Lesson 1.5: Oak Woodlands Energy Transfer

LESSON INTRODUCTION

Time Frame: Multiple class periods
Materials:

- Oak Woodlands Species Cards
- Oak Woodlands Energy Transfer Worksheet
- Energy Transfer Pyramid
- Energy Transfer Answer Sheet
- Optional: Calculators
- Optional Extension: Cultural Perspectives

The following lesson asks students to put their knowledge of **trophic levels** and **energy transfer** into practice. With the **Oak Woodlands ecosystem** as a backdrop, students explore values related to food and plant conservation.

Teacher Background:
To open this lesson, students explore the Indigenous value of only taking as much from the Earth as is necessary. This is important for multiple reasons. Most obviously, taking more than you need can keep others from receiving what they need. From an ecological perspective, taking more resources than the ecosystem is able to replenish can irreparably harm the ecosystem and its food webs, leading to massive shifts and even ecosystem collapse. This impacts culture, access to food, safety, and more.

Pomo and other California Natives have specific methods for harvesting, hunting, and caring for the ecosystem so as not to cause **imbalance**. When imbalance does occur, there are ways to rebalance systems, but they require adaptation and innovation.

For more information on **TEK** and Native methods for maintaining and adapting the ecosystem to support balance, read **Tending the Wild by Kat Anderson** or check out the docuseries on KCET.

Energy Transfer:

Ecosystems are composed of a diverse array of organisms. All organisms require energy to be active, grow, and reproduce. The first law of thermodynamics states that energy cannot be created nor destroyed, it can only be transferred from one form to another. In accordance with this law organisms are incapable of creating their own energy but can obtain energy from other sources. Some organisms obtain energy from consuming other organisms and are referred to as **heterotrophs** (hetero meaning "other," and troph meaning "to feed") while other organisms, mainly plants, obtain energy through **photosynthesis** and are referred to as **autotrophs** (auto meaning "self"). These principles are the basis of understanding how energy is transferred through an ecosystem and how organisms acquire the energy they need to live.

Trophic Levels:

The originator of energy in an ecosystem is the sun. When the energy from the sun reaches an ecosystem, in the form of **solar energy**, it enters into the complex hierarchy of that ecosystem's food web. The progress of solar energy being converted and transferred between organisms in an ecosystem can be visualized through an **energy pyramid**. The energy pyramid is composed of organisms arranged into several tiered levels referred to as **trophic levels**. An organism's placement within a specific trophic level is dictated by how they obtain their food.

Energy is transferred between these levels through the consumption of a lower-level organism by a higher-level organism. At the base of the pyramid are plants which are **autotrophic** and "create" their own food by converting solar energy into carbohydrates (sugars) and oxygen through the process of **photosynthesis**. Since plants do not need to consume other organisms to acquire energy and "produce" their own food they are called **primary producers.** Organisms that are incapable of photosynthesis are **heterotrophic** and so consume plants and other organisms to acquire energy. These organisms are referred to as **consumers**. Each trophic level above the first contains consumers that obtain their energy from eating organisms in the levels below them. For example, some consumers, referred to as **primary consumers** or **herbivores**, eat only plants and so typically occupy the second level of the energy pyramid with only the **primary producer** trophic level below them. In contrast, apex **consumers** eat other consumers, and sometimes primary producers, while there are no other organisms that eat them and so occupy the topmost trophic level of the energy pyramid.

Outside of this system are **decomposers** which return energy from all trophic levels back to the primary producers through decomposition of waste and dead matter.

However this recycling of energy is marginal compared to the energy delivered by the sun.

The 10% Rule:

Energy from the sun is transferred from the **primary producers** at the base of the energy pyramid through **consumers** to the eventual pinnacle of the pyramid, the **apex consumer**. However, this energy transference is not perfect and, in fact, roughly **10%** of the energy available in a lower trophic level is passed up to the next. There are several reasons for this energy loss. First, only a fraction of the solar energy that reaches an ecosystem actually lands on an individual plant, then only a fraction of that energy's wavelength is available to be used in photosynthesis. Additionally, since digestion is not a perfect process, when a consumer eats a plant much of the available energy is lost in the process of digestion and excreted as waste. Organisms also constantly lose energy in the form of **heat** which is a common byproduct of cellular processes. This inefficiency in energy transfer is more than an inconvenience as it limits the amount of trophic levels an ecosystem can accommodate. As energy availability decays over the progress of the ecosystem's energy pyramid it meets an eventual end point where further trophic levels are not sustainable. The height of an energy pyramid is typically dictated by the primary producer's ability to convert solar energy into usable nutrients for consumers. If the process is inefficient, the ecosystem will start with less available energy and not be able to support as many trophic levels as an ecosystem with primary producers that are very efficient in converting solar energy and are highly digestible by consumers.

ENGAGE

Introduce students to the concept of conserving and overharvesting through this simulation.

