RED BUTTE GARDEN BOTANY BINS

PATTERNS & PARTNERSHIPS: UTAH MOUNTAIN ECOLOGY

Lesson 3: Patterns in Plants Traits and Survival

Core Alignment: 5th Grade – Standard 5
1-d. Contrast inherited traits with traits and behaviors that are not inherited but may be learned or induced by environmental factors. 1-e. Investigate variations and similarities in plants grown from seeds of a parent plant. 2-a. Compare the traits of similar species for physical abilities, instinctual behaviors, and specialized body structures that increase the survival of one species in a specific environment over another species. 2-b. Identify that some environments give one species a survival advantage over another. 2-c. Describe how a particular physical attribute may provide an advantage for survival in one environment but not in another. 2-d. Research a specific plant or animal and report how specific physical attributes provide an advantage for survival in a specific environment.
Intended Learning Outcomes:
• Observe simple objects, patterns, and events and report their observations. • Compare things, processes, and events. • Describe or explain observations carefully and report with pictures, sentences, and models. • Cite examples of how science affects life. • Science is a way of knowing that is used by many people, not just scientists.
Vocabulary:
environment, population, specialized structure, species, survival, variation, organism, traits, parent organism, offspring, inherited, learned behavior, acquired, instincts Optional: ecology, ecologist, ecosystem
Time Commitment: These lessons are designed to provide flexibility in both length and depth. Plain text in black contains the middle-of-the-road option, while text in red contains time-saving options ,and text in purple contains options to dive deeper into the subject matter.
45-60 minutes, 30-45 minutes, and 60+ minutes.

Lesson Summary

Your students have mastered mountain organisms, conquered the canine conundrum, and are now fully familiar with the who and what of traits! Now it's time to discover the where and why with a more challenging organism (due only to its lack of familiarity), the kingdom of plants! As your students gain a better understanding of the characteristics of the Utah Mountain Ecosystem, they'll discover how an organism's traits fit into that ecosystem. Students will also explore how the structure of a trait is tied to its function. This lesson culminates in the students combining the knowledge they've learned in the first three lessons as they study the organisms

found in this bin. Like professional ecologists, they will investigate how an organism's traits help or hinder its success in an ecosystem and take a peek at what could happen if that ecosystem changes. Much of this lesson follows the same template as the previous lesson.

Essential Questions

- How do an organism's traits effect that organism?
- Does a difference in ecosystem change how those traits effect an organism?
- How does a change in ecosystem, or a changing ecosystem, effect organisms with different traits?

Enduring Understanding

- Organisms have traits that help them survive in their ecosystem.
- The traits that help an organism survive in one ecosystem could hurt them in a different ecosystem.
- The function of a trait can often be determined by its structure.
- Understanding an organism's ecosystem, and the challenges that ecosystem presents, helps scientists to understand why an organism has a particular trait.

Previous Knowledge

By now, your students should have a solid understanding of traits and how organisms obtain those traits. They may have also had personal experience with different factors that necessitate an organism to have certain traits. For example, your students may have felt cold in the winter and known a thick coat can help keep them warm. Or perhaps they've felt the pressure of a strong wind and sought shelter. When playing hide and seek, they may have discovered the benefit of blending in with their environment. Their innate knowledge of physics, that they may not even know they have, has also helped them connect the function and structure of many traits. Just ask if they'd rather wear a black shirt or a white shirt when outside on a 100^{0}F day. They know that the black shirt will be much hotter, even if they don't understand the thermodynamics behind that observation. And again, their pattern finding powers will help them to understand how similar traits can provide similar relief to similar ecosystem pressures.

The basic needs of plants and animals for survival have likely been the subject of previous years' lessons for your students. If they need a refresher we suggest reminding them of those needs. Plants need sun, air, water, space, and nutrients/stability from soil. Animals need food, water, shelter, air, and space.

