Georgia Performance Standards Framework for Biology 9-12

Unit: Energy Transformations
Inquiry Task

How Does Energy Flow Through Ecosystems?

Overview: This task allows students to correlate the volume of water in a container to the amount of energy available at different trophic levels of a food chain as they investigate the flow of energy in ecosystems in one direction from photosynthetic organisms to herbivores to carnivores and decomposers.

Standards (Content and Characteristics):

SB4. Students will assess the dependence of all organisms on one another and the flow of energy and matter within their ecosystems.

b. Explain the flow of matter and energy through ecosystems by
- Arranging components of a food chain according to energy flow.
- Comparing the quantity of a food chain according to energy flow.
- Comparing the quantity of energy in the steps of an energy pyramid.

SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.

a. Exhibit the above traits in their own scientific activities.
b. Recognize that different explanations often can be given for the same evidence.
c. Explain that further understanding of scientific problems relies on the design and execution of new experiments, which may reinforce or weaken opposing explanations.

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

a. Follow correct procedures for use of scientific apparatus.
b. Demonstrate appropriate techniques in all laboratory situations.
c. Follow correct protocol for identifying and reporting safety problems and violations.

SCSh3. Students will identify and investigate problems scientifically.

a. Suggest reasonable hypotheses for identified problems.
b. Develop procedures for solving scientific problems.
c. Collect, organize and record appropriate data.
d. Graphically compare and analyze data points and/or summary statistics.
e. Develop reasonable conclusions based on data collected.

SCSh8. Students will understand important features of the process of scientific inquiry. Students will apply the following to inquiry learning practices:

a. Scientific investigators control the conditions of their experiments in order to produce valuable data.
b. Scientific researchers are expected to critically assess the quality of data including possible sources of bias in their investigations' hypotheses, observations, data analyses, and interpretations.

Enduring Understandings:

- Energy flows through ecosystems in one direction from photosynthetic organisms to herbivores to carnivores and decomposers.
- The total energy found in organisms from one trophic level in a food chain is not available to organisms in the next trophic level as only a portion of energy consumed is stored as organic matter; the rest is utilized in metabolic processes or transformed into heat.

Essential Question(s):

1. How does energy flow through an ecosystem?
2. How much energy is available to be transferred to each level of a food chain consisting of grasses, grasshoppers, finches, and a hawk?
3. Why is the amount of energy not the same in all trophic levels in a food chain?
4. Why are there a limited number of trophic levels in a food chain?

Pre-Assessment:

Students will use the terms autotroph, heterotroph, producer, consumer, herbivore, carnivore, omnivore, and scavenger to create a food web. Write a narrative to describe relationships between organisms and how energy flows through ecosystems in one direction from photosynthetic organisms to herbivores to carnivores and decomposers.

Outcome/ Performance Expectations	Explain the concept of an ecosystem in terms of its components and the flow of matter and energy through the system
Write a concept statement…*How would you formulate an expert idea?*	Students must apply a given task to correlate the volume of water in a container with the transfer of energy in an ecosystem to formulate the idea that energy flows through ecosystems in one direction from photosynthetic organisms to herbivores to carnivores and decomposers.

Modified from M.R. Abraham, "Inquiry and the Learning Cycle Approach," Chapter 4, *Chemists Guide to Effective Teaching,* Prentice Hall, 2005

