Classroom Connections
TEACHER'S GUIDE
Season II

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EMERGING SCIENCE

Classroom Connections
TEACHER'S GUIDE

Classroom Connections is a companion piece to Vermont Public Television's Emerging Science, a locally produced television series featuring Vermonters at the frontiers of science. This guide has been assembled by the Vermont Department of Education and local science teachers for use in high school classrooms.

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• Energy

Emerging Science – Episode One
by Amy Urling, Northfield High School, Northfield, Vt.

Watch the "Energy" episode of *Emerging Science* and answer the following questions:

- How is spin transformed into electric current?
- What is meant by the U.S. electric grid?
- A complex system is one without a central governing set of rules, but rather more local rules. Explain why the grid is a complex system.
- What percentage of the U.S. electric supply does Vermont consume?
- What is the difference between large centralized power systems and distributed power systems?
- In what ways are nuclear energy and coal similar?
- What was the Manhattan Project?
- What are the pros and cons of nuclear energy?
- Where is most of the spent nuclear fuel stored in the U.S.?
- What is meant by a portfolio of energy?
- What is renewable power and what are some examples?
- How do local actions connect to global implications?
- What are some of the ways Vermont scientists are experimenting with wind energy?
- What is sustainable energy?

Now that the students have a general understanding of energy, do the following hands-on activities.

Content/Topic

Energy and Electricity Production

Essential Questions

- What is electricity, how can it be produced and what are some types of electricity?
- How can energy be transferred from one type to another?
- What are some uses of the different parts of the electromagnetic spectrum and how can they (e.g. UV rays) affect humans?
- What should be the future of electricity production in Vermont?

Engaging Activities

- Pose the following question for the students to answer:
  What is energy? What are some examples of energy?
- Using the Frayer model (see Definition of Energy supplement at http://media.vpt.org/pdfs/emergingscience/season2/teachersguide.pdf) go over the definition, examples and non-examples of energy with the students.

Classroom Activities and Suggested Connections to Video

Types of Energy:

Review the different types of energy with the students by filling out the Forms of Energy chart.

Energy Transformations:

Review with students the 1st and 2nd Laws of Thermodynamics. Give the students 20 pictures of objects and have them figure out what type of energy they use and what type of energy they produce. Have the students write the name of the objects on the Energy Transformation Chart.

Electromagnetic Spectrum (radiant energy):

Review the characteristics of the electromagnetic spectrum with the students (see part one of the Electromagnetic Spectrum supplement at http://media.vpt.org/pdfs/emergingscience/season2/teachersguide.pdf). Divide the students into six groups and have each group research a different part of the electromagnetic spectrum (radio waves, microwaves, infrared, UV rays, X-rays and gamma rays). Then one student from each group moves to a new group and they share their information with each other until they have information about each part of the electromagnetic spectrum (see part two of the Electromagnetic Spectrum supplement). Using the wavelengths, have them determine the order of the parts of the electromagnetic spectrum (see part three of the Electromagnetic Spectrum supplement) and fill out the table. Finally, they answer the questions in part four of the supplement.

UV Beads Inquiry Lab:

The students design and perform a lab investigation to test what conditions produce or effect UV light using UV beads (see the UV Beads Lab supplement at http://media.vpt.org/pdfs/emergingscience/season2/teachersguide.pdf). The students then write a lab report according to the Inquiry Lab Rubric.

Electricity Power Point Project:

Divide the students into groups and have each group research a different type of electricity production: solar, wind, fossil fuels, nuclear, biomass, hydroelectric, etc. Using the Energy Project Checklist supplement and the Electricity Power Point Rubric supplement, have each group create a Power Point of their energy source and then present it to the rest of the class.

Electricity in Vermont Persuasive Essay:

After watching the Power Point presentations, have the students write a persuasive essay answering the following question: Based on the uncertainty of nuclear power in Vermont, which type(s) of electricity production do you think Vermont should focus on in the future? To help organize the essay, the students can fill out the Persuasive Essay Idea Sheet supplement. When the students write the essay, they should follow the Persuasive Essay Rubric supplement.

