Seeing the Bigger Picture

Ecological Energy Pyramids and Science Illustration

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Grade Level	9th – 12th Grade	**Time Frame**	130-160 minutes
Subject	ICAP, Science	**Duration**	3-4 periods
Course	Biology I, Environmental Science		

Essential Question

How does energy flow through a food web? How is illustration used to convey scientific information?

Summary

This lesson introduces the idea of energy flow in ecosystems using energy pyramids. It also exposes students to a career in scientific illustration. Students participate in a game that models energy flow through trophic levels and calculate the transfer of energy up an energy pyramid. After learning about the career field of scientific illustration, students create an infographic that uses illustration to communicate each student's understanding of energy flow through food webs. While students will not explore it at a detailed level, it is recommended that students have familiarity with cellular respiration to help them connect their new learning to its context.

Snapshot

Engage

Students brainstorm what plant and animal functions require energy and review respiration.

Explore

Students play an interactive energy pyramid game.

Explain

Students calculate the percentage of energy transferred in their game and develop an understanding of relevant science concepts.

Extend

Students explore the career of a scientific illustrator.

Evaluate

Students play the role of a scientific illustrator and create an infographic to explain what they've learned.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-LS2-4: Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Oklahoma Academic Standards (Biology)

B.LS2.4 : Use a mathematical representation to support claims for the cycling of matter and the flow of energy among organisms in an ecosystem.
B.LS2.4.2: At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level.

Oklahoma Academic Standards (Biology)

EN.LS2.4 : Use a mathematical representation to support claims for the cycling of matter and the flow of energy among organisms in an ecosystem.
EN.LS2.4.2: At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level.

Attachments

- Energy Pyramid Game Cards - Seeing the Bigger Picture - Spanish.pdf
- Energy Pyramid Game Cards—Seeing the Bigger Picture.pdf
- Energy Pyramid Game Teacher Guide—Seeing the Bigger Picture.docx
- Energy Pyramid Game Teacher Guide—Seeing the Bigger Picture.pdf
- Lesson Slides—Seeing the Bigger Picture.pptx

Materials

- Lesson Slides (attached)
- Energy Pyramid Game Cards (attached; one card per student)
- Energy Pyramid Game Teacher Guide (attached)
- Trophic level cards
- Calculators (optional)
- Chart paper
- Printer paper
- Sticky notes (optional)
- Markers, colored pencils, etc.

Engage

Teacher's Note: Lesson Preparation

Prior to teaching this lesson, review the attached **Energy Pyramid Game Teacher Guide** and **Lesson Slides**. **Slides 10** and **12** are blank for you to enter your class-specific instructions for calculating energy flow and reading.

Use the attached **Lesson Slides** to guide students through the lesson. Keep in mind that you can edit, add, or omit slides to suit class needs.

Using **slides 2–4**, introduce the lesson title, Essential Questions, and Lesson Objectives.

Display **slide 5** and begin by having students use the Tell Me Everything strategy to brainstorm what they know about (1) cellular respiration and (2) the functions for which plants and animals use energy. This can be done independently, in small groups, or as an entire class directly on the board/chart paper.

As a class, discuss their ideas about how energy is used (e.g., growth, reproduction, hunting, digestion, blood circulation, etc.). Ask where the energy for these things comes from. Briefly review the function of cellular respiration with students. They will not be discussing the inputs and outputs in this lesson, but they should remember that respiration produces energy.

Teacher's Note: Guiding Class Discussion

Be sure that students can explain that our bodies break down food into the sugars that are then used in cellular respiration. It is important that they see how eating is related to energy but that eating itself is not what gives us that energy.

Explain to students that they will be exploring how energy flows through a food web of organisms in an ecosystem.

Explore

If students are not already familiar with the concept of **trophic** levels, take a moment to explain that trophic levels refer to organisms that occupy the same level in a food chain. If they are familiar already, ask for a volunteer(s) to explain what distinguishes different trophic levels from one another (e.g., primary consumers are herbivores, secondary consumers are omnivores or carnivores that eat herbivores, etc.).

Explain to the students that they will be playing a game that models how energy moves through trophic levels in an ecosystem. Specify that they are only tracing the energy used and passed on at each trophic level, not the amount of food being eaten. Refer them to the previous discussion about eating vs. producing energy.

Prepare students to play the trophic energy game. Review the **Energy Pyramid Game Teacher Guide** in advance for detailed setup instructions and facilitation details. Each student should receive one card cut out from the **Energy Pyramid Game Cards** handout. Students will need basic calculators to fill out the game cards. Go to **slide 6** and review the instructions for how to fill out the cards. This slide is animated to illustrate each step so there is no ambiguity for the students.

Have students complete three rounds of energy exchanges where each student receives energy from the trophic level directly under them in an energy pyramid, or from the sun in the case of producers. **Slides 7–9** have instructions for each round. Be sure to change the colors on the slide to reflect the colors you have used for each of your trophic levels.

Teacher's Note: Contextualizing

Since the game operates at the scale of a trophic level, it may help students understand the concept more concretely by having them think of themselves as *all* of a given organism in an environment. For example, one producer might represent all the grass and another all the trees in the ecosystem, while a tertiary consumer might represent all the wolves in an ecosystem.