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Write a concept statement / question… ***What kind of situation would cause this concept to become apparent in students' understanding?***	Design and connect the food chains into a food web. This would be a collection of the class food chains derived from the given activity or model using containers and water. Decide what each of the items in the activity represent: Initial container Cups with two holes Water Cups with one hole Water dripping from cups Cups with three holes Use the terms autotroph, heterotroph, producer, consumer, herbivore, carnivore, omnivore, scavenger as you label your food web.
Identify necessary data and observations… ***What data would demonstrate the mastery of the concept by ALL students in the classroom?***	The amount of energy available to organisms at each trophic level is not constant as only a small portion of energy is stored in organic compounds the rest is utilized in metabolic processes or transformed into heat.
Write procedures that will cause students to organize data…*Test a procedure using known concepts.*	**Teacher Notes**: *Set up the materials prior to the arrival of the students or the teacher may use chalk to mark the spots in the designated test area and have the students carry the materials to the appropriate spots. When students are all in place the TIMEKEEPER (or the teacher) will shout "Start." At the end of three minutes, the TIMEKEEPER will shout "Stop."* **Student Procedures:** 1. The first student in the line will dip a cup of water from the large container and carry it to the second student in line to transfer the water. The first student needs to keep an accurate count of the number of cups dipped. This is continued for THREE MINUTES. 2. The LINE JUDGE (or teacher) should monitor for students placing their fingers over the holes in the bottom of the cups. A reminder is given to the students by the LINE JUDGE so that appropriate data can be analyzed by the class. 3. The last student in line will pour the remaining water in the container/pan at the end of the line. 4. The person at the end of the line is responsible for measuring the water in the end container and reporting the amount to the RECORDER.

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	Teacher Note: *If you have large graduated cylinders, then use them for the first few lines as they will have transferred the largest amount of water. Although a beaker or flask would be less accurate, it may be more efficient to use for the shorter food chains. The longer food chains will be able to use a smaller graduated cylinder. While the data is gathered, the first person in the line should refill the first container to begin the next trial. The first person must also report the number of cups dipped. It will be necessary to convert the number of cups into a volume to complete the calculations. Repeat the procedure a total of three times.*
Write questions or activities to use or apply the concept (represent, model, visualize, or design new experiments).	Compose an analogy that justifies the relationship between this activity and the process of energy flow. Consider all the "energy" that was "lost" to the food chain during the activity. In an actual ecosystem how would this energy be used? Students must justify their understanding of the concept below. Create a graph based on the data collected during the container activity or models. Interpret this graph and discuss the relationship between length of a food chain and energy transfer efficiency. *Teacher Note: It may be necessary to explain that in biological terms energy is considered "lost" when it is no longer usable in living things. The use of this term does not imply that the Law of Conservation of Energy is not followed, the common description of the loss of energy as heat is an example of an energy transformation.*
Safety	Be sure to follow all Chemical, Eyewear, and Glassware Safety Rules that are specified by your teacher and in all general laboratory experiences, along with all teacher instructions.
Homework/Extension **Technology**	**Students Create a Data Table** The following website has a feature that allows student to construct food webs electronically. The food web and food pyramid are from this site as well. http://www.vtaide.com/ png/foodchains.htm

Resources	Food chain http://perso.orange.fr/prof.danglais/animations/foodchain/chainreaction.swf *Video Segment* (21:43) Food Chains and Webs. United Learning (1998). Retrieved June 13, 2007, from unitedstreaming: http://www.unitedstreaming.com/ Energy Flow http://hyperphysics.phy-astr.gsu.edu/hbase/biology/enercyc.html *Video Segments* Energy Flow (02:26) From Food to ATP (01:56) Elements of Biology: Matter and Energy: Organization in Living Systems. United Learning (2006). Retrieved June 13, 2007, from unitedstreaming: http://www.unitedstreaming.com/
Instructional Tasks Accommodations for ELL Students	• Provide students with written step by step instructions for the lab procedure; keep language simple • Review step by step instructions orally; check for understanding • Provide graphic organizer for recording data from their food chain • Provide graphic organizer for recording class results on a food web • Provide a graphic organizer for the graphing activity • Check for comprehension of expectations, instructions, and relevant vocabulary before students begin a task; repeat or reinforce as needed • Modify language requirements for written assessments • Pair with more advanced native language speaking partner (allow for translation in native language for comprehension) as needed • Post all new vocabulary on a word wall; allow student to interact with the word wall using yarn to make connections between vocabulary words • Allow extended time for written tasks
Instructional Tasks Accommodations for Students with Disabilities	• **Review and Implement IEP accommodations for specific student needs** Other accommodations may include:

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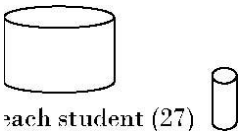
	• Post all new vocabulary on a word wall; allow student to interact with the word wall using yarn to make connections between vocabulary words • Allow extended time for written tasks • Provide students with written step by step instructions for the lab procedure; keep language simple • Review step by step instructions orally; check for understanding • Provide graphic organizer for recording data from their food chain • Provide graphic organizer for recording class results on a food web.
Instructional Tasks Accommodations for Gifted Students	Using multimedia, students research and create a food webs for other biomes or transitional zones between two biomes

How Does Energy Flow Through an Ecosystem?

