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Transfer of Energy through a Food Chain

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by Joseph Jackson

Introduction / Rationale

If plants could not produce their own food, then there would be little life on this planet of ours. Plants are not only the basis of the food chain, but they also produce the oxygen we need to live and breathe. This unique ability comes from the miracle of photosynthesis and their capacity to store energy in chemical bonds that consumers eat to get the energy they need to survive. Energy is defined as the capacity to do work and all organisms need it to survive. The first law of thermodynamics states that energy can neither be created nor destroyed, only transformed from one form to another. Plants start this process by transforming the radiant energy of the sun into sugar. Consumers take advantage of this as their primary food source. After the consumer's life cycle is complete and the consumer is no longer alive decomposers come along and break the organisms down. This relationship returns the organism's remains back to the soil for the plants to start anew. Food chains are nature's way of transferring energy, allowing life to continue to grow, repeat, and the basis for this unit.

I teach in an urban, Title I elementary school where several of the children's parents are working more than one job and don't get to spend the time with their children that they would like. When they reach fifth grade, they are below grade level in multiple subjects and it takes a lot to get them to where they need to be. Our school uses departmentalized block periods, so 80 minutes per block allows me time to cover certain ideas in much detail. After getting to know my students, I find what their interests are and ways to better motivate them. An excellent hook is relating material to animals and the world around them.

With curriculum pacing in mind, I am always looking for ways to better integrate ideas within application. Science is a subject where boundless cause and effect relationships occur, and when observed and documented, lead to repetition and cycles. Because of this, there are many connections between interrelated ideas. This unit allows the concept of energy transfer to be modeled from its beginning to end. Life continues this planet because of the relationship between plants and animals. Plants need animals for carbon dioxide and animals need plants for food and oxygen. The driving force for this relationship is the energy of the sun, but the real miracle is that plants can make (or produce) their own food. Tremendous amounts of energy come from the sun, but only a small portion of it is used by plants for this process. Producers store energy in chemical bonds creating organic compounds that can last for a long, long time. Animals consume plants to get the energy they need to live. All of these organisms live, breed, and die. Then it's up to the decomposers to come along and recycle it all, putting the nutrients back in the ground and starting the process anew. It is this circle of life that sustains everything else and what we will investigate in this unit.

Content Objectives

Light Energy

The source of energy for most life on this planet comes from sunlight. When you think of light, one tends to consider only what you can see, but there is much more to ponder! When it's dark you need something to illuminate things so you can see, like a flashlight, a lamp, or a candle. You stand outside in the sun when it is daylight and you can see because it's not dark. When you feel the warmth of the sun on your skin, one quickly starts to question if you need sunscreen. You see a sunrise or sunset and wonder how something can be so beautiful. As a child, I can remember seeing a rainbow and wondering what kind of magic put that there. Was it a leprechaun leading you to their pot of gold? There is no magic or leprechauns; it's the natural world of Science and light traveling through a medium, being absorbed by matter, or reflecting off a surface. All these things that we can see are an effect of light, which is radiant energy from the sun. Yet the strange thing you need to comprehend is that this energy has characteristics of both a wave and a particle. The wave is based on the light energy's frequency and wavelength. The packet of light energy known as a photon is what we will first discuss.

Before opening a unit, I like to get an idea of the student's prior knowledge to gauge their understanding. This also helps address misconceptions that will arise during the lessons that can be used as teachable moments. I use interactive notebooks in class, so the first page is always entitled "What I Know". Our content standards are already written on the board at the start of each unit, so I ask the students to simply tell me anything they know about them and any connections they are aware of based on other content that relates to the discussed topic. After this informal assessment, we begin with the lesson.

Light is a form of energy coming from the sun, which is about 93 million miles away. It takes about 8 & ½ minutes to get here traveling at the speed of light, which is 186,282 miles per second (299,792 kilometers per second). It can exist as both a particle and a wave. “In physics, a photon is a bundle of electromagnetic energy making the basic unit that makes up all light and is sometimes referred to as a "quantum" of electromagnetic energy.”[1] This principle eludes that some photons are absorbed giving off heat and some materials emit electrons after absorbing a photon. “This process is called the photoelectric effect. The photoelectric effect is a property of light that is not explained by the theory that light is a wave, leading scientists to treat light as both a wave and a stream of particles”[2] With an idea as abstract as moving particles of energy, I need something to give students to link ideas to. A video segment from Discovery Education or BrainPOP comes in handy about photons and what they are!

Next, we consider the concept of light as a wave. To do this, we will discuss what a transverse wave is. “Transverse waves are waves in which the oscillations are at right angles to the direction of energy (wave) movement.”[3] This back and forth movement is a way of measuring and comparing different wavelengths (distance between successive wave crests) based on comparisons to the X-axis and its frequency or number of wavelengths per second. Simply put, frequency is how many cycles have been completed in one second (usually crest to crest or trough to trough). This translates into comparing short, strong frequencies of energy to long, weak frequencies. An excellent way to model this is with a slinky on the floor by undulating it back and forth. Quick movements represent high energy, while slow movements represent low energy. I also include Flocabulary and Bill Nye the Science Guy video segments. My students respond very well to both video platforms because they are entertaining, presented on a child's level, and understandable. Frequencies and wavelengths are the basis of understanding the next concept dealing with the Electromagnetic Spectrum.