Background Information

The Utah Mountain Ecosystem, and the Rocky Mountains as a whole, encompass five main ecosystem types or zones including: foothills, montane, subalpine, alpine, and riparian (see the Utah Mountain Ecosystem Zones handout for reference). These five zones overlap and intertwine across the differing elevations and aspects. We chose these five zones because they have noticeable differences, are easy to separate, and best facilitate the discussion points of this lesson, but there are many ways to define different types of ecosystems (see the USB documents for this lesson for more information). As mentioned before, humans love trying to put nature into neat, discrete boxes. Nature, however, rarely fits cleanly within those strict boundaries. That being said, by discussing the five main ecosystem types we can more easily explore the environmental pressures and resulting traits that an organism would experience in those ecosystems. If you or your students venture into the mountains, you will find that these ecosystems edges are greatly blurred.

Ecosystems, as studied by ecologists, are typically delineated by the dominant vegetation present as the flora of a region is the base of all the associated fauna, a reflection of the climate, and often the geology of the area. The range in elevation for each zone represents the difference in climate found between the significantly warmer open southern exposures and the much colder deep canyons with a northern exposure.

- The Foothills ecosystem is the first zone encountered when climbing into the mountains with elevations of ~4,600–8,200 feet. It is dominated by open stands of drought-tolerant sagebrush (*Artemisia tridentata*) and juniper (*Juniperus osteosperma*). Tall grasses make up much of the area between trees and shrubs, with seasonal flowers appearing in succession through the summer. This area is the first to thaw and bloom in spring and the last to freeze over in winter. It is the hottest and driest of the ecosystems we are studying, but still faces snow covered winters. The soil here is typically the deepest.
- The Montane ecosystem zone occurs higher in elevation at ~7,800–10,200 feet. This is where the forest begins with stands of quaking aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta*), and douglas fir (*Pseudotsuga menziesii*) dominating the landscape. While meadows are common, the forest in general is far less open than the foothills with a denser understory of shrubs, grasses and wildflowers. The Montane zone is not as hot and dry as the foothills, but it is warmer by around 10°F and can receive as much as five feet less snow than higher-elevation ecosystems. The soil starts to become shallower as we climb in elevation, but not to an extreme extent.
- The Subalpine ecosystem zone exists at elevations between ~8,500–11,200 feet. There begins to be an increase in areas that are too steep or rocky for much plant life to grow in this zone, but in areas that are hospitable the dominant fauna includes

Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). Meadows abound in the subalpine zone along with seasonal wildflowers, grasses, and shrubs that create the understory of the forest. This area has long winters and deep snow, often with only a 3-4 month growing season. Bedrock scree (bedrock broken into rock fragments of various sizes, often seen as a rockslide near a steep area) is fairly common and soil is noticeably shallower than lower zones.

- The Alpine ecosystem zone begins at around 11,000 feet and extends to Utah's highest mountain peak, Kings Peak, at 13,528 feet. The landscape is largely bedrock scree, with only around 16-30% of the ground surface covered with vegetation during the growing season. The dominant flora are dwarf shrubs closer to the transition from subalpine and a patchwork of dwarfed or low growing plants scattered in the more hospitable areas. Winters are long and cold at this elevation, with deep snow and howling winds. The growing season is typically around a month, and even then, the winds are strong and the average temperature doesn't exceed 50°F. The soil here is thin and often little more than a pocket of debris between rocks.
- The Riparian ecosystem zone exists within all the preceding ecosystem zones, comprising the myriad of creeks, streams, rivers, ponds, lakes, and their adjacent banks that occur in Utah's Mountain Ecosystem. Along the banks, woody plants like plane-leaf willow (*Salix planifolia*) and red-osier dogwood (*Cornus sericea*) are commonly found, as well as a variety of horse-tail, grasses, wildflowers, sedges, and rushes. Pondlily (*Nuphar polysepala*) and a variety of aquatic plants and algae colonize the water. The abundant water found in this zone acts as a buffer to the dry heat of the foothill zone and allows for more plant growth. Through the montane and into the subalpine zone the riparian zone has a similar effect, staying lush and green even into the drier end of the growing season when much of the surrounding seasonal growth has begun to brown. In the alpine zone there is less differentiation between the riparian and non-riparian areas as the growing season is so short. The soil near riparian areas is typically thicker or richer in nutrients.