Ask students:

1. **What does it mean to harvest food responsibly?**
2. **What happens when food is not harvested responsibly?**
3. **Based on the game, what do you understand about the ethics of harvesting food in our ecosystem?**

EXPLORE

Guide students towards the lesson topic by asking the following questions:

1. **When you are hungry, how do you decide what you are going to eat?**
2. **What is most important to you when eating:**
    - *The food tastes really good.*
    - *The food gives me energy that will last me all day.*
    - *The food gives me a quick burst of energy right away.*

Ask students to make a list of all the physical activities they enjoy doing (ie. swimming, hiking, playing sports, etc). Note that all of these activities burn energy, and that in order to stay energized, students need to eat food that will give them sustained energy.

Explain to students that traditionally, Pomo people would have been very active, and would have taken part in many physical activities such as:

Hunting
Gathering foods
Fishing
Waking/running
Lifting and building
Cooking
Dancing
Swimming

Project the **Oak Woodland Ecosystem Species Cards** from **Lesson 1.4**

Ask the following questions:

1. **All of the cards here represent food traditionally consumed by the Pomo people. Which food do you think provides the most energy to humans when eaten? Explain your answer.**
2. **Which food do you think provides the least amount of energy to humans when eaten? Explain your answer.**

Project the **Energy Transfer Pyramid** for students to see. Guide the class through a discussion exploring the following questions:

1. What do you notice about energy transfer in the diagram?

- **What do you wonder about the diagram?**
- **What percentage of energy is carried over between trophic levels?**
- **What role do you think the heat plays?**
- **What role do you think the decomposer plays?**

EXPLAIN

Have students review **energy transfer** and **trophic levels** through the following **EdPuzzle** video. The video features a Khan Academy lesson, which can be accessed for free and used to further student support if needed.

EdPuzzle Video: Flow of energy and matter through ecosystems

Review the answers with students, exploring the **10% Energy rule.**

Before moving onto the class practice in the next step, walk through this computer simulation scenario to support student understanding and fill in any missing information that students might need:

PBS Link: Energy Flow: From Sunlight to Plants to Animals

ELABORATE

Provide students with the "**Oak Woodland Ecosystem Energy Transfer Practice**" worksheet. Guide students through the first problem set as a class. Notice that the directions ask students to draw out the problems as they work. This is an important part of the modeling process and should not be skipped. It also further solidifies student familiarity with the species.

Note: The practice sets are designed to increase in difficulty. Younger students may struggle with some of the sets, in which case you could do them as a class or in partners.

EVALUATE

Review student answers according to the teacher's answer sheet.

As a class, walk through **Section 4** of the worksheet, exploring the concept of only taking what one needs, ecosystem collapse, etc.

1. **The energy transfer questions above have humans consuming only deer meat in their diet. Do humans only eat one kind of food? How do you think the human diet should be designed instead?**
2. **The questions above have humans eating all the deer meat available in the food web. Is this responsible? Why or why not?**
3. **If humans were to consume all the possible deer in their food web, what would happen to the deer population? What about the grass population?**
4. **Why is it important that humans only take what they need from their ecosystem?**

Extension option: Students who finish early may choose to read the added extension excerpt. The excerpt provides an example of the traditional preparation of deer meat by Pomo people. It asks students to compare the traditional Native approach to food waste to the common approach in the United States.

VOCABULARY

Consumer: An organism that derives the organic compounds and energy it needs from the consumption of other organisms; a heterotroph.

Primary Producers: Organisms that convert energy from light or heat into organic tissue. Plants are an example of a primary producer.

Apex Predator: A predator at the top of a food chain that is not preyed upon by any other animal.

Autotroph: An organism that can produce its own food using light, water, carbon dioxide, or other chemicals. Because autotrophs produce their own food, they are sometimes called producers.

Heterotroph: An organism that relies on consuming other organisms in order to receive energy.

Decomposer: An organism, especially a soil bacterium, fungus, or invertebrate, that decomposes organic material.

Trophic Level: One of the hierarchical strata of a food web characterized by organisms which are the same number of steps removed from the primary producers.

Photosynthesis: The process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a byproduct.

Matter: A substance or material.

Ecosystem: A biological community of interacting organisms and their physical environment.

Energy: Power that comes from the use of physical or chemical resources.

STANDARDS

Common Core:

ELA/Literacy:

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flow chart, diagram, model, graph, or table).

Math

MP.4 Model with mathematics.

6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems.

6.EE.C.9 Use variables to represent two quantities in a re- al-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable. In terms of the other quantity, thought of as the independent

variable.Analyze The relationship between dependent And independent variables using graphs and tables, and relate these to the equation.

CA Indian Essential Understandings:

Essential Understanding 1: California is home to the largest number of culturally diverse American Indian tribes in the country; each with distinct language and cultural heritage and histories.

NGSS Standards:
Section 1: Lessons 3-8 work together to reach the following standards:

MS-LS2-1.	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-2.	Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
MS-LS2-3.	Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-LS2-4.	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-5.	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

RESOURCES

- KCET Tending the Wild
- Lessons of Our Land simulation
- PBS interactive: Energy Flow: From Sunlight to Plants to Animals

- **Khan Academy:** Flow of energy and matter through ecosystems
    - EdPuzzle