Extension Activities

- Bring in a guest speaker from Vermont Energy Education Program (VEEP). Their Electricity and Environment program is a 90-minute presentation that reviews how electricity is created, the types of electricity production and energy efficiency (they bring the energy bike). www.veep.org
- Bring in a guest speaker from Efficiency Vermont. www.efficiencyvermont.com
- Vermonters and Energy Fact Sheet: www.vtearthinstitute.org/energyuse.html
- Bring in a guest speaker from CVPS to discuss cow power. www.cvps.com/cowpower/
- Take a field trip to the Burlington McNeil Biomass Power Plant. www.burlingtonelectric.com/SpecialTopics/Mcneil.htm
- Take a field trip to NRG in Hinesburg, Vt. www.nrgsystems.com

Some Additional Useful Websites

http://publicservice.vermont.gov/energy-efficiency/energy.html

www.vermontbiofuels.org/

www.grosolar.com/

www.gmpvt.com/whoweare/searsburg.html

www.vtwindprogram.org/

www.solarfest.org/

Vermont Science Grade Expectations

S9-12: 1-8	Scientific Inquiry
S9-12: 23	Energy Transformations
S9-12: 26	Electromagnetic Waves
S9-12: 28	Electromagnetic Waves
S9-12: 49	Natural Resources

● Food Webs

Emerging Science – Episode Two
by Sheila Tymon, Peoples Academy High School, Morrisville, Vt.

Watch the "Food Webs" episode of *Emerging Science* and answer the following questions:

- What is meant by food webs and why are they important?
- How are pitcher plants used as biological indicators of air quality?
- What is the basic premise of Nick Gotelli and Aaron Ellison's work?
- Why is this work important?
- How does Nick mimic the two major problems associated with food webs?
- Give some examples of predators in food webs.
- What happens when you lose the top predator in an ecological system?
- How do food webs impact the lives of humans and human activity?
- How can the local food movement in Vermont enhance food webs?
- What are some of the major problems with food webs throughout the world?

Now that the students have a general understanding of food webs, do the following hands-on activities.

Content/Topic

Life on Earth depends on three interconnected factors:

- the cycling of matter
- the one-way flow of energy
- the interdependence of matter and energy

Essential Questions

- How does matter cycle and energy flow through a food web?
- What might happen to an ecosystem if the top predator were removed?

Engaging Activity: The Ecosphere

Like a pitcher plant, an ecosphere is a self-contained ecosystem. This activity is used to engage students in understanding the concept of matter cycling. Making their own ecosphere with gravel, pond water, plants, and snails is truly engaging. Kids name their snails, name their "world," pat each other on the back for becoming proud grandparents when their snails reproduce… it's really fun. Have Vernier probes that measure pH, CO_2 and DO available if students inquire. The ecosphere is versatile and very student-centered. Kids, no matter what age, have a sense of ownership and naturally want to take care of and learn more about the world they create.

- Have students prepare their own ecosphere, following directions in Bottle Biology p.111. To their container, they add pond water, aquatic plants, snails and fish. (NEVER release ecosphere contents outdoors.)
- Using a microscope, students examine/draw/identify the plant and animal microorganisms in their ecosphere and record observations.
- After observation, research and discussion, students explain and diagram how carbon dioxide, oxygen and nutrients cycle in their ecosystem.
- Have students draw the food web in their ecosphere. The food web should include autotrophs and different levels of heterotrophs. For example, the rooted and floating plants (algae) take in the sun's energy which is transferred to the omnivorous cyclops that eat algae, small animals and detritus, and daphnia, who eat by filtering very small algae particles, small bacteria and fine detritus. The sun's energy is also transferred to the snails and fish via plants and small animals. When organisms die, decomposing bacteria will break down bodies into simple nutrients that fertilize the plants.

Law of Conservation of Matter:
Matter is not created or destroyed; it changes from one form to another.

- Have each student explain how the law of conservation of matter is illustrated in their ecosphere's food web.
- Show the balanced equations for photosynthesis and cellular respiration, and explain how the law of conservation of matter is expressed in these reactions.

