THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

Lion's Share of Energy

How can I quantify the flow of energy within an ecosystem?

GRADES 6–8

Life Science

VAN ANDEL EDUCATION INSTITUTE
VAEI.ORG

INQUIRY-BASED SCIENCE

Life Science

Lion's Share of Energy

Grade Level/ Content	6–8/Life Science
Lesson Summary	In this lesson, students will model the flow of energy through an ecosystem.
Estimated Time	1, 45-minute class period
Materials	Materials for making models (may include a sheet of paper or poster board, markers, pens, colored pencils, scissors, tape or glue), computer with Internet access (or sheets containing lists of organisms from various habitats), Investigation Plan, Observation Form, Journal
Secondary Resources	Ducksters: Ecosystem: Food Chain and Food Web Meredith Middle School: Science Rocks: Energy transfer BBC: Energy in Ecosystems
NGSS Connection	**MS-LS2–3** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
Learning Objectives	• Students will describe the roles of producers, consumers, and decomposers within their chosen ecosystem. • Students will develop a model to quantify the transfer of energy between trophic levels. • Students will explain how energy is conserved through transfers, and eventually lost, within an ecosystem.

How can I quantify the flow of energy within an ecosystem?

All life needs energy. Cells need energy to carry out their functions. Organisms need energy to run, fly, swim, and even think! Top predators, like all consumers, get their energy from the foods they eat. But, where does the food energy come from? Most of life's energy comes from the sun. In this lesson, students will explore the path energy takes from the sun to top predators. Students will also construct a model showing how energy from the sun is captured and flows through an ecosystem.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science. In all investigations:

Students don't know the "answer" they are supposed to get.

Students play a driving role in determining the process for learning.

Teachers and students construct meaning together by journaling.

Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Students will need the following materials:

- Sheet of paper or poster board for building a model
- Markers, pens, or colored pencils
- Scissors and tape or glue
- Investigation Plan
- Observation Form
- Journal

Part 2

INVESTIGATION FACILITATION

Question

Introduce the investigation question.

How can I quantify the flow of energy within an ecosystem?

CURIOSITY

To introduce the investigation question, show an image of an ecosystem, such as a mountain lion habitat or any others available from print and online resources highlighting ecosystems of local interest and importance. Ask students which organisms are producers and which organisms are consumers. Explore the concept of trophic levels by asking them which organisms eat others in the image. Then, introduce the investigation question.

Mountain Lion Habitat

Personal Knowledge

Students capture what they already know about energy within ecosystems.

- Find out what students already know about the roles of producers, consumers, and decomposers.
- Create a class definition for each term based on student input. Include examples of producers, consumers, and decomposers from the image used to introduce the investigation question.

DISCOURSE

Conduct a *Think, Write, Pair, Share* to encourage student participation. Ask students to write down examples of producers, consumers, and decomposers. Then, ask them to define each term in their own words. Have students share their thoughts with a partner, before calling on a few pairs of students to provide their definitions.

COLLABORATION

Working in small groups provides opportunities for students to engage in rich student discourse as they work to accomplish shared goals. Collaboration requires interpersonal skills and a shared commitment to these shared goals.

Prediction

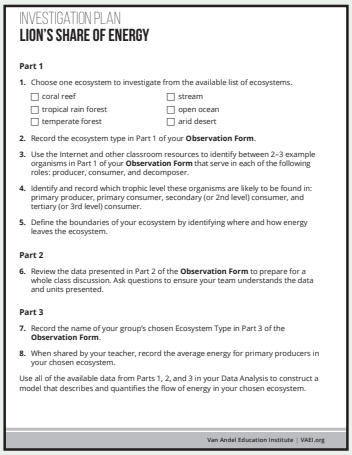
Students communicate an expected outcome, based on prior knowledge.

Give students an opportunity to predict what their findings will be to answer the investigation question: How can I quantify the flow of energy within an ecosystem? They can use the frame: *I predict _____ because _____.*

Investigation Plan

Student groups choose an ecosystem and determine a plan to identify example organisms.

- Divide the class into groups of 3 or 4 and provide each team their materials.
- Determine a way to track group choices of available ecosystems. Each group will choose a separate ecosystem and use available data to build a model that quantifies energy flow within their chosen ecosystem.
- Instruct students to follow the Investigation Plan to select their ecosystem and identify example organisms.
- Have students look up example organisms from their ecosystem to include in their model or provide lists of example organisms from the various ecosystems. You can also work with students to identify appropriate example organisms.



