressed before we consume all our resources.
Population Potential
Using information taken from the handouts “Koa Bug Stages of Life” and “What is a Koa Bug” we will estimate the population size from a single mating pair with no limiting biotic or abiotic factors over a course of a year. For this exercise, we will assume that food is plentiful, predators and disease are absent, and all environmental conditions are perfect for Koa bugs to survive and thrive. Here are some questions to help you with the calculations on the worksheet below.

How long do Koa bugs live? ______________

How old are Adults before they begin to mate? ______________

How many eggs does a female lay in a lifetime? ______________

What is the ratio of males to females (hint: “What is a Koa Bug” reading)? ______________

For fun, without any limiting factors, take a guess at what the population will be in 1 year starting with just 1 mating pair and each pair can produce 100 new koa bugs (don’t forget to remember what the male to female ratio is). ______________

In the worksheet below, you will estimate population size after 2.5 months, 5 months, 7.5 months, 10 months, and 12.5 months and 15 months. Show your work on the attached scratch paper.
# Koa Bug Stages of Life

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<tr>
<th>Stage</th>
<th>How Long Each Stage</th>
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<td>Eggs</td>
<td>10 days</td>
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<td>1&lt;sup&gt;st&lt;/sup&gt; Instar</td>
<td>4 days</td>
<td>14 days</td>
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<td>2&lt;sup&gt;nd&lt;/sup&gt; Instar</td>
<td>6 days</td>
<td>20 days</td>
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<td>3&lt;sup&gt;rd&lt;/sup&gt; Instar</td>
<td>5 days</td>
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<td>4&lt;sup&gt;th&lt;/sup&gt; Instar</td>
<td>7 days</td>
<td>1 month</td>
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<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Instar</td>
<td>15 days</td>
<td>1.5 months</td>
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<tr>
<td>Mature Adults</td>
<td>30 days</td>
<td>2.5 months</td>
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<tr>
<td>Adults Die</td>
<td>120 days</td>
<td>4 months</td>
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</tbody>
</table>

Eggs produced per clutch: 25

# of clutches per female: 4

Using the information in the table above will answer the following questions. However, if you still have questions, please ask.

**How long do Koa bugs live?** __________

**How many instars do they have?** __________

**How long does it take for nymphs to emerge from eggs after they are laid?** ______

**What is the shortest instar stage?** __________

**What is the longest instar stage?** __________

**How many total eggs will one female lay?** __________

**Extra Credit**

**How many shed exoskeletons would be at the bottom of the cage for one adult Koa bug?** ______

**How many stages are there in a Koa bug life cycle?** ______

**Why is it important to know the ratio of males to females in a population?**

________________________________________________________________________

________________________________________________________________________
Population Potential

Using information taken from the handouts “Koa bugs stages of life” and “What is a Koa Bug”, estimate the population size after one year from a single mating pair. There are no limiting abiotic and biotic factors in this exercise. We will assume that food is plentiful, predators and disease are absent, and all environmental conditions are ideal for Koa Bugs to survive and thrive.

Use handouts to answer these questions and then try and calculate population size after one year.

How long do Koa Bugs live?_____________________

How long before adult Koa Bugs begin mating?_____________________

How many eggs does a single female Koa Bug lay in her lifetime?_____________________

What is the ratio of males to females in Koa Bugs (Hint: What is a Koa Bug reading)?_____________________

For Fun, take a guess at what you think the population will be from a single pair of Koa Bugs after one year._____________________

<table>
<thead>
<tr>
<th>Population Reduction</th>
<th>Parents (male and female)</th>
<th>Offspring (male and female)</th>
<th>Total Population</th>
<th>Total Elapsed Time</th>
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<tr>
<td>2.5 months</td>
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<td>5 months</td>
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<td>7.5 months</td>
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<td>10 months</td>
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<td>12.5 months</td>
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<td>15 months</td>
<td>♂♀</td>
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</table>
Populations

Day 2
“Koa bugs on the run”/Populations with limiting factors

Concepts
All organisms need a source of energy to survive and reproduce.
Organisms within an ecosystem interact with each other.
Non-living and living things can affect how an ecosystem functions.
Students will explore some of the abiotic and biotic factors that affect the carrying capacity and sustainability of an ecosystem. (Benchmark SC.7.3.3)

Overview
This activity ideally takes place outdoors and will require them to do some physical exercise. Students should be advised ahead of time to wear appropriate clothing and footwear. This lesson will simulate an increase and decrease of populations resulting from variations in resources and habitat. In the activity, students will represent koa bugs, as well as some of the biotic and abiotic factors around them. Students will be able to identify the interdependence between different organism as well as the interactions between them. This exercise will also incorporate the use of mathematics and graphing.