Energy comes in many forms and light and its many parts are no exception. "Light is energy in motion and the amount of energy transmitted through light is based entirely on the light's frequency or wavelength, so the higher the frequency, the more energy."[4] "Light consists of a combination of electric and magnetic fields called electromagnetic waves."[5] This spectrum consists of seven different parts based on their wavelengths which include: Radio waves, microwaves, infrared, visible light, ultraviolet, X-ray, and gamma rays. When you think of light, you think of being able to see it; well, the only part detectable to humans is visible light (hence the name). Radio waves, microwaves, infrared, and visible light are longer, weaker, lower energy wavelengths that are not harmful (non-ionizing radiation). On the other hand, ultraviolet, X-ray, and gamma rays are shorter, stronger, higher energy wavelengths that are quite harmful (ionizing radiation). "Ionizing radiation in high-frequency, tiny-wavelength light (from ultraviolet light to X-rays and gamma rays) pack such an energy wallop that it can knock electrons right out of their atoms, making for an unstable chemical situation. These reactive atoms are called free radicals and are infamous for their destructive effects."[6] What is important to the lesson is for students to distinguish the differences in wavelengths and types of energy, but more importantly they understand the visible light spectrum and what colors really are.

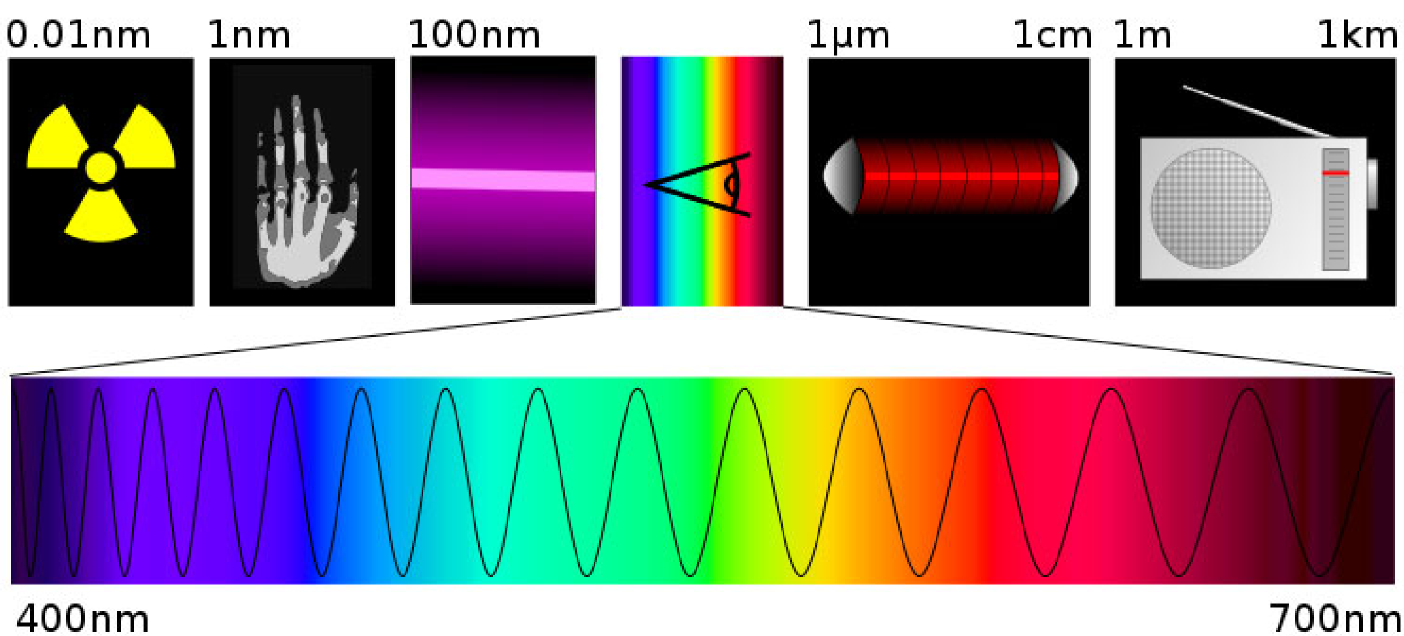

Figure 1. Electromagnetic Spectrum. https://commons.wikimedia.org/wiki/File:Spectre.svg (Accessed July 31, 2019)

Electromagnetic radiation is classified only by its differences in amounts of energy. The entire electromagnetic spectrum consists of sunlight. "Light consists of electromagnetic waves of particular frequencies and wavelengths but is commonly referred to and dramatically represented as rays."[7] A ray is the straight line, in this case representing the path of white light. With a prism white light can be separated into the colors of the rainbow. ROYGBIV is an acronym for the colors in wavelength order from longest to shortest. Red is the long, weak side of the color spectrum and violet is the short, strong side with the other colors following suit in between. Colors are measured in nanometers (nm) in wavelength intervals. The color red bottoms out at 740nm and violet extends to 380nm. “It’s the infrared that makes you sweat on a hot day, but it’s the ultraviolet that can give you a sunburn or worse.”[8] We have come to the point where you may be asking yourself what different wavelengths have to do with plants. The answer is that plants like certain parts of visible light more than others in photosynthesis operations. Next, we will discuss how plants produce their own food and how this energy is part of the process.