This lesson is written in a similar manner to the previous two to allow for quicker implementation.

Lesson Plan:
Patterns in Plants – Traits and Survival

Materials	Location
Eriogonum plant riker *Achillea* plant riker *Castilleja* plant riker	Botany Bin – These rikers are the largest sized riker.
Blackline: L3 Patterns in Plants – The Why of Traits	Addendum Folder – Tab L3 OR USB – L3 folder
Patterns in Plants – Teacher Hints	Addendum Folder – Tab L3 OR USB – L3 folder
Pencils or Pens	Classroom supplies
White/Smart Board for group discussion	Classroom supplies
Optional:	
Hand lenses	Botany Bin – Pull Out Compartment
Fauna Photos	Fauna Photo Folder
Plant & Organism Rikers	Botany Bin
Blackline: L3 Traits and Survival in the Mountain Ecosystem	Addendum Folder – Tab L3 or USB – L3 Folder

Preparation

- For the main section of this lesson, you will be working with three specific rikers. These three specimens are all in the largest sized riker.
- For the optional additional part of the lesson you, or your students, will be choosing organisms from the 108 different specimens in the bin. You may not want to lay out all of the organisms in the bin for your students to choose from. If preselecting a variety of organisms for your class to choose from, we suggest choosing organisms that will be more engaging to your classroom. You can also aim your selections towards the difficulty level that is best for your class, for example some plants can be more challenging as they are less familiar to students. We recommend taking 5–10 minutes to familiarize yourself with the organisms in the bin before you conduct any of the lessons.

Set-up

- To make this activity more phenomenon-based it is written to have the vocabulary of population, specialized structure, survival, and variation revealed after the activity.

- Ask the students if where an organism lives matters to that organism. Some good prompts could include: Does it matter if a fish lives in the ocean or on land? Does it matter if a plant lives on a hillside or in the back of a cave?
    - Introduce students to the concept of an environment (where an organism lives).
- Further discuss whether the different components of an environment can affect an organism. You could include the climate (glaciers, desert, jungle), the soils (fresh lava flows, solid rock, deep rich soils), and other organisms (plants, pollinators, predators, prey).
    - Introduce students to the concept of an ecosystem (all of the interconnected living and non-living components of a given area). This can be done quickly to save time, or you can expand on this concept by giving examples of the biotic and abiotic components. We suggest specifically mentioning the abiotic components of water, climate, and rocks/soils. This exploration can be continued in the ecology extension found at the end of the lesson.
- Discuss the 5 ecosystem zones (environments) with your students. Explain that all of the organisms they have been studying exist within some or all of those zones. You can find PDFs of the handouts on the USB if you'd like to display them with your projector during your discussion. Distribute copies of the handouts to your class so that they can follow along and/or take notes.
    - Teacher Tip: If your students haven't recently covered the needs of organisms for survival, it can be helpful to include a brief reminder before introducing the ecosystems. We suggest the following. Plants need sun, air, water, space, and nutrients/stability from soil. Animals need food, water, shelter, air, and space.
    - To save time, highlight the alpine and foothill ecosystem zones that will be used in the first section. The remaining zones will only need to be covered if you are doing the final activity investigating all the organisms.
    - As you discuss the ecosystem zones emphasize the factors that can create difficulties and/or opportunities for the organisms that live there (see hints below).
        - Foothills: Dry, hot, largely open areas with tall grasses, longer growing season, seasonal snow.
        - Montane: Dense forest with canopy that can block much of the sun to the understory, moderately dry, some open meadows.

- Subalpine: Long, cold winters with deep snow and a shorter growing season. Many open meadows and lakes.
- Alpine: Vey cold, very windy, deep snow for much of the year, short growing season, rocky with thin soils.
- Riparian: Wet, densely populated with plants and highly utilized by animals.

