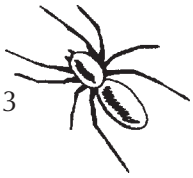


Activity #1

Alpine/Aeolian Challenges and Adaptations

● ● ● Class Period One *Slide Show and Challenges & Adaptations*

Materials & Setup

- Slide projector and screen
- "Living in the Extremes" slide show and script (pp. 7-9)

For each of four student groups

- Student Page "Alpine/Aeolian Challenges and Adaptations" (p. 16)
- One set of Alpine/Aeolian Challenge and Adaptation Cards (master, pp. 12-15)
- Five paper clips
- Pencil with eraser

Instructions

1) Before presenting the slide show, divide the class into four teams. Encourage teams to listen carefully to the information presented for a later activity that focuses on how plants and animals are adapted to life in the alpine/aeolian ecosystem. Show the "Living in the Extremes" slide show, reading the script that accompanies it.

2) Hand out one copy of the Student Page "Alpine/Aeolian Challenges and Adaptations" and one set of Alpine/Aeolian Challenge and Adaptation Cards to each group.

3) Allow student groups the remainder of the class to complete the activity outlined on the student page by matching the adaptations cards to the challenges.

● ● ● Class Period Two *Challenges & Adaptations Discussion*

Materials & Setup

- "Alpine/Aeolian Challenges and Adaptations Answer Key" (teacher background, pp. 10-11)

Instructions

1) Take half a class period to discuss teams' results from the previous day's activity. Begin by asking one team to share the adaptations they matched to one of the challenges and explain their reasoning. Use the answer key to evaluate their responses, keeping in mind that logical reasoning may lead students to slightly different responses in some cases.

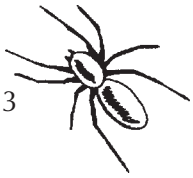
2) Continue the discussion by asking other teams to discuss their responses to each challenge until all have been covered.

Journal Ideas

- How do you think ancient Hawaiians could have protected themselves from the environmental extremes of the alpine/aeolian ecosystem?
- If you were going to spend several days in the summit area of Haleakalā, how would you protect yourself from the environmental conditions?
- Compare the things that people can do to protect themselves with plant and animal adaptations that allow them to survive in the alpine/aeolian ecosystem.

Assessment Tools

- Participation in group activity and class discussions
- Student Page "Alpine/Aeolian Challenges and Adaptations" (teacher version, pp. 10-11)
- Journal entries



Teacher Background

"Living in the Extremes" Slide Show

Photos courtesy of Haleakalā National Park, unless otherwise noted

Slide 1 – Scenery shot

Welcome to Haleakalā. What comes to mind for you when you think about the top of Haleakalā? (Have students call out answers.)

Slide 2 – Archaeological sites near Pu'u Naue

In Hawaiian tradition, this is the sacred House of the Sun. At the height of Hawaiian society, this place was revered as an especially sacred place and visited by few people. *Kāhuna*, Hawaiian spiritual leaders and elders, came here for meditation and to receive spiritual information. Important people were buried up here. There are places where people buried *nā piko* (umbilical cords) of their babies to make sure that they would grow well and that no one had the power to manipulate them.

Slide 3 - Hawaiian adze quarry

Hawaiians constructed shelters in the summit area, but no one lived there. Among those who were given permission to enter this sacred place were men who quarried basalt rock for making adzes and other tools.

Slide 4 – Sunrise shot (Photo: Jeff Bagshaw)

Before going to the summit of Haleakalā, early Hawaiians had to ask permission from human authorities and from the gods. Today, many Hawaiians still pray for permission from the land itself before they go to the summit. This area is no less a sacred place today than it was in times past.

The sun has always been an important part of traditional Hawaiian stories about Haleakalā. Have any of you heard the story of how Māui snared the sun? Here's how it goes:

Early one day, long before sunrise, Māui, the mischievous demigod known throughout the Pacific Islands, crept to the summit of Haleakalā, where he lay waiting for the sun's first spidery legs to appear. As they came over the edge of the rim one by one, he lassoed each ray and secured it to a tree. The sun, now unable to move, begged for its freedom. Māui would not release the sun until it had promised to slow its daily rush across the sky—so that the people could do their work and his mother could finish the drying of the *kapa* (bark cloth) while there was yet daylight.