INVESTIGATION PLAN

LION'S SHARE OF ENERGY

Part 1

1. Choose one ecosystem to investigate from the available list of ecosystems.
   - ☐ coral reef
   - ☐ tropical rain forest
   - ☐ temperate forest
   - ☐ stream
   - ☐ open ocean
   - ☐ arid desert
2. Record the ecosystem type in Part 1 of your **Observation Form**.
3. Use the Internet and other classroom resources to identify between 2–3 example organisms in Part 1 of your **Observation Form** that serve in each of the following roles: producer, consumer, and decomposer.
4. Identify and record which trophic level these organisms are likely to be found in: primary producer, primary consumer, secondary (or 2nd level) consumer, and tertiary (or 3rd level) consumer.
5. Define the boundaries of your ecosystem by identifying where and how energy leaves the ecosystem.

Part 2

6. Review the data presented in Part 2 of the **Observation Form** to prepare for a whole class discussion. Ask questions to ensure your team understands the data and units presented.

Part 3

7. Record the name of your group's chosen Ecosystem Type in Part 3 of the **Observation Form.**
8. When shared by your teacher, record the average energy for primary producers in your chosen ecosystem.

Use all of the available data from Parts 1, 2, and 3 in your Data Analysis to construct a model that describes and quantifies the flow of energy in your chosen ecosystem.

Van Andel Education Institute | VAEI.org

Investigation Plan

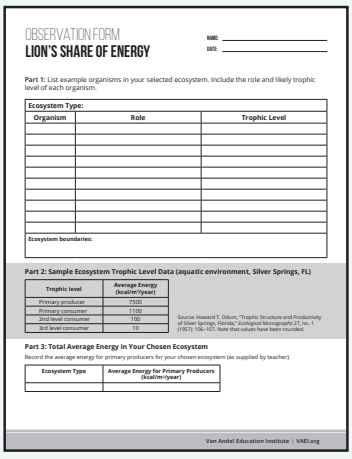
CRITICAL THINKING

Use the Fair Test checklist to help students think critically about the investigation plan. Help them understand that a good investigation plan must include a test that is repeatable, generates quality data, and minimizes error. The more critically students think about their investigation plan, the more confident they will be in their results.

Observation

Students identify ecological roles and record available information to quantify how much energy is at a given trophic level.

- Have students indicate the ecological roles and likely trophic levels (primary producer, primary consumer, 2nd level consumer and 3rd level consumer) of each example organism included in their model from Part 1 of the Observation Form.
- Challenge teams to include decomposers.
- Remind students to include the boundaries of an ecosystem in their model. In doing so, they should determine where and how energy enters and leaves their ecosystem.
- Instruct struggling students to start by deciding what each example organism eats.
- Highlight and help students understand the trophic level data for the sample ecosystem (aquatic environment, Silver Springs, FL) included in Part 2 of the student Observation Form.



OBSERVATION FORM

LION'S SHARE OF ENERGY

NAME: _____

DATE: _____

Part 1: List example organisms in your selected ecosystem. Include the role and likely trophic level of each organism.

Ecosystem Type:

Organism	Role	Trophic Level

Ecosystem boundaries:

Part 2: Sample Ecosystem Trophic Level Data (aquatic environment, Silver Springs, FL)

Trophic level	Average Energy (kcal/m²/year)
Primary producer	7500
Primary consumer	1100
2nd level consumer	100
3rd level consumer	10

Source: Howard T. Odum, "Trophic Structure and Productivity of Silver Springs, Florida," Ecological Monographs 27, no. 1 (1957): 106–107. Note that values have been rounded.

Part 3: Total Average Energy in Your Chosen Ecosystem

Record the average energy for primary producers for your chosen ecosystem (as supplied by teacher).

Ecosystem Type	Average Energy for Primary Producers (kcal/m²/year)

Van Andel Education Institute | VAEI.org

Observation Form

- Note: During Data Analysis, students will use this trophic level data to guide their development of a model to quantify energy flow within their chosen ecosystem. Ideally students will quantify the amount of energy as a percent moving from one trophic level to the next.

Continued

Sample Ecosystem Trophic Level Data	
Trophic Level	**Average Energy** kcal/m²/year
Primary producer	7500
Primary consumer	1100
2nd level consumer	100
3rd level consumer	10

Energy stored as biomass at different trophic levels in one aquatic environment: Silver Springs, FL.