- Explain that students will investigate some of the plants that live in the two most extreme ecosystem zones you just discussed, the alpine and the foothills. They will identify traits and patterns in the plants and explore why the plants have those traits.
  - This is a great time to introduce the idea/importance of scale in science! Equip the students with a hand lens and ask them to find at least one trait that is only observable with the help of the lens. Using the lenses does have a learning curve, so it can be helpful to familiarize yourself with using them ahead of time. Students can practice using the lens to magnify their hands (the cuticle around the fingernail is ideal). There are links to videos and instructions on the USB, one of which is condensed below.
    - Hold the lens with your writing hand and move it as close to that same eye (right hand to right eye) as is comfortable (not touching the eye). Rest the hand holding the lens on your face for stability.
    - Hold the specimen in the other hand and bring it towards the lens until it comes into sharp focus (typically within a few inches of the lens) or move your face with the lens in place towards the specimen until it comes into sharp focus.

- It can be helpful to remind students that there is more than one right answer. Practicing scientific thought processes and logic are more important than the "right" answer.
- Break the students into 3 teams
  - This activity can be done as a class to save time, either by selecting one of the three plant samples, or working through all three.
  - To practice the scientific skills of Engaging in Argument from Evidence and Communicating Information; we suggest breaking the teams into roles, namely; Facilitator, Spokesperson, Timekeeper, and Devil's Advocate as outlined in the USB addendum folder document "Suggested Group Discussion Roles."
    - If you have the same student teams as the previous lesson, we suggest shuffling the roles among the students.
- Distribute one of the plant samples to each of the teams.
  - Explain that the plant samples show the same type of plants within the riker, just found in different ecosystem zones.

- Allow the students time to look at the specimens individually to search for traits and theorize on why they exist. This can help them to form their own conclusions. We suggest approximately two minutes.

Activity

- Give the teams a set amount of time to complete the activity. We suggest 8–10 minutes.
  - If your students need guidance, encourage them to think about what the plants need to live, what challenges they potentially face in the ecosystems they live in, and how the traits they notice might help them deal with those challenges. Basically, what the plants need, what they have, and how they bridge any gaps between the two.
  - You can also refer to the teacher hint sheet, "Patterns in Plants – Hints" found on the USB.
- Ask the students to decide on at least one trait they have noticed that they think helps the plant to live in each of the two ecosystem zones (alpine and foothill).
  - The goal is to have students think about how traits could help (or hinder) an organism in a given ecosystem. As long as they can tie their observations together logically there is no "wrong" answer.
- Have students record their observations on the worksheet "Patterns in Plants – The Why of Traits."

Discussion

- Have each team share their observations from "The Why of Traits" worksheet.
  - We suggest dividing your board into two sections, one for each ecosystem. Within each section record the challenges of the ecosystem and the trait your students found that addresses that challenge.
  - To save time, combine this step with with displaying the plant specimens. As a class, identify traits and which ecosystem challenge they help the plant to overcome. Ask the students to voice their agreement or disagreement and reasons why.
  - You can use this time as an exercise in Engaging in Argument from Evidence when students have conflicting ideas on the why of the traits. If you had a Devil's Advocate, he or she could help to assemble and voice their team's objections. The worksheet can help students record the results of that discussion.

- Introduce the vocabulary terms of variation (differences in inherited traits within a species), survival (an organisms ability to continue to live), and population (a group of a type of organisms living in a given area), and specialized structure a trait that gives an organism type or species a better chance at survival).
    - As a class list examples of the variations they saw in the plants from different populations (alpine and foothill). Choose one trait variation that they believe was the most important to the plants ability to survive.
    - Ask the class if they can identify any specialized structures in the plants. Some hints include different flower colors to attract different pollinators, shorter stems to keep the plant protected and low to the ground, taller stems to project the flowers above the grass canopy.
    - Point out the seeds in the plant rikers. Ask if the variations seen in the adult plants are visible in the seeds. Ask the students if they can think of any other examples of organisms that don't initially resemble their parents.
    - The second page of the worksheet "Patterns in Plants – The Why of Traits" can be used in class or as a take home to reinforce the vocabulary learned through the lesson.

