1.5

Oak Woodlands Energy Transfer

Grade Level

6-9

Subjects

Science
Mathematics

Time Frame

Multiple class periods

Teacher Materials

- Oak Woodlands Energy Transfer Worksheet
- Energy Transfer Reference Sheet/ Answer Key

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 that 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 foodwebs, 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 to never take so much as 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: https://www.kcet.org/shows/tending-the-wild?gclid=CjwKCAjwps75BRAcEiwAEiACMdxxxQfPFWOlg7tMh2otyYWJj7zM-6jrERt-MoASMN7bTGbapm2_fDRoCh9YQAvD_BwE

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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 or 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** (see page 30). 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.

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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.

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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 from the use of physical or chemical resources.

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Engage

Introduce students to the concept of conserving and overharvesting through this simulation: https://www.lessonsofourland.org/wp-content/uploads/2017/09/61_Sharing_Resources_The_Nuts_Game_-_2016-08-09.pdf

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:**
   a. **The food tastes really good.**
   b. **The food gives me energy that will last me all day.**
   c. **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.

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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 Card List** 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?**
    a. **What do you wonder about the diagram?**
    b. **What percentage of energy is carried over between trophic levels?**
    c. **What role do you think the heat plays?**
    d. **What role do you think the decomposer plays?**

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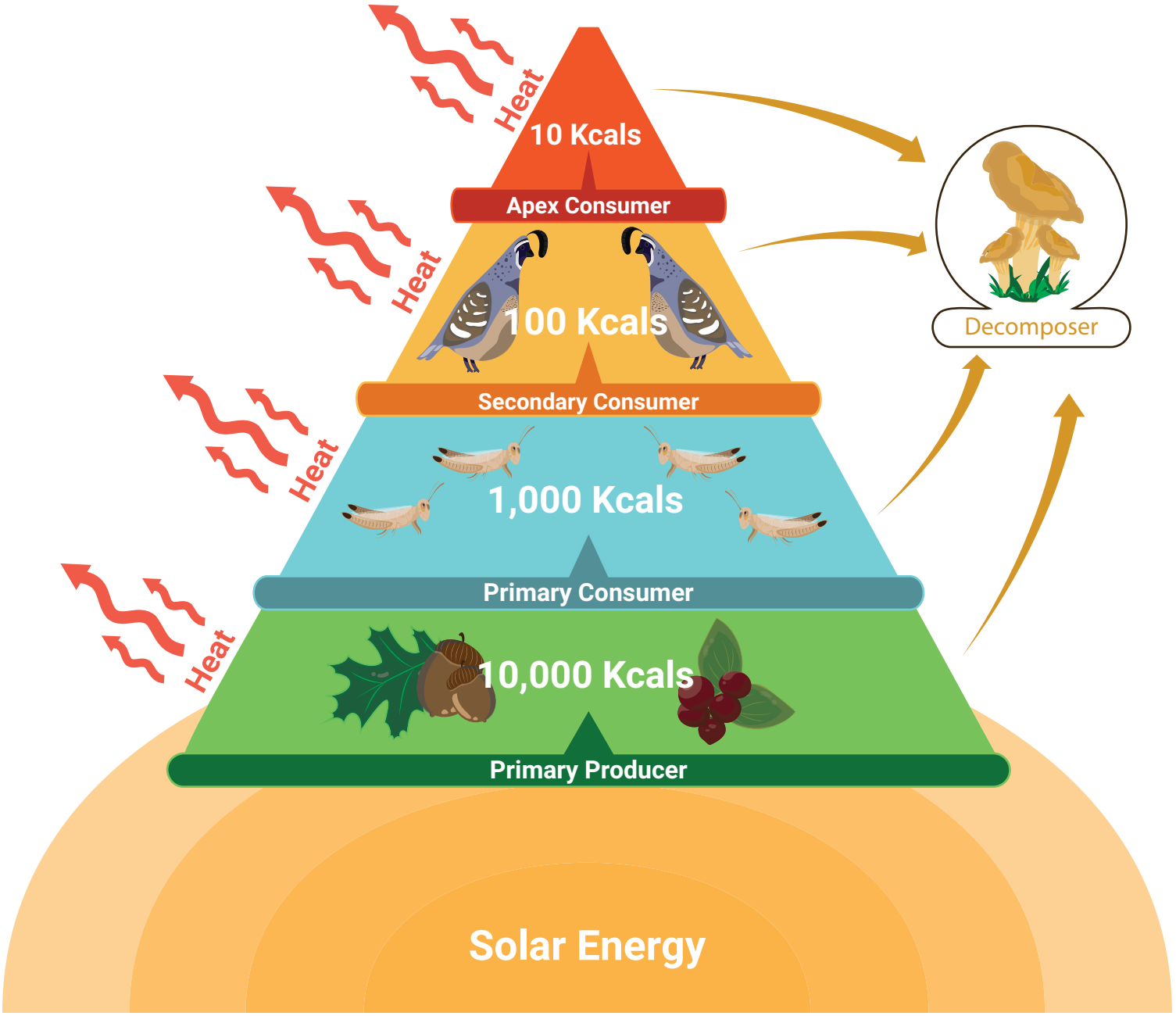
Energy Transfer Pyramid