The Flow of Energy in a Meadow Ecosystem

What would happen to the plants and animals in the meadow if the top predator was removed?

Introduction:

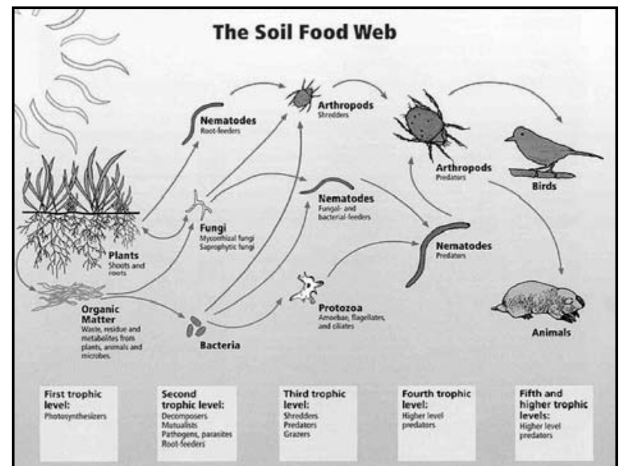
View the 15-minute video, "The Barn Owl: An Introduction to Owl Pellet Labs" from Carolina Biological Supply Company. I show the video up to the point where the owl animation ejects an owl pellet so students understand what they are working with.

Background Information:

The owl pellets that students will be examining in this lab have been collected, and fumigated, from common barn owls (Tyto alba) from around the U.S. Owls feed on small mammals, birds and reptiles. Their prey's undigested bones, hair and feathers are compacted into pellets and are regurgitated. An owl ejects an average of 2.5 pellets/day. The common barn owl has an average mass of 0.52kg (520 mg). (König, Weick and Becking. 1999. "Owls: A Guide to the Owls of the World." Yale University Press)

Procedure:

- Using probes and fingers, have the students gently pull the pellet apart. Separate the skull bones by size, length of snout and eye socket shape.
- Compare the skulls/bones of the mammal(s) to Peterson's Mammal Field Guide pgs. 248 - 254 and other identification charts to figure out what each student's owl ate.
- Have each student research the prey's diet and draw a food chain with arrows drawn from the sun to the vegetation to the prey and to the owl.
- Have one student draw his/her food chain on the board. Then have each student add theirs, drawing arrows in the direction of energy flow. The result will be a complex food web. Discuss food chains and food webs. Key idea: the more complex the food web, the more resilient to impact.



Relationships between soil food web, plants, organic matter, and birds and mammals
Image courtesy of USDA Natural Resources Conservation Service
http://soils.usda.gov/sqi/soil_quality/soil_biology/soil_food_web.html.

- Have students copy the food web from the board and add to their drawing three abiotic factors that support the food web (CO_2, radiant energy and water).
- Have students label the components of the food web with these terms: autotrophs/producers, heterotrophs/primary consumers, secondary consumers, tertiary consumers, herbivores and carnivores.
- Have students calculate the total number of mammals their owl ate in one year using Table 1.

Table 1: Number of prey eaten by owl in one year

PREY	Number found in pellet	Number of prey consumed in a day (multiply # by 2.5)	Number of prey consumed in a year (x 365 days)
Mouse			
Rat			
Vole			
Mole			
Shrew			
Bird			

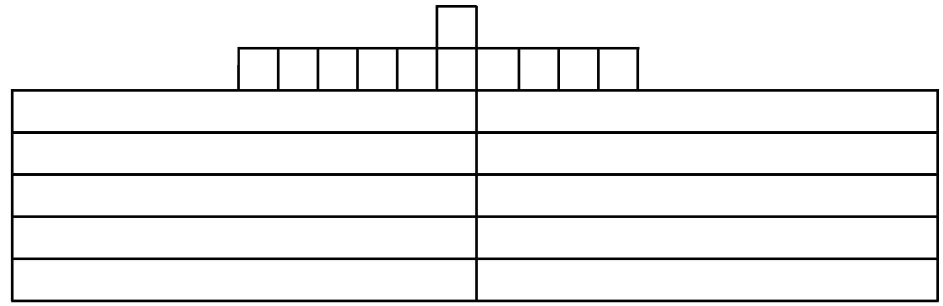
(Table 2 Data for mass of prey and producers came from the following webpage: apesroom.mandarin.groupfusion.net/modules/locker/files/get_group_file.phtml?fid=1056727&gid=28479&sessionid.)