Photosynthesis / Energy to Matter

Life on Earth exists because plants have the capability to make their own food. This process is called photosynthesis and is a vital link in the complex web of life. It is an essential process animals need plants to be able to do. “It is without a doubt, the most important biochemical reaction for life on Earth.”[9] When I begin our discussions about plants, I tell the students that plants perform a miracle. They don’t have to hunt or scavenge for their food like animals do; this uses energy. They don’t have to go to the grocery store and get it from elsewhere like us humans do. They just stay right where they are and let all the materials they need come to them. Just the term photosynthesis itself means, to put together (synthesis) with light (photo). I tell my students that plants eat sunshine and poop out oxygen. In a generalized sense, that is only half and it is much more complicated, but it gets their attention and sticks in their head.

Photosynthesis is the autotrophic (self-feeders) process by which plants use sunlight, water, and carbon dioxide to live. These components are used along with chlorophyll to convert them into food, which is used for energy. Oxygen is a byproduct of this process which is released into the atmosphere because they have no use for it. All plants use photosynthesis, so they all need sunlight. The idea that every type of green plant makes their own food is essential to understand. Students will need the context of this material to further build on new and interrelated plant and life science materials.

Plants’ survival depends on their ability to make food. Food is made in the leaves of the plant. It is here where materials are collected and used so this complex process can take place. We will begin with the ingredients, so we know how the materials get to where they need to be (the leaf). Water, carbon dioxide, sunlight, and chloroplasts are needed for the process to begin. Water is sucked up from the soil through the root system. It is then transported through the stem to the leaf. Carbon dioxide enters the leaf through tiny microscopic holes or pores in the leaf called stomata. Sunlight’s energy is absorbed by the leaf and collects inside the plant cells. The main organelles (cell parts) in the cell are called chloroplasts. Chloroplasts contain a green pigment called chlorophyll. This is where the sun’s light energy is used to power photosynthesis. Amazingly these organelles can move around in the cell based on the intensity and direction of light being collected for the best absorption possible. In this process, a type of sugar (called glucose) and oxygen are made. Oxygen is not wanted, so it is released through the stomata. Water is released through the stomata as well. This water vapor is part of the water cycle we know as transpiration. The chemical formula for photosynthesis is:

$6CO_2 + 6H_2O + \text{Energy} \rightarrow C_6H_{12}O_6 + 6O_2$.

If you remember the joys of balancing an equation you will first notice that it requires six molecules of both carbon dioxide and water to make one molecule of glucose (simple sugar). Leaves are the primary food-producing part of the plant and all photosynthetic activity takes place here. This paragraph is the simplified version of this chemical reaction. We will now discuss more detailed chemical aspects of photosynthesis for content knowledge so that an educator really knows what is going on.

As I have previously stated, “Photosynthesis a complex series of reactions, driven by light energy absorbed by chlorophyll and other pigments, that results in the synthesis of organic compounds from carbon dioxide and water.”[10] We will now analyze these complex reactions in their simplest forms. There are two separate processes occurring, making the molecules and then storing them. Light absorbing chlorophyll captures energy from light and uses it to oxidize water. This causes water molecules to split apart (oxidation) causing it to energize and turns it from a low energy chemical to a high energy chemical. Oxygens from water molecules pair up and go one way and hydrogens then mix with parts of carbon dioxide to make carbohydrates (reduction) that the plant uses for food. The process gives us energized electrons to produce and store chemical energy in two high energy compounds. The first is called ATP (Adenosine triphosphate). The second is called NADPH (Nicotinamide adenine dinucleotide phosphate). There are two types of reactions in photosynthesis: light reactions (requiring light) that form energized electrons and dark reactions (not requiring light) that use energized electrons. The process where ATP & NADPH compounds are produced occurs in the light reactions. Next comes the complicated process of glucose synthesis called the Calvin Cycle. The light reactions process is known as the Z Scheme (a.k.a. energy transduction) where light energy is converted into electrical energy by exciting chlorophyll with photons. This is where those little packets of light energy (photons) allow electrons to transfer to NADPH. It takes two stages because the photon doesn’t carry enough power, so it must happen twice. There are two photosystems labeled PSI & PSII and there are two types of chlorophyll (types a & b) that allow it to occur. It occurs in two stages of a strong oxidant (PSII) and a weak oxidant (PSI). Chlorophyll a absorbs higher energy (blue, indigo, violet) wavelengths, while chlorophyll b absorbs lower energy (red, orange, yellow) wavelengths giving it the energy required to complete the reaction. It is here where solar energy is absorbed and electrons can transfer completing compound transformation from solar energy into chemical energy stored within carbohydrates. The final photosynthesis process is the dark reaction where carbon dioxide is reduced and electrons are accepted. This process requires a series of biochemical steps; therefore, it will not be covered in this material. This is a very complicated process for those of us who don’t have chemistry degrees, but incredibly important in the bigger picture of life on this planet. We have talked about sunlight, photosynthesis, and the energy involved in the process. We will now talk about how plants provide the energy for the rest of the organisms on the planet and how they use this energy and return it back into the system to be reused.