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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 support student support if needed.

EdPuzzle Video: https://edpuzzle.com/media/5f1b250a9c-5cf93f17f0875d

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: https://contrib.pbslearningmedia.org/WGBH/conv20/tdc02-int-energyflow/index.html

Elaborate & Extend

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.

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Evaluate

Review student answers according to the teacher 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 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, and asks students to compare the traditional Native approach to food waste to the approach to food waste in the United Stated.

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Lesson Resources

Supporting resources for educators:

- **KCET Tending the Wild:** https://www.kcet.org/shows/tending-the-wild?g-clid=CjwKCAjwps75BRAcEiwAEiACMdxxxQfPFWOlg7tMh2otyYWJj7zM-6jrERt-MoASMN7bTGbapm2_fDRoCh9YQAvD_BwE

Source URLs:

- **Khan Academy:** https://www.khanacademy.org/science/high-school-biology/hs-ecology/trophic-levels/v/flow-of-energy-and-matter-through-ecosystems
- **EdPuzzle**: https://edpuzzle.com/media/5f1b250a9c5cf93f17f0875d
- **Lessons of Our Land simulation**: https://edpuzzle.com/media/5f1b250a9c-5cf93f17f0875d
- **Online Energy Flow Simulation:** https://contrib.pbslearningmedia.org/WGBH/conv20/tdc02-int-energyflow/index.html

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Learning Standards

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.

CA Content Standard

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 real-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.

NGSS Standards

Performance 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-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

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Science and Engineering Practices:

Disciplinary Core Ideas:

MS-LS2.A: Interdependent Relationships in Ecosystems

Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

MS-LS2- 1 In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.

MS-LS2-1 Growth of organisms and population increases are limited by access to resources.

MS-LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

MS-LS2-4 Ecosystems Are Dynamic Nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

LS4.D: Biodiversity and Humans

Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)

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Cross-cutting concepts:

Patterns

Patterns can be used to identify cause and effect relationships**. (M S-LS 2-2)**

Cause and Effect

Cause and effect relationships may be used to predict phenomena in natural or designed systems. **(MS-LS2-1)**

Energy and Matter

The transfer of energy can be tracked as energy flows through a natural system. **(MS- LS2-3)**

Stability and Change

Small Changes One part of a system might cause large changes in another part. **(M S - LS 2-4),(M S -LS2-5)**

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Energy Transfer Practice

Name:_____ Date: ____/_____/_____

Part 1

Acorns are a traditional staple food and energy source for the Native people of Northern California. Oak trees take energy from the sun and convert that energy into nutritional organic compounds that other animals eat. Acorns are highly nutritious! Native peoples have used acorns to cook traditional foods for thousands of years. Humans do not consume raw acorns. In addition to cooked acorns, humans also consume other animals that eat acorns such as grasshoppers and quails.