- Transfer the number of prey consumed in a year to Table 2.
- Have each student calculate the total biomass of prey and producers consumed in their owl's food web using Table 2.

Table 2: Biomass of prey eaten by owl and producers eaten by prey in a year

PREY	Number prey/ year from Table 1 (Y)	Mass in kg (M)	Mass of prey / year (Y x M)	Mass of producers in kg eaten by prey (PROD)	Biomass of producers (PM x PROD)
Mouse/Vole		0.020		45.6	
Rat		0.24		12.8	
Mole		0.055		365	
Shrew		0.006		1168	
Bird		0.02		127	
		Total Mass Prey →	Σ=	Total Mass Producers →	Σ=

- Have students use their calculations to create a pyramid of biomass to scale (remember that a barn owl has an average mass of 0.52 k)



- Have each student calculate the change in the mass of prey if the top predator was removed and describe the effect this might have on the producer biomass?
- Have each student explain how their pyramid of biomass illustrates the second law of thermodynamics.

Vermont Science Grade Expectations

Vermont Framework Standard 7.13

S9-12: 34 Energy Flow in an Ecosystem

S9-12: 35 Food Webs in an Ecosystem

S9-12: 36 Equilibrium in an Ecosystem

S9-12: 37 Recycling in an Ecosystem

● Technology of Social Sciences

Emerging Science – Episode Three
by Eli Rosenberg, Main Street Middle School, Montpelier, Vt.

Watch the "Technology of Social Sciences" episode of *Emerging Science* and answer the following questions:

- In what way do technology and social sciences intersect?
- Why don't we currently see robotics integrated more fully into our everyday lives?
- In humans and in robots, what's the next step after imitation?
- Can robots think?
- What is social intelligence?
- How does the Internet contribute to understanding the social sciences?
- What is one of the major impacts that computers/social networks have had on social science?
- What is data-mining?
- What is collective participation?
- How did Howard Dean's presidential campaign change the way in which campaigns are carried out?

Now that the students have a general understanding of the technology of social sciences, do the following hands-on activities.

Content/Topic

Social Science: Degrees of Freedom

Designing and engineering a technical solution.

Essential Questions

- How closely should a robot hand match a human hand?
- Which types of human joints are simplest to build into a robot?
- How can biophysics be used to improve robot performance?

Engaging Activities

Consider the range of motions that your hand can make. Try and count every independent type of motion, or 'degree of freedom,' that you can make with your hands; for example, rotating the wrist counts as one displacement, curling and uncurling the first joint of your index finger counts as another. Draw a model of your hand that shows how each of these degrees of freedom can displace the hand.

Classroom Activities and Suggested Connections to Video

Watch, with your students, the segment of *Emerging Science* that shows Josh Bongard's UVM robotics lab. Freeze the video at a frame that allows you to see the robot arm in some detail. As you examine the video, see how many degrees of freedom you can spot in the robot arm. Based on students' observations, draw a model of the arm that shows how each of these degrees of freedom can displace the arm. Compare this model to the six types of joints found in the human body (ball and socket, condyloid, hinge, gliding, pivot and saddle). Then discuss some functions that this arm could perform (picking up a rod, for example) and some that it could not (buttering toast, perhaps). Speculate as to why Dr. Bongard chose to build his robot with this setup. Further discuss the design of other robots, like the industrial robots in the car manufacturing plant. Lead students to the conclusion that the types of joints and the degrees of freedom incorporated into the design of a robot are based on the function of the robot. Note that androids must have a great many more degrees of freedom than auto plant robots or Roomba vacuums.

Ask student lab groups to find short video clips of a robot at work (YouTube and Google Video are excellent sources). Have them draw a model of the robot that illustrates the type of joints and the degrees of freedom built into the robot and write a short explanation relating the design of the robot to its function. Students may also propose additional degrees of freedom that would increase the functionality of the robot.