- Discuss the implications of traits affecting an organism's ability to survive.
    - What will happen to plants who have inherited traits that make it harder for a plant to survive in their environment? Will they have more or fewer offspring?
    - What will happen to plants who have inherited traits that make it easier for a plant to survive in their environment? Will they have more or fewer offspring?
    - How might this increase or decrease in the number of offspring with different traits affect the entire plant population over long periods of time?

Traits Capstone

Your students now have a solid grasp of the who, what, where, when and why of traits. That gives them a solid footing to step into the shoes of a professional ecologist (a scientist who studies the interactions between the biotic and abiotic components of ecosystems). Now they can hone their trait finding skills on an organism of their choosing.

- Make the organism specimens found in the botany bin available to the students (plants, animals, insects) and have each student choose one organism to study during class time.
- Have the students record the information on the organism's label onto their worksheet, "Traits and Survival in the Mountain Ecosystem."

- Ask students to research their chosen organism online and to look for more information on the its traits.
- Have students use their research and their newfound knowledge of traits, environments, and survival to create a report on how the organism's traits allow it to survive the challenges of its environment or ecosystem and how the organism might do if it lived in a different ecosystem as outlined in the worksheet, "Traits and Survival in the Mountain Ecosystem."
- When the reports are done, having the students present their findings to the class can create a last opportunity to clear up confusion and reinforce the concepts they've learned. This also presents another opportunity to practice the scientific skills of Engaging in Argument from Evidence and Obtaining, Evaluating and Communicating Information.

Assessment

Students should demonstrate an understanding that an organism's traits are not random, but because they are beneficial, or at least not harmful, to the organism. Students should further demonstrate an understanding that beneficial traits are tied to an organism's survival, and that traits are not universally beneficial or detrimental, but dependent on the conditions of an organism's ecosystem. Informal observations can be made as students are working; observe how they participate in discussions, if they are engaged, etc. Make anecdotal notes of students' verbal responses during discussions. The worksheets can also be used as either a note of participation, understanding, or critical thinking.

Extensions

- A set of the *Natural Inquirer*'s Scientist & Engineer Cards are included in your Botany Bin along with an activity wheel. These cards highlight a diverse range of scientists, including different kinds of ecologists. Have your students find and read/report on the different types of ecologists and what they do/study can open their minds to what scientists really do. The activity wheel allows for a more focused exploration of the cards and scientists highlighted within.

- The University of Utah has a fun and free video and accompanying simulation that explores the variation in traits of fur color in mice on light and dark colored lands and their relative ability to survive. The simulation is very well thought out and provides the opportunity to discuss recessive and dominant traits as well as the effects of behavioral traits to survival.
  - Video at: https://learn.genetics.utah.edu/content/evolution/pocketmice
  - Simulation at: https://learn.genetics.utah.edu/content/evolution/advantage/