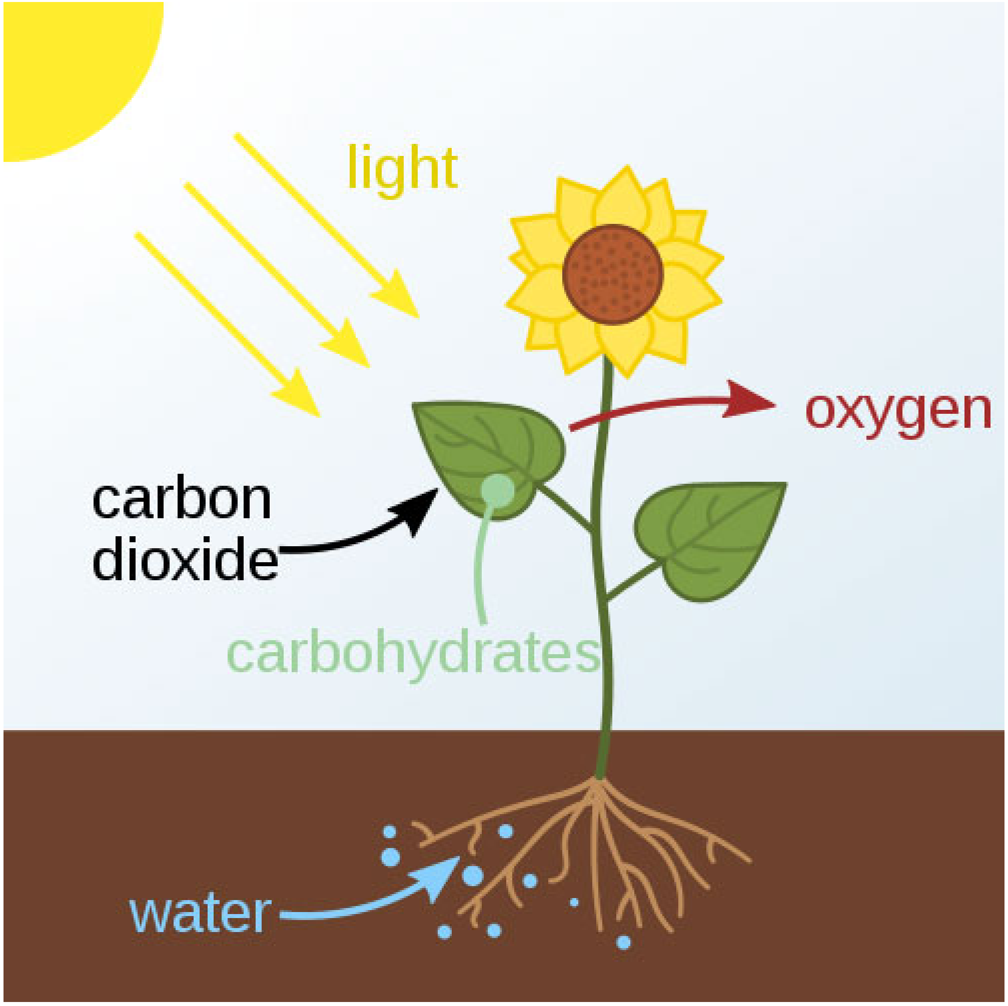

Figure 2. Photosynthesis. https://commons.wikimedia.org/wiki/File:Photosynthesis_en.svg

(Accessed July 30, 2019)

Ecosystem / Energy Transfer

All living things must have energy to survive. We have spoken in depth of the sun emitting electromagnetic radiation and plants using certain parts of that energy to make food for their own survival in the process of photosynthesis. We will now begin to look at how this energy is transferred to other organisms. Consumers eat food to get the energy they need to survive. When food is consumed by organisms it is digested and the bonds within the food are broken, releasing the energy they need. This process is known as cellular respiration and amazingly it is the exact opposite of photosynthesis. The chemical formulas are:

Photosynthesis

$6CO_2 + 6H_2O + \text{Energy} \rightarrow C_6H_{12}O_6 + 6O_2$

Cellular Respiration

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$

Instead of making bonds and storing energy in photosynthesis, cellular respiration breaks the bonds and releases the energy. Also, instead of organisms releasing oxygen like plants do, they release carbon dioxide, which is exactly what plants need to continue their process of photosynthesis. This balancing act is a symbiotic relationship also known as interdependence. We are now ready to consider a bigger picture in this energy transfer across organisms known as ecosystems.

An ecosystem is the relationships within a community between living and nonliving things. Plants produce the food and animals consume plants and other animals. Decomposers recycle all living organisms in this revolving process. “Two basic laws underlie ecosystem function: Nutrients constantly cycle and recycle within and among ecosystems, while energy moves through ecological communities (the various populations of interacting organisms that inhabit ecosystems) in a continuous one-way flow.”[11] Detritivores (earthworms) and decomposers are the main organisms that contribute to this nutrient cycle. Returning nutrients back to the soil allows for this process to ever continue by giving plants back the nutrients they need. As previously stated in the first law of thermodynamics, energy can neither be created nor destroyed only transformed from one form to another. Decomposers are a vital link in an ecosystem’s ability to recycle needed matter, not only by putting it into the soil, but by providing matter for the carbon and nitrogen cycles as well.

Ecosystems consist of food chains and food webs. Food chains consist of organisms consuming (eating) one another for sustenance in the ecosystem. This is based on predator, prey relationship where one organism is the hunter and the other is the hunted. Last there are three types of organisms starting with a producer, a consumer, and then ending with a decomposer. Hence, what an organism eats determines where they are in the order of the food chain. We also have three types of consumers ranging from herbivores (plants only), carnivores (meat eaters), and omnivores (both meat and plants). Each level of a food chain represents a different trophic level, or number of steps the organism is from the start of the food chain. An example of a food chain would be as follows:

-Grass (producer) is eaten by a grasshopper (herbivores/omnivores which are primary consumers).

-Grasshopper (herbivore) is eaten by a frog (carnivores/omnivores which are secondary consumers).