Extension Activities

If you have robotics controllers (like the NXT and Legos shown in the video), have either the whole class, lab partners, or individual students choose an activity that they would like their robot to perform. Encourage students to choose simple activities like picking up a paper, harder ones like picking up a ball, or very hard ones like turning the pages of a book or opening a soda can. Have students consider the types of joints required to perform the task and to draw a model of a possible solution. Then ask students to design the robot using the controllers and materials at your disposal.

Vermont Science Grade Expectations

S9-12: 3	Designing Experiments
S9-12: 41	The Human Body

• Transportation

Emerging Science – Episode Four
by Christopher Waring, Lake Region High School

Watch the "Transportation" episode of *Emerging Science* and answer the following questions:

- How has transportation driven (no pun intended) the systems we've built as humans?
- How does design play a role in the execution of transportation in America?
- What are some of the pros and cons of biofuels?
- What is meant by a secondary form of energy?
- What is the most promising energy alternative for transportation?
- Why are electric cars creating such a buzz nowadays?
- What do hydrogen, electric and gasoline cars all have in common?
- Could the Vermont energy grid support all Vermonters with electric cars?
- What is vehicle-to-grid?

Now that the students have a general understanding of transportation, do the following hands-on activities.

Content/Topic

Transportation: Engine Efficiency

A lesson to demonstrate the differences between hydrocarbon fueled vehicles and electric vehicles, designed for a high school science class.

The intent is:

- To demonstrate the differences between a gasoline or diesel powered vehicle and an electrically powered and driven vehicle;
- To have students think about the differences in energy conversion inherent in the two different systems of energy conversion within vehicles;
- To have the students think about regenerating power from the motion of the car; and,
- To have the students think about and understand what kind of by-products are created by burning a hydrocarbon as compared to using electric power.

Essential Questions

- What is the difference between electric and internal combustion-engine (ICE) vehicles?
- Which vehicle produces the least amount of harmful by-products?

Engaging Activity 1

View *Emerging Science:* "Transportation" (30 min).

Engaging Activity 2

Before you start the experiment ask if there is a student who is willing to hold a battery in his/her hand. Then ask if there is a student who is willing to hold a candle and beaker in her/his hands while the candle is lit.(NOTE: be sure no one actually does this.) None of the students will be willing to hold the candle and beaker. Have the students discuss why they are unwilling to do this.(They are unwilling because there is so much waste heat generated by the candle and emitted to the air and the beaker that holding them would actually be painful.)

Now ask the class these questions, one at a time:

- What is the purpose of the radiator in an ICE vehicle?
- What is the source of the heat that the radiator disperses?
- Do you think an electric car needs a radiator? Why or why not? (The energy process in an electric motor generates very little waste heat. In an ICE vehicle 70% of the fuel energy is released as heat. This waste heat comes from the fuel, but is not used to propel a car.)

Background Information for the Teacher:

Materials Needed:

1 C-size dry cell battery
Any small, model-sized electric motor
A fan made of light cardboard with the blades quite pitched
Several wires and a battery holder
A single plumber's candle
A small (100 cc) heat tolerant container
A stand to hold the container above the candle
A simple water-tolerant thermometer
A hot melt glue gun
A calculator

The Set Up:

Create a small light cardboard fan (3x5 card is good material for this) about 2" in diameter and hot melt glue it to the shaft of the electric motor. Take care that it is balanced and a true circle shape so when it is spinning it will not vibrate too much. The fan should push quite a bit of air when turning, to provide a job for the motor to do.

Using the battery holder and the wire, connect all but the last wire, so the motor is ready to run when the last connection is made.

Cut the plumber's candle in such a way that the part with the wick is as close to the size of the battery as possible. Set the properly-sized candle on a plate under the stand that will hold the small beaker of water. Place the beaker above the candle with 100 cc of water in it.

Both the battery/motor and the candle/water set ups are energy storage systems that can be used to do a job. Each one represents a model of a particular type of vehicle.