Energy is measured in kilocalories per square meter per year (kcal/m²/year). (Source: Howard T. Odum, "Trophic Structure and Productivity of Silver Springs, Florida," Ecological Monographs 27, no. 1 (1957): 106–107) Values have been rounded.

- Share the following table that shows average energy from primary producers for a variety of ecosystem types with the whole class. Instruct students to record the ecosystem type and average energy that corresponds with their chosen ecosystem in Part 3 of their **Observation Form**.

Ecosystem Type	Average Energy for Primary Producers kcal/m²/year
coral reef	9000
tropical rain forest	9000
temperate forest	6000
stream	2000
open ocean	500
desert	200

Average energy stored as primary producer biomass in various ecosystems.

Part 3 INVESTIGATION ANALYSIS

Data Analysis

Students make sense of their data by organizing it and representing it as a visual model showing the transfer of energy through their ecosystem.

- Have students use the data in Parts 2 and 3 of their **Observation Form** to quantify the energy flow through trophic levels of their chosen ecosystem.
- They should analyze the mathematical patterns in Part 2 to determine how much energy is passed from one trophic level to another for the sample ecosystem.
- They should then apply this pattern to their chosen ecosystem, using the average energy for primary producers from Part 3.
- They may wish to use the Data Analysis prompt as a guide.

Continued

- Have students **evaluate** the trustworthiness of the collected data.
- Have students analyze data from Parts 1, 2, and 3 of their **Observation Form** to find patterns and trends. As they find patterns and trends, have them **organize** the data and/or **represent** it visually within their model to construct meaning. They may use math as appropriate (percentages of energy transferred from one trophic level to another, etc.).
  - *Encourage them to consider various model designs to visually represent the data. Encourage students to consider alternative model designs before settling on one. For example, students may draw an ecological pyramid, with producers on the bottom and predators at the top. They could also use concentric circles to show how energy availability decreases with each trophic level. Students may use arrows of different sizes to represent more or less energy flow.*
- Have students **interpret** what the identified patterns or trends mean.

CREATIVE THINKING

- Encourage students to be creative in how they build their models. They can use colors, shapes, and patterns to include more information or sort organisms into categories. Challenge teams to design models to show both the direction and amount of energy transferred.

OPENNESS TO NEW IDEAS

- Encourage teams to recognize that differences between models do not mean that one is wrong. Have them discuss within their group their reasoning for building their models the way they did. Any misconceptions that are revealed can be addressed after the development of student explanations.

RISK-TAKING

- Reassure students that there is no perfect or correct way to make this model. Student answers will vary based on which habitat and organisms they choose.

Secondary Knowledge

Students use secondary resources to understand how energy flows through an ecosystem.

- Use the suggested resources (or your own) to develop students' understanding of energy flow within an ecosystem.
  Ducksters: Ecosystem: Food Chain and Food Web
  Meredith Middle School: Science Rocks: Energy transfer
  BBC: Energy in Ecosystems
- After reviewing these resources, students should understand that energy generally flows from producers to consumers to decomposers. They should also know that total available energy decreases with each transfer as energy is lost as heat, used to support life within each trophic level, and spent through incomplete digestion of available energy by each consumer.
- Students use this information in the reasoning part of their explanation.

CONSTRUCTION OF MEANING

Using these outside sources to reiterate concepts and show additional examples will help clear up any remaining misconceptions, and solidify the students' understanding prior to the development of their Explanation. Student teams can also take this opportunity to further explore additional habitats or diet details of any of the organisms that they have remaining questions about.

Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from their analyzed data to write an Explanation that answers their investigation question in their Journal. Students may wish to use the Explanation prompt as a guide.
- Ask students to make a **Claim** to answer the question: How can I quantify the flow of energy within an ecosystem?
- Have students explain how the data provided **Evidence** to support their claim.
- Then, have them provide the **Reasoning** they used when building their models.
- Ask them to describe the scientific principles that informed their models.
- Have students compare their habitats and discuss how energy flow differs among ecosystems.

Example student answer:

Claim

The flow of energy in an ecosystem can be quantified and modeled as a pyramid that shows lower trophic levels with more energy than upper trophic levels. Top predators have very little energy left for them.

Evidence

The provided real-life data shows that producers store more energy in biomass than top level consumers.