It may help to contextualize the game in terms of calories if students are having a hard time making the conceptual distinction between food and energy. Each game card lists energy in kilocalories. Calories are a measurement of energy and can be thought of in the game as a representation of however much food organisms had to eat to produce that much energy. For a concrete analogy, a person who eats one McDonald's cheeseburger and a person who eats 10 cups of plain popcorn could both produce about 300 kilocalories of energy from what they ate. Even though the amount of food they ate is different, once the food is broken down in their bodies, it produces the same amount of energy for each person.

Explain

Go to **slide 10**. After students have individually calculated their final energy at the end of Round 3 of the game, have them sum the final energy values for all the students in each trophic level. Next, have students calculate the percentage of energy transferred between each trophic level. The exact numbers will vary from class to class, depending on how students are grouped during the game, but it should be approximately 10% for each transition.

Go to **slide 11**. Ask students what they can conclude based on these results. Ask students to identify some of the limitations of the model (e.g., no omnivores; calculations at the scale of trophic levels, not the population levels where energy transfers occur).

Teacher's Note: Class Sizes and Precision

The trophic level game has been tested with class sizes of 10, 20, and 30 with resulting energy transfers between trophic levels of 7–14%.

It will likely be necessary to reinforce for students the idea that their class size is very small relative to populations in an actual ecosystem where interactions are more complex and the percentages are more stable over time. Have them round to the nearest ten (e.g., 9% would round up to 10%, 12% would round down to 10%, etc.) if you think it will help make the idea more recognizable to students.

Next, go to **slide 12**. Have students read a text over energy transfer in ecosystems and food webs. If you do not have a textbook with appropriate content, students can read the text and watch the videos in this CK-12 Flexbook: 6.4 Trophic Level.

Go to **slide 13**. Split the class into small groups of 3-4 students to complete the Strike Out strategy. They should not reference the reading or other class materials while trying to come up with their ideas, instead developing the big ideas from memory. Have groups share out their answers as a class and fill in any blanks they have in their conceptual understanding as necessary. Consider posting the students' ideas in a public place for them to reference or copy down later.

Extend

Go to **slide 14**. Play the following videos for students as an introduction to the career of scientific illustration. The first video discusses what the job of a scientific illustrator entails and the second describes how a person can enter the field. Prompt students to think about what the experience of being a scientific illustrator would be like.

Embedded video
https://youtube.com/watch?v=6hmbGg9rMWQ

After watching the videos, go to **slide 15**. Ask students to use the Looks Like, Sounds Like, Feels Like strategy to imagine they are a scientific illustrator and describe what their career would be like. Students can put their answers on sticky notes and hang them up on the board or a designated chart paper for each of the three "...like" categories or record their ideas on their own paper. Ask students to share out some of their descriptions to get a sense of what the students took away from the videos.

Before moving on, go to **slide 16**. Ask students how scientific illustration might be important for the work they have been doing so far in the lesson. You may want to broaden this question to cover anything they have learned during the year if they are struggling to identify connections.

Evaluate

Go to **slide 17**. To wrap up the lesson, assign the role of scientific illustrators to students. Ask them to explain what they have learned during the lesson. Ask each student to create an infographic that communicates, both through illustrations and explanations, how energy flows through a food web/trophic level. They should include details about the following:

- The sources of energy at different trophic levels of an ecosystem with specific emphasis on how energy is gained (i.e., through the breakdown of molecules that make up food);
- The efficiency of energy transfer through an ecosystem; and
- The ways energy is "lost" between trophic levels.

Teacher's Note: Including Additional Details

If the class is expected to be comfortable in their understanding of cellular respiration, you can also specify that they address how respiration and photosynthesis contribute to energy in an ecosystem.

Time permitting, consider doing a Gallery Walk or have students share their infographics with the rest of the class in some other way.

Resources

- Foundation, C. K.-12. (n.d.). *6.4 t*
  rophic level. CK. Retrieved January 30, 2023, from https://flexbooks.ck12.org/cbook/ck-12-biology-flexbook-2.0/section/6.4/primary/lesson/trophic-levels-bio/
- K20 Center. (n.d.). Gallery walk/carousel. Strategies. https://learn.k20center.ou.edu/strategy/118
- K20 Center. (n.d.). Tell me everything. Strategies. https://learn.k20center.ou.edu/strategy/107
- K20 Center. (n.d.). Strike out. Strategies. https://learn.k20center.ou.edu/strategy/136
- K20 Center. (n.d.). Looks like, sounds like, feels like. Strategies. https://learn.k20center.ou.edu/strategy/88
- YouTube. (2021). *Scientific Illustration I: A guided tour*. *YouTube*. Retrieved January 30, 2023, from https://www.youtube.com/watch?v=6hmbGg9rMWQ
- YouTube. (2022). *Scientific Illustration Ii: Tips from an Insider*. *YouTube*. Retrieved January 30, 2023, from https://www.youtube.com/watch?v=KvOXC2_5UCo