The battery uses chemicals to store chemical energy which can be transformed into electric energy. Electric energy flowing through the wires and the motor will cause the motor to transform that energy into rotational energy, thereby doing the job of spinning the fan (or in a real vehicle, turning the wheels). The transforming process is chemical, electrical and mechanical. As the job is done over time, the battery loses charge and has less and less chemical energy to provide. When it no longer has enough, the battery needs to be replaced or recharged.

The candle is a form of hydrocarbon fuel. By burning it, it is possible to transform the chemical energy stored in the wax into heat, which is then used to heat the water. (In a real vehicle that heat is released very quickly inside the engine, which transforms that heat into rotational energy to drive the vehicle.) Burning the candle does the job of heating the water. The energy transformational process is chemical to heat to the job intended.

Classroom Activity 1

Investigation:

Ask the students to determine the answer to the following question.

- How can we determine the efficiency of each of these fuels (wax of a candle and stored chemical energy of a battery)?

Conduct a class discussion to determine what pieces of information are needed to make this comparison and as a class group determine the procedure to do this.

Pieces of Information Needed:

For the candle:

Mass of candle in grams, before and after burning

Mass of water, before heating

Mass of beaker (analogous to engine block of vehicle)

Temperature of water, before and after heating

For the battery:

Voltage of the battery (measure or read from information on battery)

Calculation of the amps/hours for the battery (V x amps x time)

Have the students use a new fully charged C NiMH rechargeable cell battery. If possible, measure and record its voltage, or assume it is 1.2 volts.

On average NiMH batteries have amperage rating of 6000 milli AHr. Record this number as watt hours.

Students determine the energy released by each of these two systems and record results.

Classroom Activity 2

- Take all the above measurements and then burn the candle for a period of time (e.g. 12+ minutes) and re-measure the temperature of the water and the mass of the candle. Make and record any additional observations as the candle is burning.
- Using the equations below find out exactly how much heat the water picked up. Knowing that the heat of combustion of paraffin wax is 43kJ/gram, it is possible to find the efficiency of the candle-heating-water process. (The students will find a large amount of heat lost to both the air, the ring of the stand and the beaker itself.)

  Express this efficiency as a percentage.
- Read the voltage from the battery and assuming 6000 MA hours, use the equation V x amps x hours to calculate the energy produced by the battery in watts/hour. Convert watts/hour to calories.

  The site http://home.att.net/~cat6a/fuels-VII.htm has both a good explanation and a good set of equations to calculate the heat value of the heat added to the water. An interesting note here is the exact parallel between this experiment (on the web) and a vehicle. The sources of inefficiency or error in measuring the heat energy of the candle are the same ones that make a petrochemical powered
  engine beneficent: Heat loss to the air and heat loss to the container, be it the beaker or the metal engine. Finally, incomplete combustion allows some of the fuel to be used, but not burnt, instead passing through the system with no benefit.
- Use the formulas from the site mentioned above for the following.

a. Calorific value of fuels: Heat energy is measured in units of joules or calories (1 calorie = 4.18 joules). The heat generated by fuels when they burn in joules or calories measures quality of fuels. All fuels do not burn efficiently. Thus there are fuels that produce more heat than others do. This can be distinguished in terms of number of joules or calories that they generate on burning.

   The amount of energy generated when 1 unit mass of fuel is burnt completely is known as the calorific value of the fuel. The word calorific is used instead of joulific because the word calorific has been in use for a very long time. When 1 gram of charcoal is burnt, it produces 33 kilojoules. Thus the calorific value of charcoal is 33kJ/g.

b. How to measure calorific value of a fuel: The method by which the calorific value of substances is measured is called a calorimeter. The fuel whose calorific value is to be measured is first weighed. Let its mass be g grams. Let m grams of water be heated by this fuel. Measure the temperature of the water before and after the fuel is burnt completely. Look at the rise in temperature of m grams of water when g grams of fuel is burnt completely.