1. Based on the information above, to which trophic level do acorns belong? How do you know?

2. Based on the information above, to which trophic level to humans belong? How do you know?

3. If 10% of energy is transferred between trophic levels and 1 oz of acorns contains 1100kcals of energy, how much energy does a person obtain by eating 2 ozs acorns? Illustrate your work.

4. How much energy is lost in the transfer of energy from the acorn's trophic level to the person's trophic level? List at least 1 way in which energy is lost between trophic levels. Illustrate your work.

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Energy Transfer Practice

Name:_____ Date: ____/_____/_____

Part 2

1. 1lb of grass contains 40,000kcal. If only 10% of kcals are transferred from a lower trophic level to a higher trophic level, how many kcals does a deer receive from eating 1lb of grass? Illustrate your work.

2. A 150lb deer requires 160,000kcal/week. How many lbs of grass does a deer eat per week?

3. If a 150lb deer contains 750,000kcal, and a 170lb human requires 17,500kcal/week, how many lbs of deer does a human have to eat per week to get their required calories?

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Energy Transfer Practice

Name:_____ Date: ____/_____/_____

Part 3

1. If the average deer weighs 150lbs, how many people could live off of one deer for one week? Round up or down to the nearest whole number.

2. How many deer are needed to feed a group of ten people for one month?

3. 3. There is a massive drought that knocks out half of the grass population! Only 1000lbs of grass remain. For how long could 10 deer live off of 1000lbs of grass?

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Name:_____ Date: ____/_____/_____

Part 4

1. The energy transfer questions in parts 2 and 3 have humans consuming only deer meat in their diet. Do humans only eat one kind of food? How do think the human diet should be designed instead?

2. The questions in parts 2 and 3 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 food web?

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Part 1

Acorns are a traditional staple food and energy source for the Native people of Northern California. Oak trees take energy from the sun and convert that energy into nutritional organic compounds that other animals eat. Acorns are highly nutritious! Native peoples have used acorns to cook traditional foods for thousands of years. Humans do not consume raw acorns. In addition to cooked acorns, humans also consume other animals that eat acorns such as grasshoppers and quails.

1. Based on the information above, to which trophic level do acorns belong? How do you know?
    - **Primary producers, oak trees and acorns are autotrophs meaning they make their own food using solar energy.**

2. Based on the information above, to which trophic level to humans belong? How do you know?
    - **Apex consumers, humans are heterotroph meaning they consume other organisms to obtain energy. They are apex consumers specifically because there are no trophic levels above them.**

3. If 10% of energy is transferred between trophic levels and 1 oz of acorns contains 1100kcals of energy, how much energy does a person obtain by eating 2 ozs acorns? Illustrate your work.
    - **Step 1: 1100 kcals*0.1 = 110 kcals**
      Step 2: 110 kcals * 2 = 220 kcals

4. How much energy is lost in the transfer of energy from the acorn's trophic level to the person's trophic level? List at least 1 way in which energy is lost between trophic levels. Illustrate your work.
    - **Step 1: 1100 kcals*0.9 = 990 kcals**
      Step 2: 990 kcals * 2 = 1,980 kcals
      Energy can be lost between trophic levels through heat, waste, or other cellular processes.

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Part 2

1. 1lb of grass contains 40,000kcal. If only 10% of kcals are transferred from a lower trophic level to a higher trophic level, how many kcals does a deer receive from eating 1lb of grass? Illustrate your work.
    - **40,000 kcals * 0.1 = 4,000 kcals transferred between trophic levels per 1b of grass consumed**

2. A 150lb deer requires 160,000kcal/week. How many lbs of grass does a deer eat per week?
    - **(160,000 kcals/ 1 week) / (4,000 kcals/1 lb of grass) = 40 lbs of grass/week**