Māui left some of the ropes attached to the sun—to remind it of its promise to travel more slowly across the heavens. Every evening, just before the sun sets, the ropes can be seen trailing off into the night sky as daylight fades.

And to this day the sun is more careful to go slowly across the heavens, and the great mountain is known as Haleakalā—House of the Sun.

Slide 5 – Summit basin above clouds

The top of this active—but not erupting—volcano rises high above the cloud layer that often covers its slopes. Up here, at the highest elevations on Maui, some people like to say that it's summer every day and winter every night.

Slide 6 - Sunrise with visitors

At night, temperatures can fall below freezing, especially if you factor in the windchill. You know this if you've ever gone up to the summit to watch the sun rise.

Slide 7 – Ice crystals or "hoar frost" (Photo: Jeff Bagshaw)

Sometimes there are ice and frost. Most often, it's just COLD.

Slide 8 – Hikers on Sliding Sands Trail

During the day, however, temperatures can rise into the 80s, and solar radiation is intense. No matter what the temperature, you can easily get a sunburn up here! Human visitors can add or take off layers of clothing as the temperatures change, or put on a hat as the sun intensifies. But the plants and animals living near the top of Haleakalā, in the alpine/aeolian ecosystem, don't have that option.

Slide 9 – *Na'ena'e* growing in a rocky spot (Photo: Jeff Bagshaw)

Up here, the plants and animals have to contend with challenges that go beyond these temperature extremes. In order to survive, they must also be adapted to exist in harsh winds, a dry atmosphere, infrequent and sporadic precipitation, the drying and heating effects of direct sunlight, and an environment with little food.

Slide 10 – Scenic with *na'ena'e* in corner

Up here in the summit area, life isn't easy. The few species of plants and animals that do live here are special because they can survive in this harsh and most sacred of places. Let's take a look at what makes some of these plants and animals so well-adapted to life at the top, starting with *kūpaoa* or *na'ena'e*, the plant in the lower left corner of this picture. This plant has stiff, tough, concave leaves arranged close together to avoid drying by sun and wind.

Why would this leaf structure and arrangement be helpful to avoid drying by sun and wind? (Possible answers: The tough leaves have a hard shell that helps reduce water loss, leaves that are close together have less surface area exposed to direct sun and wind than leaves that are far apart.)

Slide 11 - *'Āhinahina*

Does anyone know what this plant is?

This is the *'āhinahina*, or Haleakalā silversword. It's found only here, near the top of Haleakalā. Silverswords have succulent leaves with gel-like substances and oils that store water and help prevent freezing. Tiny silver-colored leaf hairs that give the plant its name reflect bright sunlight.

Slide 12 – Silversword closeup

What advantage would it be for a silversword to have leaves that reflect bright sunlight? (Answer: Help to keep the plant cool and retain water during the hot days and intense sunlight.)

Slide 13 - Hawaiian long-horned beetle larva

This is the larva of a Hawaiian long-horned beetle. These beetles, like many other insects in the alpine/aeolian zone, directly depend on the silversword for their existence. The larva bores into the lower stems and roots of the plant where they feed on the woody tissue until they pupate and change into adults.

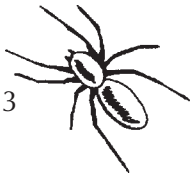
Carabid beetles are another type of insect that lives in the alpine/aeolian ecosystem. They are scavenger-predators that feed in part on insects that are blown in on upslope winds.

Slide 14 - Wolf spider

This large spider constructs shallow burrows under the rocks and cinder. It cements leaves and other windblown debris together to form a circular refuge that protects it from the cold, dry climate.