Materials Needed

The actual number of each of these items will vary according to class size. The number in parentheses is based on a class size of 27) This activity is to be completed in a large outdoor area with easy access to a water source.

5 gallon containers or similar large containers (10)
Dish pans or similar medium containers (6)
Graduated cylinders (8)
Graph paper, poster or chart paper



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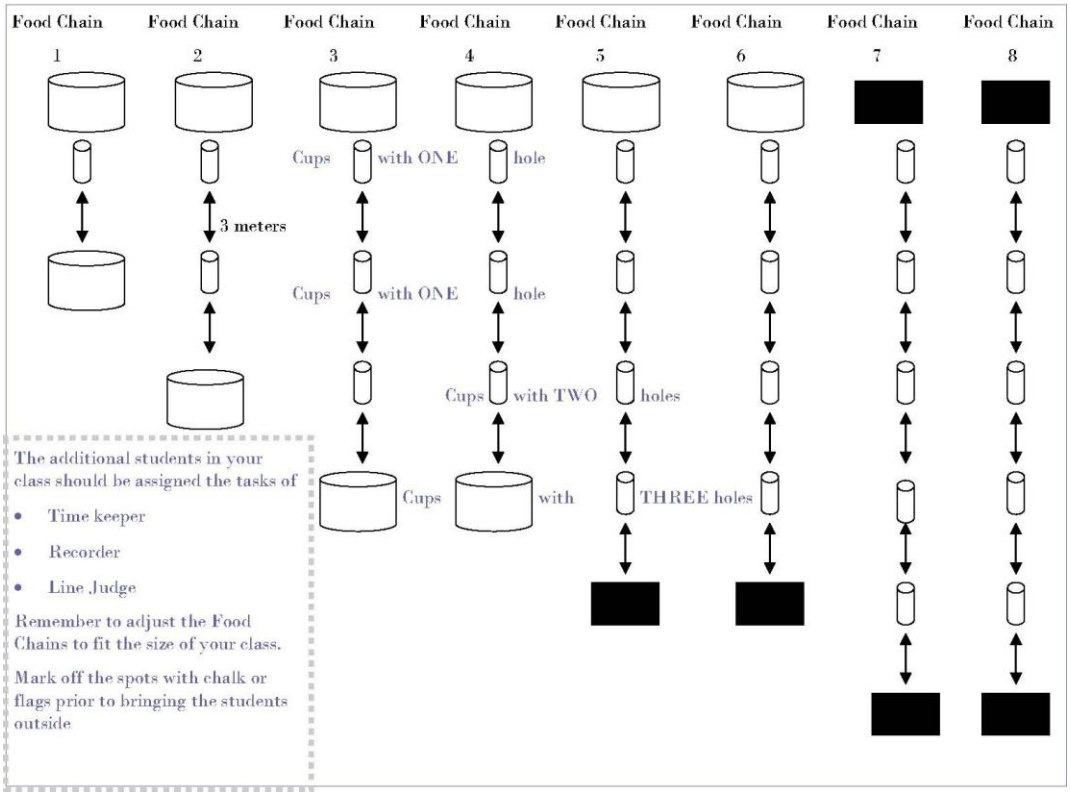
Set Up Diagram

- 20 oz cup with pencil-sized holes in the bottom for each student (27)
  15 with ONE hole, 6 with TWO holes, 6 with THREE holes
- Dish pans or similar medium containers (6)
- Graduated cylinders (8)
- Graph paper, poster or chart paper

Set Up Diagram



Procedure

- Teacher may set up the materials prior to the arrival of the students or the teacher
- may use chalk to mark the spots in the designated test area and have the students carry the materials to the appropriate spots.
- When students are all in place the TIMEKEEPER (or the teacher) will shout "Start."
- The first student in the line will dip a cup of water from the large container and carry it to the second student in line to transfer the water. The first student needs to keep an accurate count of the number of cups dipped. This is continued for THREE MINUTES.