-Frog (carnivore) is eaten by a snake (carnivores/omnivores (sometimes) which are tertiary consumers).

-Snake (carnivore) is eaten by a hawk (carnivores/omnivores (sometimes) apex predator).

-Everything listed above is decomposed by fungi. Nutrients are broken down and returned to the soil.

The energy is transferred from the producer to the different types of consumers, on to the top predators, and then to the decomposers to be broken down and put back into the system so the plants can start over. Complex overlapping food chains then create food webs, leading to the broader idea of a biosphere or the sum of all ecosystems. Finally, this energy transfer process can also be viewed in a different way. The small amount of energy that is passed on can be observed as an energy pyramid.

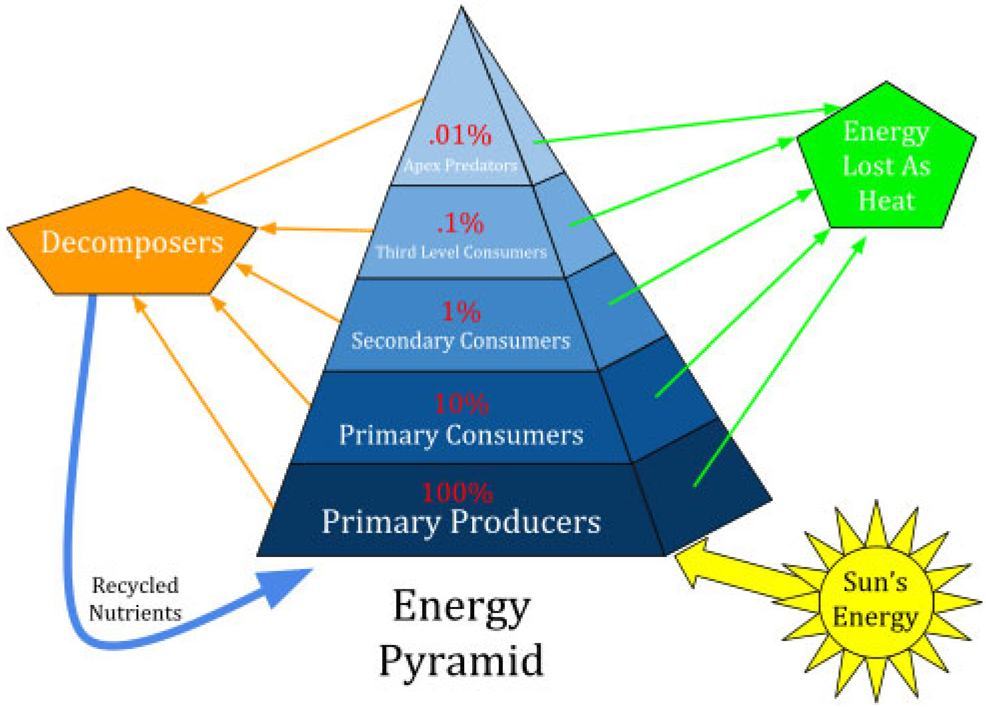

Figure 3. Energy Pyramid. https://commons.wikimedia.org/wiki/File:Ecological_Pyramid.svg (Accessed July 29, 2019)

In an energy pyramid, we model the energy that is transferred through the system. Producers go on the bottom and predators on the top (trophic levels). Only about 10% of the actual energy stored in an organism is passed on when it is consumed by another. This pyramid shape represents the flow of energy because of the way that energy is used up and lost throughout the system. We will model the food chain moving a trophic level up the pyramid each time. The grass is the primary producer at 100%. The grasshopper being the primary consumer is at 10%. The frog is the secondary consumer at 1%. The snake is the tertiary consumer at 0.1% and the falcon is the apex predator at 0.01%. Please note that 90% of the energy is lost each time you go up a level in the pyramid which is all from heat loss! This means that the falcon will need to eat several snakes to get enough energy to survive and so on, and so on, back down the pyramid for each level down.

One final note, all my examples have been that of terrestrial creatures. Please don't leave out our aquatic examples! The main terrestrial producer for land is green plants. The main aquatic producer for the ocean is phytoplankton. Both producers are at the beginning of the food chain, but both are enormous manufacturers of oxygen as well! So please keep in mind, all organisms are dependent upon photosynthesis, their organic structure, their oxygen production, and their energy whether they exist on the land or in the sea!

Teacher Strategies

The main instructional strategy that I use is Interactive Notebooks. This is helpful in so many ways! First, we start with the act of note taking and learning how to paraphrase information to take notes more efficiently. The next main goal is using the information that they are given on premade note sheets and turning them into symbolic representation. I start off by assessing prior knowledge, we cover misconceptions that come up and then introduce the information. We read the notes together, pull out main ideas, summarize, clarify, compare and contrast, sequence, classify, and find cause and effect relationships to name a few. Whenever we are using our notebooks, we are journaling, note taking, and using graphic organizers that are reviewed and monitored. Some of my favorite graphic organizers include venn diagrams, flow charts, and KWLU charts (what I know, what I want to know, what I learned, and how will I use it). We constantly check with informal and formal assessments simply by drawing pictures and taking notes. We include a vocabulary section and a historian section as well. By far, the most important aspect of this notebook is for my students to be able to make a memory key by drawing a picture to explain a concept. Before an assessment, I allow time for them to make a memory key for extra credit. My goal is to train them to make it for themselves instead of me so they will actually use it on the test.