Reasoning

Investigation: We investigated a pond ecosystem and discovered that ponds have several different types of producers: Reeds, pond weed, algae, rushes, and trees. These producers feed a number of primary consumers, including insect larvae, beavers, and fish fry. Small fish, insects, and frogs may be secondary or 2nd level consumers. Wading birds, otters, and turtles may be tertiary or 3rd level consumers.

Science: According to scientific principles, energy is not lost but transferred from one place to another. The energy from the sun is used by producers to make their own food. Various consumers get energy by eating either plants or other animals. We learned from reading and our class discussion that energy is transferred when an organism eats another one, but some energy is lost with each transfer. This supports our claim.

DISCOURSE

- Have students conduct a Present and Defend to develop presentation skills as well as audience participation. Teams show their models to the class, and defend their explanation with scientific principles and reasoning. They can also explain how they would modify their models based on evaluation from another team. If students are doing the same investigation, choose 1 or 2 to share.

Evaluation

Students reflect on the investigation.

Have students discuss:

- What would I do differently?
- What are the sources of possible error?
- What question would I like to investigate next?

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION

Application

Students demonstrate understanding of energy flow in ecosystems by applying their learning in multiple contexts.

- The title of this exercise refers to the idea of "the lion's share" which means the majority of a resource. Have students apply their learning by answering this question: Do top predators, such as mountain lions, really get "the lion's share" of energy available within an ecosystem? Explain your answer.
- Now that students understand how energy flows through a sample ecosystem, they can apply this knowledge to others, such as marine ecosystems. PBS: Arctic Food Web Game
- Many organisms live in different habitats. Have students apply what they learned studying the one habitat to produce an energy flow model based on an environment close to where they live. Remind students that their model should include producers, consumers, and decomposers. How might students go about discovering food webs that exists near where they live?

Assessment

To assess understanding, evaluate student models based on how well they:

- describe the roles of producers, consumers, and decomposers within their chosen ecosystem.
- quantify the transfer of energy between trophic levels.
- explain how energy is conserved through transfers, and eventually lost, within an ecosystem.

For additional lessons or to customize this lesson, go to www.nexgeninquiry.org.

nexgen inquiry®
Empowering Teachers. Engaging Students.

INVESTIGATION PLAN
LION'S SHARE OF ENERGY

Part 1

1. Choose one ecosystem to investigate from the available list of ecosystems.

- ☐ coral reef
- ☐ tropical rain forest
- ☐ temperate forest
- ☐ stream
- ☐ open ocean
- ☐ arid desert

2. Record the ecosystem type in Part 1 of your **Observation Form**.

3. Use the Internet and other classroom resources to identify between 2–3 example organisms in Part 1 of your **Observation Form** that serve in each of the following roles: producer, consumer, and decomposer.

4. Identify and record which trophic level these organisms are likely to be found in: primary producer, primary consumer, secondary (or 2nd level) consumer, and tertiary (or 3rd level) consumer.

5. Define the boundaries of your ecosystem by identifying where and how energy leaves the ecosystem.

Part 2

6. Review the data presented in Part 2 of the **Observation Form** to prepare for a whole class discussion. Ask questions to ensure your team understands the data and units presented.

Part 3

7. Record the name of your group's chosen Ecosystem Type in Part 3 of the **Observation Form**.

8. When shared by your teacher, record the average energy for primary producers in your chosen ecosystem.

Use all of the available data from Parts 1, 2, and 3 in your Data Analysis to construct a model that describes and quantifies the flow of energy in your chosen ecosystem.

OBSERVATION FORM
LION'S SHARE OF ENERGY

NAME: _____

DATE: _____

Part 1: List example organisms in your selected ecosystem. Include the role and likely trophic level of each organism.

Ecosystem Type:		
Organism	**Role**	**Trophic Level**
Ecosystem boundaries:		

Part 2: Sample Ecosystem Trophic Level Data (aquatic environment, Silver Springs, FL)

Trophic level	Average Energy (kcal/m^2/year)
Primary producer	7500
Primary consumer	1100
2nd level consumer	100
3rd level consumer	10

Source: Howard T. Odum, "Trophic Structure and Productivity of Silver Springs, Florida," *Ecological Monographs* 27, no. 1 (1957): 106–107. Note that values have been rounded.

Part 3: Total Average Energy in Your Chosen Ecosystem

Record the average energy for primary producers for your chosen ecosystem (as supplied by teacher).

Ecosystem Type	Average Energy for Primary Producers (kcal/m^2/year)