3. If a 150lb deer contains 750,000kcal, and a 170lb human requires 17,500kcal/week, how many lbs of deer does a human have to eat per week to get their required calories?
    - **Step 1: 750,000 kcals/150 lbs = 5,000 Kcals/ lb of deer meat**
      Step 2: 5,000 Kcals/ lb of deer meat * 0.1 = 500 Kcals transferred between trophic levels per lb of deer meat consumed
      Step 3: (17,500 kcals/week) / (500 Kcals/ lb of deer meat) = 35 lbs of deer meat a week

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Part 3

1. If the average deer weighs 150lbs, how many people could live off of one deer for one week? Round up or down to the nearest whole number.
    - **(150 lbs) / (35lbs per week per person) = ~4 people**

2. How many deer are needed to feed a group of ten people for one month?
    - **Step 1: 35lbs per week per person * 10 people = 350 lbs of deer meat needed per week**
      Step 2: 350 lbs per week * 4 week = 1,400 lbs of deer meat needed per month
      Step 3: 1,400 lbs / 150 lbs (avg deer weight) = ~10 deer needed per month

3. There is a massive drought that knocks out half of the grass population! Only 1000lbs of grass remain. For how long could 10 deer live off of 1000lbs of grass?
    - **Step 1: 40 lbs of grass * 10 deer = 400 lbs of grass per week**
      Step 2: 1000 lbs of grass / 400 lbs of grass per week = 2.5 weeks

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Part 4

1. The energy transfer questions in parts 2 and 3 have humans consuming only deer meat in their diet. Do humans only eat one kind of food? How do think the human diet should be designed instead?
    - **No. It is best to eat a diverse diet containing many different food types. Humans eat fruits, berries, birds, acorns, and many other foods from their environment.**

2. The questions in part 3 have humans eating all the deer meat available in the food web. Is this responsible? Why or why not?
    - **No. It is irresponsible to eat all the dder meat becuase you must leave behind enough deer to reproduce so there will still be deer in the future.**

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?
    - **If the humans ate all the deer there would be no deer left to eat in the future and there would be fewer animals to eat the grass so grass populations would increase.**

4. Why is it important that humans only take what they need from their food web?
    - **It is important to only take what you need from the food web to maintain balance between consumers and producers and to ensure there is enough food for the future.**

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Cultural Perspectives: Extension

Name:_____ Date: ____/_____/_____

The following excerpt is from “Kashaya Pomo Memories of Food”, included in the Food in California Indian Culture anthology, organized by Ira Jacknis. The excerpt is a part of a recording of Essie Parrish, a Kashaya Pomo cultural leader. In the excerpt, she describes the steps taken to process and prepare deer meat.

“Preparing Deer and Other Meat”

September, 1958

They are said not to have let any meat go to waste; they ate all of the deer-only the crushed bones were thrown away.

The backbone they laid on a mortar stone and pounded lightly with some kind of pestle, then they crushed, crushed, crushed- that uncovers the flesh-and then they baked it on coals. They only discarded [the bits of bone] they picked out by chewing.

That’s how Indians prepared meat-by baking it on coals. And by barbecuing-sticking [pieces of meat] up on sticks; heating them by radiation, they became cooked. It tastes delicious- I ate some that my grandmother prepared.

And as for the liver, they wrapped it in leaves and baked it under the ashes, and when it was cooked they ate it together with acorn mush. It tasted very good.

And the tripe they filled with deer blood, pinned close with small sticks, wrapped in thimbleberry leaves, and then they pinned that together too. They baked it under the ashes. When it was cooked, they took it out and opened it up- it looks good. The blood turns into dark load. But the leaves aren’t burned, only scorched on top. They say it tastes good.

And they ate the deer’s ears too. When they skinned the head, they would cut the ears off. In order to eat it, they would cook it until the tips of the ears were good and crisp.

Questions:

1. Traditionally, Pomo people consumed all parts of an animal. How is this different from food culture in the United States today?

2. When parts of an animal or plant are not eaten, where do the excess parts go? What impact can this waste have on the environment?

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