I am a firm believer that science is not learned in a book, but by doing, experimenting, and using inquiry to make new discoveries and interdisciplinary connections from one concept, use, or application to the next. Much of our fifth-grade content is based on abstract ideas, so I use as many demonstrations that I can think of to interest them and raise their curiosity. I love using scientific phenomenon or "magic" to hook them with a concept or idea. We create acronyms for students to use, making studying and memorizing bigger chunks of information easier. An example is the scientific method, which I have broken down into five steps (observe, hypothesis, experiment, results, & conclusion). We turn that into OHERC and something silly like "only humans eat rusty cookies". This allows them to make content easier on their memory key, so that they will use it when the assessments are only trying to trick them. N.O.S. stands for the "Nature of Science" and is a list of several guidelines for them to follow when thinking about scientific theory. We constantly use reading and math skills to make connections and reinforce ideas and strategies. One of my favorite strategies is called "Social Discourse Circles" where we use sentence starters to generate discussion. My goal is to have them stand behind their decisions but be able to debate them with others in a civilized manner (argue in an agreeable manner). I also use foldables (creative graphic organizers by Dinah Zike) as much as possible to make work, organization, sequence, and classification skills easier. Another favorite I have is using an LCD display and showing them science content movies like Bill Nye the Science Guy. We are also lucky to have computer resources like BrainPOP, Flocabulary, Discovery Streaming, Physics in the Classroom, and Gizmo's (Explore Learning) to name a few.

We are required to have word walls, so I use them for many things that help review concepts previously taught. Just a couple are "name that concept", "what is that related to", "and who can use that in a sentence." We constantly summarize nonfictional science content books for extra credit and play a game called Google the Unknown. When something comes up that I don't know, google it and teach it to the class later for extra credit.

Finally, specific strategies and demonstrations for this unit included in the light lesson are: create a power point, radio antenna experiment, demonstrate infrared light with a tv remote, refract light with prisms, refract light with special glasses, refract light with water in a glass (pencil, thumb, & a solution and laser), model wavelengths with a slinky, hit translucent rocks/materials with a laser, refract light with concave & convex lenses, refract light with a spoon, put the colors of the rainbow back together with a color wheel and make observations with UV light (bugs, the bathroom floor, tonic water, and a secret message pen). I also get X-rays from hospitals and show them to the students.

Plant activities include many AIMS activities (Activities Integrating Math & Science) and science content games. We also act out several situational things with sock puppets.

For ecosystems we use Aquatic & Terrestrial pictures of food chain/food webs and play a predator / prey game, name that habitat, and classroom jeopardy.

Last, for this unit we will have a culminating activity where we create a diorama of an ecosystem of their choice and model it. It can be aquatic or terrestrial. They can also make a power point if they choose.

Classroom Activities

Prior to this unit, students have been taught the sequential practice of using the scientific method and all its parts: observation (question, predict), hypothesis (educated guess), experiment (test it), results (collect data), and conclusion (summarize). At the beginning of each unit, students have concepts introduced using interactive notebooks. We gauge prior knowledge, introduce the concept, and make symbolic representations from premade notes to give context to what is being taught. We will consider each lesson taking 45 minutes.

Lesson 1: Students begin with the phenomenon of using a prism to separate white light into the colors of the rainbow (best done outside using natural sunlight). As students inquire about what is going on, they journal their findings by taking notes and drawing pictures. After 10 minutes, we come back to the classroom and share out our findings. The concept of refraction is discussed, leading to the colors of the rainbow and ROYGBIV. Conclusions are drawn, leading into tomorrow's lesson.

Lesson 2: We start off by reviewing what took place with the prism and how light was refracted. We lead this into another demonstration with a clear glass, water, a sticky note with a smiley face drawn on it, and a pencil. Start off with the face on the sticky note centered under the clear, empty glass where it is visible. Review the idea of angles and what 45 degrees is. Have students place their eyes 45^{o}'s above the glass so they can see the face through the side of the glass. Another student pours water into the glass (about 2/3's full) and they observe the face disappear. Phenomenon is discussed and journaling takes place. After adequate time is given, provide paper towels and have them stick their thumb into the water of the glass and see what takes place (their thumb will get bigger). Finally, insert a pencil in the glass with the water in it and observe what happens (pencil looks bent). Students journal and share out their ideas of refraction and what is taking place (light travels slower through glass and water than it does through air). Students share out ideas and conclusions are drawn.

Lessons 3 & 4: We review what took place the past two lessons and infer that there is more to light than just being able to see. Students are introduced to the Electromagnetic Spectrum and all seven of its parts with attention paid to the visible light spectrum. After discussion, I point out the idea that light is energy and energy can be measured by what we call a transverse wave. We then discuss a cartesian coordinate system and how it relates to graphs and measurement (keeping it basic, but applicable). I then narrow it to the components of the transverse wave and its main parts and definitions (x-axis, y-axis, peak/crest, trough, wavelength/type of light, amplitude/intensity, and frequency). After the idea of light energy traveling in a wave is covered, I touch on how light can also be classified as a particle, or photon. These are abstract concepts, and along with the math involved, I give several examples for the students to relate to. I have split this lesson in two parts because so much is going on and several students will need more time with these concepts. Students share out, journal, and have discussions on their findings.