For the Teacher:

Heat produced = Q = m x s x t

m = mass of water in grams
s = specific heat of water = 4.2 J/gm x °C
t = rise in temperature of the water

Thus Q amount of heat is generated by g amount of fuel. The calorific value is given by the following equation:

Calorific value = Q/g joules per gram measured (for value in kilojoules, divide by 1000). Heat the water for a while and note the rise in temperature.

Let:

W1 = initial weight of the candle
W2 = final weight of the candle
W1 - W2 = weight of wax burnt to heat the water

T1 = initial temperature of water
T2 = final temperature of the water
T2 - T1 = rise in temperature of water

m = mass of water
s = specific heat of water in J/gm/°C

There are many sources of error in the simple experiment described here. The table below shows how the errors can be minimized.

Type of error	How to minimize the error
Heat lost to the surrounding is neglected	Enclose the calorimeter in an insulating box
Heat lost by the beaker is neglected	Determine the thermal capacity of the beaker and include it in the equation
Incomplete or inefficient combustion of fuel in air	The fuel should be burnt in oxygen atmosphere and not air

Have the students answer the following questions:

- Why did no one actually hold the candle and beaker? (A. They would be too hot.)
- What did that waste heat do? (A. Nothing for the water, but it heated the air.)

- What is our calculated efficiency of the candle-heating-water process? (A. Whatever it is, but it will probably be less than 60%.)
- Can we turn the heat of the water back into wax? (A. No.)
- Have all the combustion products been absorbed in the water? (A. No, there is the smoke from the candle, which is now in the air. Have the students observe the carbon suit on the beaker.)
- Where did the rest of the by-products of combustion go? (A. Into the air.)
- Where did the fuel come from? (A. Wax is a by-product of crude oil, so the earth is the correct answer.)
- Will there always be crude oil for us to get wax from? (A. In the long run, the answer is no. However the more important answer is that in the near term crude oil will continue to rise in price and therefore so will wax prices until it will be too expensive to use.)
- What are the candle model's parallels to a gasoline-powered car? (A. A hydrocarbon fuel; lots of waste heat; high cost of the fuel per unit; no ability to regenerate the fuel; combustion by-products released into the air; having the fuel based on an extraction process.)

Classroom Activity 3

Now do the second half of the experiment.

- Connect the battery to the motor and run for the same amount of time as the candle was burned (12+ minutes). (Allow the battery to run the motor until is starts to show any sign of slowing down in its turning of the fan. This will happen close to the ¾ mark of the battery's total storage ability.)
- Finding the storage capacity of a battery is a bit tricky, but from many sources on the web, it is generally agreed that a NiMH battery has 6000 milli Ahr of capacity at 1.2 volts. If we take ¾ of this as the point where the motor starts to slow down, the capacity will be 4Ahr at 1.2 volts or 6 watt hours or .006 KWH. At an average of 15 cents/KWH, our electric power comes to not quite 1/10 of a penny.

  (We can use the conversion of 1 KWH = 3,600,000 joules to find the comparable energy spent between the candle and the battery. The battery will have produced electric energy equal to 21,600 joules.)

Compare the joules of energy produced by the candle and the battery, then have students answer the following questions.

- Why was Susie able to hold the battery and motor in her hand? (A. It was not hot because very little waste heat was produced.)
- What did the waste heat do? (A. Warmed the battery and the motor a little, but not much.)

- What is the efficiency of the battery/motor?
(A. Hard for students to calculate, but for such small motors it is in the range of 60%. Car-sized motors are in the 90% range of efficiency.)
- Can we turn the motion of the fan back into electric power, stored as chemical energy? (A. Yes, by turning the fan we can make electricity which can be absorbed by the battery. In a car this is regenerative braking.)
- In recovered energy, has all the energy of the battery been used by the motor? (A. In almost all of them, very little waste heat and no soot are created.)
- Where do the by-products of the electric energy go?
(A. Right now there are no by-products. However, at some point the battery will wear out and must be recycled, and the process of charging a battery has some by-products. However wind, hydro, solar electric sources have very little.)
- Where did the fuel come from?
(A. Electric power comes from several sources: the hydrocarbon fueled ones – coal, oil, gas powered plants – and the renewable energy sources – hydro, wind, solar and nuclear energy.)
- Will there always be a source of electric power for us to use?
(A. Yes. However both the hydrocarbon fuels and the nuclear power energy are based on minerals in the Earth and are limited. Only the renewable energy sources have the ability to continue to fuel our society forever.)
- What are the battery model's parallels to an electric powered car?
(A. A renewable fuel; very high efficiency; low cost of fuel per unit; the ability to regenerate fuel while driving; no local by-products released into the air; and having fuel based on natural renewable energy sources over the long run.)