Slide 15 - *'Ua'u*, the Hawaiian dark-rumped petrel

These seabirds nest primarily in burrows dug in cinders along the upper slopes of the mountain. They use this habitat only for nesting and the parents fly out each day to forage for food at sea. *'Ua'u* nesting success depends on precise timing,



to avoid seasonal temperature extremes that could kill young nestlings. An *ʻuaʻu* pair raises just one chick per year. The strong pair bond of the *ʻuaʻu* male and female also helps these birds reproduce successfully. Parent birds share responsibility for incubating the egg and rearing the young bird.

Slide 16 - Haleakalā flightless moth

This small moth has dagger-shaped wings and walks and hops rather than flying. Originally there were no natural predators in this habitat, so it didn't need wings to escape. Now it is preyed on by carnivorous nonnative yellowjackets and Argentine ants.

Slide 17 – *Tetramolopium*

Many alpine plants are members of the sunflower family and have disc or ray flowers that produce a large number of small seeds. These are accessible to moths, beetles, and other small insects and are easily spread by the wind.

Slide 18 – Petrel habitat

The summit of the sacred house of the sun tests all that might enter or live there with high winds, scorching sun, freezing nights, sparse rainfall, and a substrate that doesn't hold water.

Slide 19 – Lava bomb in shape of bird, Magnetic Peak

This bird is obviously well adapted and well camoflauged for living in the harsh extremes of the alpine/aeolian zone. (Note: This lava bomb, shaped like a bird, has broken due to the elements since the photo was taken.)

Teacher Background

Alpine/Aeolian Challenges and Adaptations

Use this answer key to evaluate student performance on the activity. Note that well-reasoned responses that do not match this key are acceptable. Key numbers match those on the adaptations cards and parenthetical notes following many of the adaptations provide you more information for discussion and explanation.

Extreme Challenge #1: Dry Conditions

- Low rainfall levels and low humidity
- Winds that draw moisture out of plant tissues and out of the ground surface
- Sparse, periodic rains and a long dry season
- Quick water drainage through the lava and cinders
- No ponds or even puddles

Adaptations

1 Some plants, like this *ʻāhinahina*, have succulent leaves that contain gel-like tissues and oils. (These tissues retain and store water.)

4 Insects like this Hawaiian ground beetle (*Barypristus rupicola*) have thick exoskeletons. (These help prevent water loss.)

7 Many insects become semi-dormant or go into deep burrows for extended times.

12 Many plants have large networks of spreading roots. (These networks allow plants to draw in large amounts of water quickly.)

Extreme Challenge #2: Winds

Dry air and winds draw moisture out of the soil and out of plant and animal tissues. Winds contribute to cold temperatures, especially at night. High winds cause damage to soft plant stems and leaves and make flight difficult for insects. On the other hand, the upslope winds blow insects and other organic matter (such as leaves) into the alpine/aeolian zone, providing nutrients and other resources.

Adaptations

5 Some plants, like this *naʻenaʻe,* have waxy leaf surfaces, tough leaves, and strong woody stems. (These characteristics provide strength and durability against the wind.)

6 Tall flower stems or flowers on branch ends release small seeds (which may then be easily transported by winds).

8 Some insects are flightless. (This keeps them out of the wind. Biologists believe flightlessness evolved in response to the absence of mammalian predators. Flying drains energy and may have little adaptive value where there are no major predators to escape.)

9 Many alpine/aeolian insects are scavenger-predators that eat dead and stunned insects as well as plant matter. (These nutrient sources are blown in on the winds.)

11 On some plants, compact, dense foliage grows close to the ground (where it is out of the wind).

13 Many insects take shelter in crevices or under rocks.

14 Some insects use windblown leaves and other debris in constructing burrows or larval tubes.

Extreme Challenge #3: Cold Nighttime and Seasonal Temperatures

Frost and ice often form on the ground and around plants. Occasionally it snows. Freezing can damage or destroy soft leaves and sensitive new growth and flowering parts.

Adaptations

1 Some plants, like this *ʻāhinahina*, have succulent leaves that contain gel-like tissues and oils. (These help prevent freezing and cell damage.)