Purpose
To have students understand that abiotic and biotic factors influence the populations of organisms and why these factors are important to their survival. To investigate food webs and interactions of organisms. (Benchmark SC.7.3.3)

Materials
- Tape measure, yard stick, or 10 yard long rope (to measure out area).
- 4 x 4 inch colored cards: brown (representing koa pods), blue (representing water), and green (representing shelter).
  (Going Further Extension: include 1 white card which will introduce a predator).
- Alternate method: use hand placement on the body as a substitution to the color cards, for example, hands on head for shelter, hands on hips for seed pods, and hands behind back for water. This makes running difficult for all, and through experience, the cards eliminate cheating or changing of hand signals during game play.
- Two boxes (to hold cards).
- Data sheet to record yearly population (blank and example at end of lesson).
- 6 orange cones (to mark each position).
- Graphing paper or computer with Microsoft Excel and printer
Background information
Introduce or revisit the Koa bug: Hawaii’s largest endemic true bug. Discuss the results of the classroom exercise dealing with the population of koa bugs after on year without limiting factors. Is this what we see in nature? How are populations determined? Are populations affected by predator and prey relationships? Can we predict the results?

Motivation
Come on! It’s an outdoor activity!

Activity
The activity should take place on the playground or in a gym if the weather isn’t conducive. The students will be formed into two groups, those representing “Koa bugs” and those representing abiotic and biotic factors or “resources” (seed pods, water, and shelter).

• Once on the field, line students up and have them count off 1 through 4. This will divide you class up into four groups. Ones will be koa bugs, everyone one else is a resource.

• Have the koa bugs and resources move to their start position. A diagram at the end of lesson illustrates the activity setup.
  
  **Note:** This is a good time to review the purpose of the exercise, discuss the abiotic and biotic factors. Remind them that Koa bugs need food, water, and shelter in order to survive. Have them to take notice of the population of koa bugs from turn to turn.

• Instruct the students representing koa bugs and the students representing the resources to turn their backs on one another. Give the students a chance to select only one color card or resource of their choice. All players should have a one color card in hand at this point. The game is about to begin.
  
  **Note:** Hand signals can be substituted for color cards but students tend to cheat and will changes signals just to match a resource. Cards work well because you can’t change its color once it is selected.

• The koa bugs will each seek only one of the “resources” necessary for survival during each simulated “year” or turn. This will be based on the color card they have chosen. Koa bugs will only survive to the next turn if they “capture” a matching resource. Think of it as an outdoor version of “Go Fish”, brown with brown, green with green, etc...
  
  **Note:** Capture does not mean tackling, pushing, punching or any other inappropriate behavior. A simple tag will be sufficient.

• Ensure that **Koa bug students** and **resource students** do not communicate with each other about their selections, we want it to be unbiased. However, encourage each group to talk quietly amongst themselves.
Note: The **teacher will be the one and only referee** to make the necessary activity rulings.

- Once cards have been selected, Give them the “Go” signal that simultaneously has koa bug students and resource students turn to one another with their cards displayed in front of them. The capture begins.

- The “resource” students are encouraged to stay in their area, while the koa bugs move toward them seeking the matching resource represented by their color cards (or hand signals).

  **Note:** “Resource” students are encouraged to run within their area. We want to limit the time needed per turn and this doesn’t allow students to run all over campus!

- Koa bugs must “capture” the matching resource they seek and only those that do so can move on to the next “year” or turn. The teacher will explain to the koa bugs that the number of successful Koa bug captures divided by 2 will represent successful reproduction and turn a “resource” student into a koa bug for the next year. The **teacher will select** the captured resource students that will be converted to a koa bug for the next turn. For example, if four koa bugs start the year and all are successful in capturing a resource, the next year will begin with 6 koa bugs (4/2=2, 2+4=6). If you end up with an uneven number, round down (For example, 5/2=2.5, therefore 2+5=7). Also, if any koa bug fails to capture the matching resource, they become a “resource” for the next year. This is the end of one turn or year.

- Surviving and new koa bug students will move back to their start position while new and old resource students move back to theirs. Have them turn away from each other again and give them a chance to select a new card or keep the same one. The next run starts with the “Go” signal.

- Repeat the exercise for as many turns as you can facilitate during your class period. Each turn represents a year. If there is a student which does not want to actively participate they can be designated as the data recorder. The recorder should input the data for each year on the data sheet provided. You can have more than one recorder if necessary.