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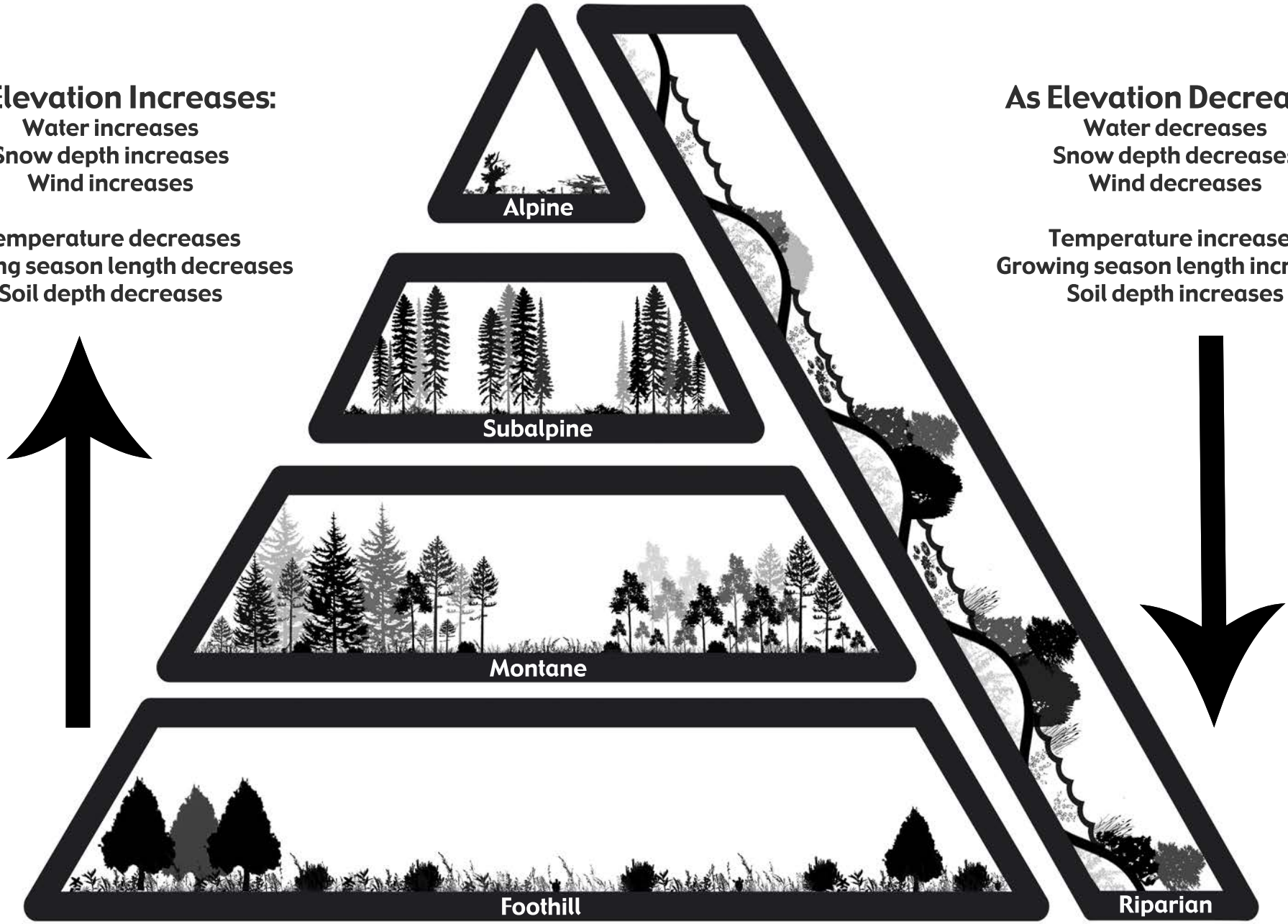
Utah Mountain Ecosystem Zones

As Elevation Increases:
Water increases
Snow depth increases
Wind increases

Temperature decreases
Growing season length decreases
Soil depth decreases



As Elevation Decreases:
Water decreases
Snow depth decreases
Wind decreases

Temperature increases
Growing season length increases
Soil depth increases

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Patterns in Plants – The Why of Traits

Name(s): _____ **Date:** _____

Specimen Observed (plant name): _____

Alpine Ecosystem Zone Traits

What challenges do plants face in the alpine ecosystem? _____

_____

_____

What traits did you observe in the plant found in this ecosystem? _____

_____

How do you think the trait you found helps the plant to survive the challenges in its ecosystem zone?

_____

_____

_____

How would having that trait effect the plant if it was in the foothill ecosystem? _____

_____

_____

Foothill Ecosystem Zone Traits

What challenges do plants face in the foothill ecosystem? _____

_____

_____

What traits did you observe in the plant found in this ecosystem? _____

_____

How do you think the trait you found helps the plant to survive the challenges in its ecosystem zone?

_____

_____

_____

How would having that trait effect the plant if it was in the alpine ecosystem? _____

_____

_____

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Patterns in Plants – The Why of Traits

Name(s): _____ **Date:** _____

Match the terms below with the best definition for that term.