2 Many larval forms, such as this Cerambycid moth larva, burrow into plant stems or roots (where they live, sheltered from the cold).

3 Some plants, like the *ʻāhinahina,* grow in a rosette form. (This growth form holds warmth in the center of the plant.)

10 A covering of small hairs grows on leaf surfaces (insulating them from cold).

16 Some insects and their larvae are covered with hairs (which may help to insulate them from the cold).

17 Many insects have seasonal life cycles. Moth larvae, for example, are sheltered in a chrysalis in winter, emerging in the spring as plants begin to flower.

21 Some adult insects build burrows.

Extreme Challenge #4: Intense Solar Radiation

Intense sunlight can cause rapid expiration of water, overheating, and cellular damage in plants and animals alike. The heating effect of the sun is intensified by dark colored lava rocks and soils that become extremely warm over the course of a sunny day.

Adaptations

15 Leaf surfaces are covered by small, silvery hairs or waxy coatings. (These reflect the sun's rays, insulate leaf surfaces from extreme heat, and help hold in moisture.)

18 Many insects are active during the mid-morning hours and around dusk. During mid-day, they seek shelter in crevices, under rocks, or in burrows.

22 Light-colored leaves spread out from the plants. (These help shade the dark cinders and lava rock below the plant from the sun, protecting roots from overheating.)

23 Some insects burrow in cinders all day and feed at night.

Extreme Challenge #5: Pollination and Seed Dispersal

Many insects are small and flightless—some are not particularly efficient pollinators. Moths and beetles are the most numerous types of insects in the alpine/aeolian ecosystem. They act as both pollinators and predators to plants. There are too few birds and no native rodents to help plants disperse seeds.

Adaptations

19 Many plants have disc or ray flowers that look like small sunflowers. (These open flower shapes are accessible to moths, beetles, and other small insects.)

20 Some plant seeds have hard coatings (which protect against predation).

24 Plants produce large numbers of seeds (which is an advantage when it is difficult to produce seeds at all).

25 Seeds are small (so they are easily dispersed by winds and rain).

Alpine/Aeolian Challenge and Adaptation Cards

Extreme Challenge #1: Dry Conditions

- Low rainfall levels and low humidity
- Winds that draw moisture out of plant tissues and out of the ground surface
- Sparse, periodic rains and a long dry season
- Quick water drainage through the lava and cinders
- No ponds or even puddles

Extreme Challenge #2: Winds

Dry air and winds draw moisture out of the soil and out of plant and animal tissues. Winds contribute to cold temperatures, especially at night. High winds cause damage to soft plant stems and leaves and make flight difficult for insects. On the other hand, the upslope winds blow insects and other organic matter (such as leaves) into the alpine/aeolian zone, providing nutrients and other resources.

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Adaptation #1

Some plants, like this *ʻāhinahina*, have succulent leaves that contain gel-like tissues and oils.

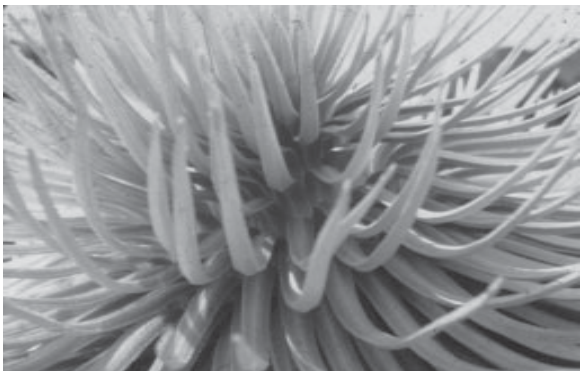

Photo: Haleakalā National Park

Adaptation #3

Some plants, like this *ʻāhinahina* (photographed from the top), grow in a rosette form.