- Teachers should designate a resource unavailable due to drought, fire, or disease for at least one turn during the game (teacher should only tell the resource group). Furthermore, do not discourage resource students who collaborate and decide to all be the same resource, thereby “killing” all the koa bugs not seeking that resource. Also, a predator can be added during the game. Successful reproduction of a predator is accomplished for each successful capture of a koa bug. The result is a new predator. If a predator fails to capture a koa bug, they become a resource.

  **Note:** Ensure these catastrophic events (drought, fire, and disease) are recorded for that particular year. This will help explain the graphical data generated later in this lesson.

- Once you have completed at least “20 years” of data or run out of time, move your students back into the classroom. Prepare the data for class use by
transferring the information to the chalkboard for all students to record. Have the students determine the mean, median, maximum, minimum, and range of the population and have them create a line scatterplot or histogram graph of their population data on graphing paper or using Microsoft Excel on the computer.

- Discuss the population trends, what happens when catastrophic events occur, what happened when a predator was introduced.

Safety
Ensure students are properly equipped and that “capturing” a habitat only requires an appropriately placed touch. No tackling, grabbing, throwing, pushing, or rough play.

Concept discovery
Students will begin to see that changes in resources will influence the population of organisms. Abiotic and biotic factors influence the population of an organism.

Going further
Students can compare data collected from previous years or from other classes. They will see that populations fluctuate and random factors influence populations differently. Students can discuss line scatterplots or histogram graphs which represent the population year to year and class to class (an example of both can be seen at the end of this lesson). Students can also discuss the effects of catastrophic events that took place, for example, a fire that may have dramatically reduced the population.

Introduce a predator into the discussion or exercise. Students can discuss how the population of a predator would change from year to year, and they should draw upon what they learned to predict the fluctuation of predator and prey.

Add a single white card in which represents a predator, for this exercise you could designate a bird, spider, or praying mantis (the options are numerous). This individual can capture any koa bug that has not yet captured a resource. If a koa bug is captured it is converted into a predator for the next year. If the predator is unable to catch any prey in time, then they are “dead”.

Why is it important to understand your organism’s life cycle when sampling populations? Why should you sample populations more than once? Is it important to understand population fluctuations?

Concept Discovery
Students will discover that life is complex. They will understand that abiotic and biotic factors in an environment limit a population.

Example of a histogram and line scatterplot with spreadsheet.
Population of Species X

Years
0 1 3 5 7 9 11 13 15 17 19
Population size
0 2 4 6 8 10 12

Population of Species X

Years
0 5 10 15 20 25
Population size
0 2 4 6 8 10 12

(Teacher designates it a drought year) No water as a resource.
Data Sheet (Koa bugs on the run)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Koa Bugs</th>
<th>Koa bug deaths</th>
<th>Captured water</th>
<th>Captured shelter</th>
<th>Captured pods</th>
<th>Number of Predators</th>
<th>Predator deaths</th>
<th>Catastrophic event</th>
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The graphs below were generated from the sample data above.

What is happening here?
What is a Koa Bug?

Koa bugs are structured like all other insects: six legs, three body parts (head, thorax, and abdomen), and two antennae. The koa bug is the largest endemic true bug found in the Hawaiian Islands. Endemic species are native to or confined to a certain region. A true bug is one that has no mouth parts for biting, cutting, or chewing food. Instead, they possess a tube like beak for sucking fluids called a proboscis. In nature, the koa bug uses its proboscis to suck nutrients out of seeds from several Koa plants (Koa, Koai‘a, Formosa Koa) and the native ‘A’ali‘i. Anything native occurs naturally in an area, and has not been introduced by humans either intentionally or unintentionally. The koa bugs in your classroom are taken from populations found in the wild.

How Do Koa Bugs Grow?

Koa bugs start life in tiny eggs that hatch about 9 days after being laid. The eggs are about the size of tiny beads, slightly smaller than the “o” on this page. These eggs are laid in a tight cluster and are green at first, but eventually the tiny koa bugs begin to develop in the eggs. Their eyes and mouths become apparent and the eggs start to turn red. Newly hatched koa bugs are called nymphs, which is an immature bug. Nymphs
possess six legs, a head, abdomen, and thorax much like the adults; however, for the koa bug, they are different in color, being black and red, and have no wings.