Lesson 5: While teaching photosynthesis we can start off with three demonstrations to show some of these processes in action. 1) In the morning, bring the children outside and have them place a zip lock bag around a green leaf of a tree (zip it shut as close as you can to the stem of the leaf). Come back out at the end of the day and the children observe the bag full of moisture. This is the plant releasing water from photosynthesis in a part of the water cycle known as transpiration. 2) Show the children you are covering healthy grass with a board. Come back in a couple days and lift it up showing yellow grass. This is the green chlorophyll production slowing from a lack of sunlight and one of the other pigments in the chlorophyll like xanthophylls is showing (making the grass turn yellow). 3) Take a piece of romaine lettuce and put it in a clear glass jar almost full of water. Invert it in a pan with water in it and stick it in direct sunlight. Come back in a couple hours and you will see bubbles forming on the lettuce. This is oxygen being released from the leaf performing photosynthesis. This one is most interesting because you would think the lettuce is dead, but it can still perform this extraordinary process!

Lesson 6: For this lesson, have students bring in pictures of different kinds of plants, bugs, and animals (both aquatic and terrestrial). Mount pictures on cardstock, laminate, and write a number on the back of each one. Students are assigned numbers through random sampling of the organism that corresponds to the number chosen. Students then research their organism, finding out its habitat, niche in that community, predator, prey, producer, a consumer (primary, secondary, tertiary), decomposer, parasite, or host. After researching, students write a summary of their findings. All animal pictures are then put in a box for students in assigned groups to get 5 organisms (pictures) through random sampling. For the lesson to flow better, separate organisms into groups of land, water and habitat (depending on pictures of organisms). Groups take their organisms and create simple food chains with the other groups critiquing them. After everyone agrees, groups combine their food chains and make complex food webs. Students then share out their findings focusing on interdependence, systems, and relationships questioning if they are competitive or mutually beneficial to one another. This lesson should take three class periods.

Lesson 7: In this lesson, students will examine how much a tertiary consumer / apex predator needs to eat in order to sustain the energy required to survive. Before this activity, students will need to be taught how 10% of the actual energy stored in an organism is passed on when it is consumed by another. Students use the same pictures (from previous lesson) with the teacher selecting tertiary consumer / apex predator assigned to groups (all other organism pictures are placed in a box). Each group draws one organism out of the box. Groups must determine where their consumer / predator (and what they are getting ready to eat) is located at in the energy pyramid. After everyone in the group agrees, they must then deduce how much of this organism needs to be consumed in order to meet their required needs to survive. In an example, you are a grizzly bear and you drew a picture of a salmon. Where is each organism in an energy pyramid and how many salmon must this predator consume to survive? This may require students performing additional research to find out eating habits and sustainability of certain creatures.

Lesson 8: After completion of a unit, I hold a Social Discourse Circle. Students make a large group circle and use “sentence starters” which are posted in the room to help them respond to a question generated. I start the discourse with a general opinion or statement like, “What is better, Fruit Loops or Frosted Flakes”? Someone starts off by answering the question and then someone either agrees or disagrees with them. The key is that they must use a preselected sentence starter (listed below) leading them into a conversation. My goal is for them to appreciate what other’s viewpoints are and what they have to say. I also want to teach them how they don’t necessarily have to agree with someone, if they can back up a response with an intelligent reply. The hardest part is having them not talk over one another and to wait their turn. A strategy I use involves two talking sticks. When someone wants to speak, they stick their hand out, silently asking for the stick and permission to speak next. After the conversation has taken its course, a new question is generated. My main questions for this unit discussion would be: How is life sustained on this planet of ours? & How is energy transferred from one organism to another on this planet? This leads into the culminating project of how energy is transferred in a food chain.

Discourse Sentence Starters:

“I see...”

“I noticed...”

“I think that...”

“My idea is...”

“The reason I think that is...”

“My evidence is...”

“I think it’s true because...”

“How come...”

“Can you say more about...”

“I agree with ____ because...”

“I disagree with ____ because...”

“I want to add to what ____ said...”

“I want to piggyback on ____’s idea...”

Lesson 9: Our final lesson is a culminating project of this unit where a student creates a diorama or power point of an animal (of their choice) and its niche in a food chain. Students select an animal, research it, and create a flow of energy from producer to decomposer and where “their choice” fits into its niche in a habitat. The diorama or power point project represents all these features in this complex chain from the source of its energy (the sun), to its death and energy / nutrient redistribution. Students must be able to explain interdependencies, relationships, and systems that their organism is a part of. The overarching goal is for the student to realize the energy flow, originating from the sun, how it transforms from one organism to another (producer to consumer), and how it is returned to Earth (decomposer) to start the process again.

Appendix

Implementing District Standards

3.5 In third grade, the student will investigate and understand relationships among organisms in aquatic and terrestrial food chains. Key concepts include:

a) producer, consumer, decomposer

b) herbivore, carnivore, omnivore

c) predator and prey

In order to meet this standard, it is expected that students will:

- differentiate between predators and prey
- distinguish among producers, consumers, herbivores, omnivores, carnivores, and decomposers
- infer that most food chains begin with a green plant.
- identify sequences of feeding relationships in a food chain.
- explain how a change in one part of a food chain might affect the rest of the food chain.
- create and interpret a model of a food chain showing producers and consumers.

4.4 In fourth grade, the student will investigate and understand basic plant anatomy and life processes. Key concepts include:

a) the structures of typical plants and the function of each structure

c) photosynthesis

In order to meet this standard, it is expected that students will:

- analyze a common plant: identify the roots, stems, leaves, and flowers, and explain the function of each.
- explain the process of photosynthesis, using the following terminology: sunlight, chlorophyll, water, carbon dioxide, oxygen, and sugar.