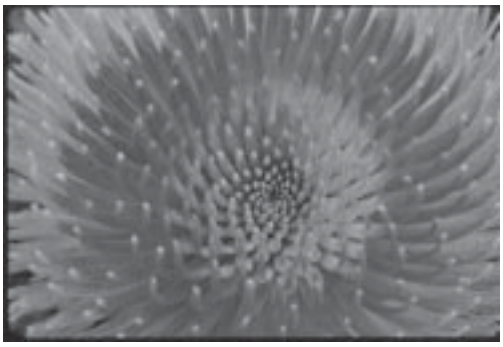

Photo: Haleakalā National Park

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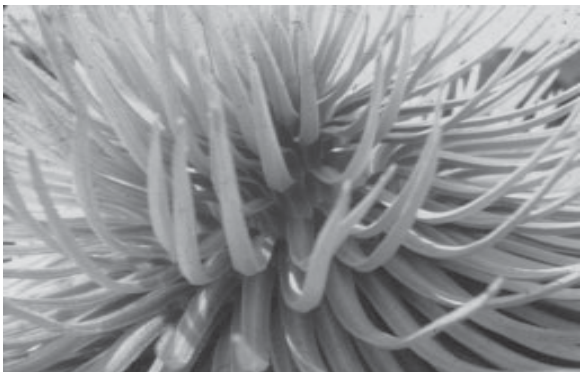

Photo: Haleakalā National Park

Adaptation #4

Insects like this Hawaiian ground beetle (*Barypristus rupicola*) have thick outer or exoskeletons.

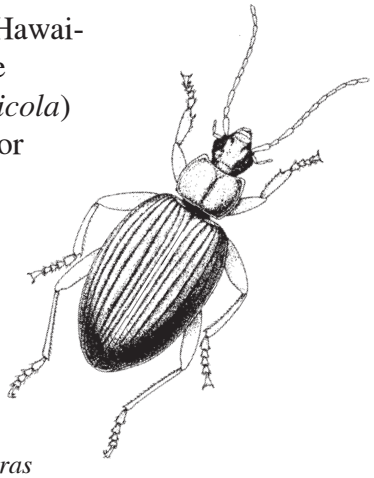

Image: Nancy Sidaras

Adaptation #2

Many larval forms, such as this Cerambycid moth larva, burrow into plant stems or roots.

Photo: Haleakalā National Park

Adaptation #5

Some plants, like this *naʻenaʻe,* have waxy leaf surfaces, tough leaves, and strong woody stems.

Photo: Haleakalā National Park

Adaptation #6

Tall flower stems or flowers on branch ends release small seeds.

Adaptation #11

On some plants, compact, dense foliage grows close to the ground.

Adaptation #7

Many insects become semi-dormant or go into deep burrows for extended times.

Adaptation #12

Many plants have a large network of spreading roots.

Adaptation #8

Some insects are flightless.

Adaptation #13

Many insects take shelter in crevices or under rocks.

Adaptation #9

Many alpine/aeolian insects are scavenger-predators that eat dead and stunned insects as well as plant matter.

Adaptation #14

Some insects use windblown leaves and other debris in constructing burrows or larval tubes.

Adaptation #10

A covering of small hairs grows on leaf surfaces.

Adaptation #15

Leaf surfaces are covered by small, silvery hairs or waxy coatings.

Adaptation #16

Some insects and their larvae are covered with hairs.

Adaptation #21

Some adult insects build burrows.

Adaptation #17

Many insects have seasonal life cycles. Moth larvae, for example, are sheltered in a cocoon or chrysalis in winter, emerging in the spring as plants begin to flower.

Adaptation #22

Light-colored leaves spread out from the plants.

Adaptation #18

Many insects are active during the mid-morning hours and around dusk. During mid-day, they seek shelter in crevices, under rocks, or in burrows.

Adaptation #23

Some insects burrow in cinders all day and feed at night.

Adaptation #19

Many plants have disc or ray flowers that look like small sunflowers, with petals extending from a central, flat disc.

Adaptation #24

Plants produce large numbers of seeds.

Adaptation #20

Some plant seeds have hard coatings.

Adaptation #25

Seeds are small.