Insects grow by shedding their outer covering called the **exoskeleton**. The exoskeleton is the hard outer surface of the insect and it provides protection and support. The exoskeleton is not flexible so in order to increase in size, a new exoskeleton needs to be produced under the old. The old exoskeleton is split and the insect emerges from it while the new exoskeleton is still moist and flexible. The insect pumps itself up, increasing its size before the new exoskeleton hardens. The process of shedding the exoskeleton is called **molting**. Insects sometimes require several molts before emerging as adults. The koa bug requires 5 molts before taking its adult form. Each molt represents a nymphal stage called an **instar**. So, when the nymph emerges from the egg it is called a 1\textsuperscript{st} instar, once it molts and changes size it becomes a 2\textsuperscript{nd} instar. This continues until adulthood when molting ceases. Adult koa bugs are easily identified by their attractive iridescent colors. In the cages you will begin to see an accumulation of shed exoskeletons.
The nymphs of koa bugs are flightless and are red and black in color. The gradual maturing of koa bugs is called **incomplete metamorphosis**. Incomplete metamorphosis is when the immature young look much like the adults, but without wings. Koa bugs take about 38 days to move from 1\textsuperscript{st} instar to adults (25º Celsius). The koa bug hatches out in a ratio of 1:1 male to females. The life cycle from egg to egg takes ~77 days (11 weeks) at 25º Celsius.

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Development of insects can be influenced by different things, one of which is temperature. It is important to understand that temperature determines the rate of development in insects. Development occurs slower at colder temperatures and faster at higher temperatures. Development does not occur at the upper and lower temperature thresholds, which varies from insect to insect.

**How do Koa Bugs Mate?**

Koa bugs begin mating about 30 days after molting to adulthood. Mating is easily recognized as the mating pair will be attached end to end at the rear of the abdomen. Determining males from females takes more effort and patience. The only means to identify males from females is to observe the reproductive parts. Females are determined by observing a flat triangle shaped reproductive part at the end of the abdomen, while
males have a single rectangular shaped reproductive part. Each can be seen in the photos below.

A few days after mating, females begin to lay clutches of eggs averaging about 25 eggs per clutch. A female will continue to mate and lay eggs about once every two weeks throughout her life. The eggs are either laid on seed pods or on a leaf directly adjacent to seed pods.

*Coleotichus blackburniae*

All living organism are organized under a classification system. The animal kingdom is divided into major groups called phyla. Each phylum is divided into classes. Each class is divided into orders. Each order is divided into families. Each family is divided into genera, and each genus into species. A species is a basic category or a kind of animal. There are many definitions for species!

The koa bug is in the kingdom Animalia, phylum Arthropoda, the class Insecta, the order Hemiptera, the family Scutelleridae, the genus *Coleotichus*, and the species *blackburniae*. The common name is koa bug and the scientific name is *Coleotichus blackburniae*. A relative of the koa bug found in Hawaii is the southern green stink bug, *Nezara viridula* (Hemiptera: Pentatomidae).

Insect introductions have negatively impacted the population of koa bugs in Hawaii over the last few decades. Yet, the koa bug is still found on all of the major islands and in various climate areas.
Ecosystem Investigation

Ecosystem/Biodiversity of Life

Concepts
An ecosystem is a group of interacting organisms and nonliving factors in a specific area. All ecosystems have similar characteristics (Trophic levels: consumers, producers, decomposers). Native species arrived in Hawaii by wind, wing, or wave. Alien or introduced species are accidentally or intentionally brought by human activities. Endemic species are only found in a given area.

Overview
In this lesson, students will explore an ecosystem of Hawaii with a focus on “Biodiversity”. Teachers may choose their own ecosystem, but this exercise will use the ecosystems found in Hawaii Volcanoes National Park. “Biodiversity” will be introduced to the students and they will begin to discuss why biodiversity is important. Biodiversity is the variability among living organisms on the earth, including the variability within and between species and within and between ecosystems. Students will be exposed to photographs of study areas and the ecosystems within them. Then they will be broken up into small groups to further explore organisms of assigned ecosystem. The goal of this exercise is to learn about flora and fauna in their own “backyard” while identifying potential threats to the ecosystems and their “biodiversity”. They will have to identify at least 2 native and or endemic species and two introduced or invasive species. Students will research these species and be tasked to understand their importance to the ecosystem, and identify the threats each faces. In conclusion, the class will share their findings with each other and then be prompted to compare and contrast these areas.

Purpose
Students will be able to define ecosystem and biodiversity and understand the importance of biodiversity to an ecosystem. They will also identify the abiotic and biotic factors that make up an ecosystem and understand that human and natural actions has a affect on their surroundings. Students will identify environmental conditions that are associated with certain ecosystems.