Population	**A behavioral trait that is inherited and does not need to be taught to an organism.**
Variation	**All the interconnected living and non-living parts of a given area.**
Species	**A person or scientist who identifies and selects parent organisms with desirable traits in order to breed them to create offspring with those traits.**
Survival	**Where an organism lives.**
Offspring	**A scientist who studies the interactions between the living and non-living parts of an ecosystem.**
Parent Organism	**A behavioral trait that is acquired through trial and error or due to the environment.**
Specialized Structure	**The difference in inherited traits within a species or type of animal.**
Organism	**The young of an organism.**
Trait	**Organisms that are very similar to each other and are able to breed with one another.**
Environment	**An organism's ability to continue to live.**
Inherited	**The physical or behavioral characteristics of an organism.**
Acquired	**A group of a type of organism living in a given area.**
Instinct	**A living thing that can act as an individual and carry out its life activities on its own.**
Learned Behavior	**A trait that gives an organism type or species a better chance at survival.**
Ecosystem	**A scientist who studies the patterns of traits and genetics in organisms to understand and categorize organisms.**
Ecologist	**Traits that an organism gets during its life and that cannot be passed from parent organism to offspring.**
Taxonomist	**An organism that produces offspring.**
Breeder	**Traits that are passed from a parent organism to their offspring.**

Patterns in Plants – Hints

This list is by no means exhaustive and is just meant to give you a few ideas if your students are struggling. You and your students will likely discover adaptation ideas that are not listed below (and we'd love to hear about them!)

Size:

You and your students may notice that there is a pattern of plants being taller in the lower elevation ecosystems and shorter in the higher elevation ecosystems. In the foothills the plants are competing with tall grasses for both sun and pollinators, in order to reach both they grow taller (and they are able to do so due to the longer growing season). In the alpine region, the short growing season and extreme wind leads to plants that are significantly smaller. In the montane and subalpine zones plants size can be more variable as they are potentially dealing with taller understory competition along with shorter growing seasons.

Flower Color:

Flower color can vary not only within flowers in general, but even within a type or species of a plant. Different pollinators are attracted to different colors. There are lots of wonderful resources on the full spectrum of pollinators and colors, but as a quick guide many hummingbirds prefer red/purples, bees prefer purple/blue, butterflies like orange/yellows, and moths prefer white. There are even ultra-violet colors that act as billboards and landing strips to pollinators that humans can't see without assistance. Different pollinators may be more abundant in different ecosystem zones and so what might be successful for pollination in one ecosystem, could be a failure in another.

Leaf Shape:

Beyond making food, leaves have a lot to contend with. They have to worry about herbivory, sun burn (yes, even plants can get sunburns!), wind, loss of water, and more. In order to deal with all these issues plants come up with a huge variety of leaf shapes, sizes and structures. By increasing surface area, they create more surface for photosynthesis but also have to deal with increased stress from wind and the weight of snow. Some grow hairs along their surface to act as a barrier to keep in moisture and reflect intense u.v. rays. If you look at the inside of a leaf you can even find thick waxy layers to protect the leaves water and cells or giant open cells to allow the leaf to float.

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Traits and Survival in the Mountain Ecosystem

Name: _____ **Date:** _____

Specimen observed (scientific and common name): _____

_____

What ecosystem zone does this organism live in? _____

Research the organism you've chosen looking for the traits the organism has and the environmental pressures that organism might face. You can find some information on the organism's tag and in the ecosystem handouts. Create a report on how the traits you've discovered help the organism to survive the challenges of its ecosystem, and how those traits would affect the organism if it was living in a different ecosystem (for example a desert or jungle). Try to answer the following questions in your report.

- **What ecosystem does your organism live in?**
- **What does your organism need to live?**
- **What challenges does your organisms face in its ecosystem?**
- **What traits does your organism have that help or hurt its ability to survive in its ecosystem?**
- **Think of another ecosystem you know of that is different than the Utah Mountain Ecosystem. What are the challenges of that ecosystem and how would your organism's traits effect its chances for survival in this new ecosystem?**