5.3 In fifth grade, the student will investigate and understand basic characteristics of visible light and how it behaves. Key concepts include:

a) transverse waves

b) the visible spectrum

e) refraction of light through water and prisms

In order to meet this standard, it is expected that students will:

- diagram and label a representation of a light wave, including wavelength, crest, and trough.
- explain the relationships between wavelength and the color of light. Name the colors of the visible spectrum.
- analyze the effects of a prism on white light and describe why this occurs.
- explain the relationship between the refraction of light and the formation of a rainbow.

Teaching Resources

Recommended Read Aloud Books

Anderson, Margaret J, and Gretchen Bracher. 1991. *Food Chains*. Hillside, NJ; Enslow Publishers Inc. A useful book that children can use to research food chains and food webs.

Brinkman, Patricia. 2006. *The Solar System*. Pelham, N.Y.: Benchmark Education.

Lafferty, Peter. 1989. *Energy And Light*. New York: Scholastic. A beginner science book full of illustrations introducing children to the sun as both a source of energy and light.

O'Donnell, Liam, Richard Dominguez, and Charles Barnett. 2007. *Understanding Photosynthesis With Max Axiom, Super Scientist*. Mankato, Minn.: Capstone Press. A comic book version illustrating plants and photosynthesis that children enjoy reading.

Latham, Donna. 2009. *Respiration And Photosynthesis*. Chicago, Illinois: Raintree. An excellent illustrated book relating plants and animals to the world around them.

O'Donnell, Liam, Cynthia Martin, and Bill Anderson. 2007. *The World Of Food Chains With Max Axiom, Super Scientist*. Mankato, Minn.: Capstone Press. A comic book version illustrating producers, consumers, food chains, food webs, energy pyramids, and humans impact on them.

Pipe, Jim, and Suzy Gazlay. 2008. *Earth's Ecosystems*. Pleasantville, NY: Gareth Stevens Pub. Beautifully illustrated and informative book about ecosystems, natural cycles, and biomes in an ever changing world.

Activity Materials

Interactive Notes

Notebooks

Glue

Scissors

Prisms (Set of 5 – 10 per class size)

Clear drinking glasses (1 per 4 students)

Sticky notes

Paper towels

Zip lock bags

Access to trees with green leaves on them

Board / bucket to cover grass with

Romaine lettuce

Glass jar

Pie dish

Assorted pictures of plants, animals, and decomposers (aquatic and terrestrial)

Cardstock

Laminator

Bibliography

Audesirk, Teresa, Gerald Audesirk, and Bruce E. Byers. 2011. Biology life on Earth. San Francisco, Calif: Benjamin Cummings. Biology textbook I used to research photosynthesis.

Blatner, David. 2012. Spectrums: our mindboggling universe from infinitesimal to infinity.

Lafferty, Peter. 1989. Energy and light. New York: Scholastic. Interesting book I used researching light, wavelengths, and photons.

Carambo, Cristobal. “The Dry-Sensitized Solar Cell.” Yale National Initiative: National Seminars.http://teachers.yale.edu/curriculum/viewer/initiative_16.04.02_u (accessed July 7, 2019). A useful article for understanding the deeper intricacies of photosynthesis.

Chalker-Scott, Linda. 2015. How plants work: the science behind the amazing things plants do. I only read a few chapters of this book, but I found its contents very interesting in my research.

Royal Society of Chemistry. “Photosynthesis” rsc.org. https://www.rsc.org/Education/Teachers/Resources/cfb/Photosynthesis.htm Informative website used to research photosynthesis.

Stockley, Corinne, Chris Oxlade, Jane Wertheim, G. Smith, Kuo Kang Chen, and Kirsteen Rogers. 2007. The Usborne illustrated dictionary of science: physics, chemistry, biology. Tulsa, Okla: EDC Pub. Excellent science resource book used to research light, photosynthesis, and food chains.

Taiz, Lincoln, and Eduardo Zeiger. 2010. Plant physiology. Sunderland (Mass.): Sinauer. Interesting book about plants that I used to research photosynthesis.

Walker, David, and Richard Walker. 1993. Energy, plants and man. Brighton: Oxygraphics. This provided a wealth of knowledge about photosynthesis.

www.ducksters.com/science/physics/photons.php (Accessed July 13, 2019) Informative educational website used to research light, photosynthesis, and food chains.

Endnotes

1. www.ducksters.com
2. www.ducksters.com
3. Stockley, The Usborne illustrated dictionary of science: physics, chemistry, biology, 34
4. Blatner, David. 2012. Spectrums: our mindboggling universe from infinitesimal to infinity. 68
5. Lafferty, Peter. 1989. Energy and light. New York: Scholastic. 22
6. Blatner, David. 2012. Spectrums: our mindboggling universe from infinitesimal to infinity. 69
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8. Blatner, David. 2012. Spectrums: our mindboggling universe from infinitesimal to infinity. 69
9. Chalker-Scott, Linda. 2015. How plants work: the science behind the amazing things plants do. 86
10. Greulach, Victor A. 1973. Plant function and structure. New York, Macmillan. 58
11. Audesirk, Teresa, Gerald Audesirk, and Bruce E. Byers. 2011. Biology life on Earth. San Francisco, Calif: Benjamin Cummings. 533