Materials
- Classroom computers with Internet access
- PowerPoint: Images of your area of investigation (Hawaiian Rain forest, montane forest, Dry forest, lowland dry desert, intertidal zone, sandy shore, and Coral Reef).
- Map of Area (Hawaii, poster size, Map of Hawaii Volcanoes National Park, poster size).
- Books, magazines, video, websites or any other literature relevant to your ecosystem.
- Worksheets to help student gather information for presentation.

Background Information/Preparation
Gather photographs and information on the area or ecosystem you are going to investigate. For example, photos of Hawaiian rain forests and it in habitats like the Hawaiian Honeycreeper, Coral reefs and the reef fish and invertebrates. Gather literature materials for student research. Review abiotic and biotic factors, native, endemic, and introduced species. Review organism interactions and the different trophic levels: consumers, producers, and decomposers. Place the maps in your classroom.

Motivation
The students in your classroom should be aware of the natural world around them, especially here in Hawaii, where over 90% of its native terrestrial flora and fauna are endemic. Many of these species are threatened and the student will help educate each other about what organisms are present and identify potential threats to the ecosystem. Explain to the students that every action taken has a reaction. Human activity along with environmental conditions can dramatically impact organisms and the habitat they live in. Review native and endemic species and suggest what kinds of impacts introduce alien species can have on them.

Safety
This is a no stress activity and worrying is not allowed.

Activity
Day 1 (total time 3-4 hrs)
1. First, identify how native and endemic species arrived in Hawaii. Introduce the three “W’s” which are wind, waves, and wing. Students can be challenged to identify ways native species arrived. For example, how do you think the Hawaiian Hawk arrived? How about native grasses? The Hawaiian Picture Winged Flies? Then have students brainstorm about how introduced species arrived. Create a list on the board.
2. Explain to students that in this lesson, they will be answering the following questions: What is biodiversity? Why is biodiversity important? What kind of effect can alien introduced species have on an ecosystem and its biodiversity? 
   Note: Students may not be aware of organisms present in the ecosystem. It might be necessary to introduce images of identified organisms (both introduced and native or endemic) found there.
3. Introduce the maps, in this lesson, it will be a map of Hawaii and the area of Hawaii Volcanoes National Park (HVNP). Provide some background information to the students and identify the ecosystem(s). In this particular lesson, Hawaii Volcanoes National Park boundaries include several ecosystems or ecological life zones: Coastal (sandy shore, coral reef, intertidal), lowlands, rain forest, mid-elevation forest, upland forest, sub-alpine and alpine. HVNP is one of a few natural areas in the State of Hawaii protecting habitat from sea level to the summit.
4. Introduce images of the ecosystems and organisms. This will peak their interests and also help give them some idea of what they are researching. (PowerPoint).
5. Assign your classroom into small research groups of 3-4, and have them randomly draw out an ecosystem to investigate. For homework, task them to begin the research of their ecosystems.
Note: Assign groups that allow at least one student with internet access to gather research materials for the group.

Day 2+ (Researching information using computers with internet access or the library)

6. Students will brainstorm abiotic and biotic factors found in their ecosystem and verify their list when they conduct their research. They will also create a list of the organisms found in their ecosystem. This list will help determine what species they chose to investigate.

   Note: Identifying species will likely be guided by the teacher. The students may also need to be pointed in the right direction to find actual species in their ecosystem.

7. Students will be tasked to identify the characteristics of the ecosystem (elevation, temperature, rainfall, etc.) and plot the area on the classroom map. They will also investigate at least 2 native and or endemic species, and at least 1 introduced or invasive species. They will present to the class the importance of their ecosystem or one of the species they researched. They will also discuss the challenges facing the ecosystem or species, and whether or not they are human-induced.

8. Computers with internet access should be made available for this portion as well as a trip to the library to gather materials.

Presentation Day

9. Finally, each group will share their research to each other. Once all groups are done, students will compare and contrast ecosystems. They will discuss environmental factors common to all and some that are unique to a specific ecosystem. Organisms may also be categorized this way also. Students should discuss why biodiversity is important and why preserving biodiversity enhances the life of everyone. Have them discuss habitat and species loss around the world.

Concept Discovery

Students will understand that organisms are critical to the survival of their ecosystem and the stability of the ecosystem is crucial to species survival. Environmental factors help define the limits of an ecosystem and the inhabitants of it. Human activity can help preserve or threaten ecosystems stability. Conservation and awareness of our natural environment is everyone’s responsibility.