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- The LINE JUDGE (or teacher) should monitor for students placing their fingers over the holes in the bottom of the cups. A reminder is given to the students by the LINE JUDGE so that appropriate data can be analyzed by the class.
- The last student in line will pour the remaining water in the container/pan at the end of the line.
- At the end of three minutes, the TIMEKEEPER will shout "Stop."
- The person at the end of the line is responsible for measuring the water in the end container and reporting the amount to the RECORDER. If you have large graduated cylinders, then use them for the first few lines as they will have transferred the largest amount of water. Although a beaker or flask would be less accurate, it may be more efficient to use for the shorter food chains. The longer food chains will be able to use a smaller graduated cylinder.
- While the data is gathered, the first person in the line should refill the first container to begin the next trial. The first person must also report the number of cups dipped. It will be necessary to convert the number of cups into a volume to complete the calculations.
- Repeat the procedure a total of three times.

Data Table You may want to ask your students to construct their own data table.
The following website has a feature that allows student to construct food webs electronically. The food web and food pyramid are from this site as well.
http://www.vtaide.com/ png/foodchains.htm

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Sample Data Table:

Food Chain	Trial 1 Volume taken from first container	Trial 1 Volume in final container	Efficiency of energy transfer	Trial 2 Volume taken from first container	Trial 2 Volume in final container	Efficiency of energy transfer	Trial 3 Volume taken from first container	Trial 3 Volume in final container	Efficiency of energy transfer	Average Efficiency of energy transfer
1										
2										
3										
4										
5										
6										
7										
8										

Student Page

Calculations:

Conversion from cup to mL:
Volume taken from container (mL) = Volume of cup in mL x Number times cup was filled

Calculation of efficient of energy transfer:
Efficiency = Volume of water in end container (mL) / Volume taken from container (mL) x 100

Graph the data:
Efficiency

Food chain length
Analogies:

- Decide what each of the items in the activity represent:

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Initial container Cups with two holes
Water
Cups with one hole
Water dripping from cups
Cups with three holes

Applications:

- Use examples of organisms to label each of the food chains (1, 2, 3, 4, 5 organisms). This could be assigned to the members of the food chain group and the results used as a class to construct a food web. This could also be represented in a energy pyramid.
- Connect the food chains into a food web. This would be a collection of the class food chains.
- Use the terms autotroph, heterotroph, producer, consumer, herbivore, carnivore, omnivore, scavenger as you label your food web. Teachers may choose to substitute terms commonly used in their classrooms
- Consider all the "energy" that was lost to the food chain during the activity. In an actual ecosystem how would this energy be used? Explain. In the one link food chain what process is being modeled?
- Using your graph, discuss the relationship between length of food chain and energy transfer efficiency.
- Ecologists estimate that only about 10% of the energy available at one food-chain level becomes available at the next level. Using this rule known as the 10% rule, calculate the energy needed at each level of the food chains in the activity that would be needed if the top consumer of each chain requires 2000 calories (1, 2, 3, 4, 5 organisms). Record your results in an energy pyramid.

Student Page

Procedure:

1. You will need to pour the water from your cup into the cup of the person behind you. If you are the FIRST person in line, you will need to count the number of cups you remove from the container. If you are the LAST person in line, you will need to measure the amount of water in the last container/pan.
2. Timekeeper: Start the energy transfer. Allow the transfer to continue for 3 minutes. Stop the transfer.
3. Line Judge: Monitor the passing of the water. No fingers over the holes. The water must be poured. Cups cannot be traded.
4. Recorder: Collect the number of cups the first person in each line removed and record in the data table. Record the amount of water in the final container/pan from each line.

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Data Table:

Food Chain	Trial 1 Volume taken from first container	Trial 1 Volume in final container	Efficiency of energy transfer	Trial 2 Volume taken from first container	Trial 2 Volume in final container	Efficiency of energy transfer	Trial 3 Volume taken from first container	Trial 3 Volume in final container	Efficiency of energy transfer	Average Efficiency of energy transfer
1										
2										
3										
4										
5										
6										
7										
8										

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