Going Further/Extension

Have students research like conservation areas in other states or countries and compare them to the one they researched focusing on the similarities in environmental factors, threats, and the variety of species found in each. Have students develop management plans for the problems they researched.

Assessment

Students will present as a group the ecosystem characteristics and organisms researched. Alternately, students will write an essays that provide information about the ecosystem and organisms they researched, detailing the challenges they may face.
Ecosystems: A look at Hawaii Volcanoes National Park

Lily Edmon
Waimea Middle School
Steve Souder
Gk-12 PRISM Fellow
The Park is located on the Southeastern side of the Big Island
- It encompasses 330,000 Acres
- Ranges from sea level to 13,677 feet.
- Established in 1916
- Average annual rainfall 110 inches
- Average high temperature 63.5º F
- Average low temperature 52.5º F
Rain Forest

Hawaii Volcanoes National Park
Feral Pig
Iiwi
Happy Faced Spider
Hapuu
Sub-Alpine/Alpine

- Mauna Loa
- Palila
- Silversword
- Mamane forest
- Wekiu Bug
Mid-elevation Forest

- Koa and Ohia Forest
- Pueo
- Picture Winged Flies
Coastal

- Halape
Desert

- Kau Desert
- Pukiawe
- Nene
- Mongoose
- Aalii
Hawaii Volcanoes National Park (75 pts total, 100 with extra credit)

Instructions: This portion will be information on the Park itself. Read the entire worksheet before visiting the websites listed at the bottom of the page. This will make it easier for you to answer the questions. Do not forget to include the measurement type of each answer (Feet, Celsius, Acres, etc.). Answering “of your ecosystem” is optional; you will get extra credit (5 pts each) if you can find your specific ecosystems environmental characteristics on your own. This will require some research.

When was the Park Established? (Date)______________

What is the elevation range of the Park? _______of your ecosystem______

What is the annual rainfall in the Park? _______of your ecosystem______

What is the average high and low temperature in the Park? _________

of your ecosystem___________

What is the area of the Park?__________________

Name 5 of the ecological-zones found in the Park (there are 7 of them)?

________________________________________________________

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Name 5 organisms found in the park (extra credit 5 pts: if you can name one bird, one insect, one mammal, one non-insect, and one reptile).

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(BONUS Questions)

(2pts) What is the average annual visitor rate? _______________

(3pts) Name 3 volcanic features in the Park.________________
The following websites can help you with the questions above.
http://www.nps.gov/archive/havo/visitor/climate.htm

Give each team about 20 index cards. As they research the above points, teams should use index cards to describe the oceanographic, meteorological, and physical features of the sanctuary. They should also create a card for each species found in the sanctuary, writing its name on the front and any other pertinent information about it (is it endangered? what threats does it face? is it unique to this area? what is its food source?) on the back. (These cards will be used later in a whole class activity.) Give groups about 45 minutes to an hour to complete their research. When teams have completed their research, bring the class back together and show the video interviews with sanctuary managers. Then invite teams to share their information. Have teams present their findings first for one sanctuary then the other. Instruct the students to take notes on the findings of each team.

After each team has presented their findings, draw a large Venn diagram on the board. Using one circle to represent Cordell Bank National Marine Sanctuary and one to represent the Hawaiian Islands Humpback Whale National Marine Sanctuary, have the students place their cards on the diagram using magnets or tape. When all the cards have been placed, lead a class discussion about the results. Ask students:
Which aspects of the physical environment are the same in both sanctuaries? Which are different?
How many species are found in both sanctuaries?
Are there more species that are unique to one or the other sanctuary, or can many be found in both? Why do you think this is?
Which species can be found in both sanctuaries? Do they use the sanctuaries for different purposes (breeding, feeding, etc.)? What does this imply about the importance of the sanctuaries?

Direct students to go back to their teams and return their species cards to them. Tell them they will now be investigating food webs. (A review of food webs can be found here.) Using their species cards, each team should create a basic food web for their sanctuary. Have each team use half of the board to arrange their cards and use arrows to show which animals eat and are eaten by others. When the food webs are complete, have students return to their seats. Ask students to consider the effects of changes to the environment or one or more species in each food web. For example, ask "What would happen if there were a sudden dying of phytoplankton in the Cordell Bank sanctuary?" Students should note that as primary producers, phytoplankton support the entire food web and the effects would be felt throughout. Help guide students in reflecting on the effects on the various levels of the food web of different changes.