Have the students write, draw or explain several differences between hydrocarbon-powered vehicles and electric-powered vehicles, using evidence from this investigation to support their claims. Perhaps create a poster board list of charactistics of each type of vehicle. One trait that is not modeled with this demonstration is that of noise; internal combustion machines are noisy by nature and electric drive is quiet by nature, quite a difference for a town or city.

There are lots of sites that have in-depth information about all these issues. Do continue your learning with your students. As they learn more, they will be better able to make educated vehicle purchases in their future.

Vermont Science Grade Expectations

S9-12: 23 Students demonstrate their understanding of heat energy by explaining the changes in energy (transformation) that occur in different reactions (e.g. chemical, physical) through analysis of the input and output of energies in the system (e.g.calorimetry) and using evidence to justify the explanation.

● Fresh Water

Emerging Science – Episode Five
by Brian Slope, U-32 High School

Watch the "Fresh Water" episode of *Emerging Science* and answer the following questions:

- What are some basic issues related to water that humans face?
- What are some water challenges faced by states other than Vermont?
- How does climate change impact water supplies and cycles?
- What is a water table? Is it growing or shrinking in Vermont?
- A complex system is comprised of many different interacting entities, often with local rules. Why are water systems considered complex systems?
- What are intelligent agents?
- What is the Vermont-based Streams Project?

Now that the students have a general understanding of fresh water, do the following hands-on activities.

Content/Topic

Fresh Water: Dams, Logging, Floods, Erosion … Oh My!

Vermont's environmental past: people have responded to Vermont's environment and the environment has responded to the actions of people. Many of today's Vermonters know very little about what the state's past was like. Historical images contain evidence of the changes made over time, and photographs are particularly useful in trying to understand our environmental past.

Essential Questions

- What effects have the watersheds of Vermont had on its people?
- What effect have people had on Vermont watersheds from 1700 to the present?

Engaging Activities

Materials Needed:

Pictures, with location numbers, printed and cut up to give to students
(see http://media.vpt.org/pdfs/emergingscience/season2/teachersguide.pdf)

Johnson's Nature of Vermont (pages 43-63) and Outwater's Water (pages 35-45 and 50-53)

Important Web Addresses:

www.uvm.edu/perkins/landscape/

www.uvm.edu/~erehmeye/gs/

Engaging Activity – Part 1 (30 minutes):

- Divide students into groups of two to four. Give each group location numbers of at least five images, one each from dams, erosion, flooding, logging, mining and industry along a river.
- Have each group collect evidence from each photo about watersheds, groundwater, water cycle, phosphorous cycle, nitrogen cycle, water pollution, mines, sustainability, economic growth, rivers, lakes, dams, ecosystems, recovery, succession, non-point source pollution, source point pollution, forests or lack thereof, and wild animals and plants.

Engaging Activity – Part 2 (30 minutes):

- Have the students write a few paragraphs with supporting evidence from the images about the environmental history of Vermont from 1700 to the present and how watersheds have been affected over that time. Include activities of people, wild animals and plants, soil, water quality, sustainability, farms, deforestation and reforestation. (Since we have few images, particularly photographs, from 1700 until 1850 use your common sense and general knowledge for this time period.)

For Homework (60 minutes):

- Have the students compare excerpts from Johnson's Nature of Vermont (pages 43-63) and Outwater's Water (pages 35-45 and 50-53) to their group's history. How did their description agree or disagree with the excerpts?

Engaging Activity – Part 3 (60 minutes):

- The next day, have each group create a PowerPoint presentation explaining the effect of Vermont's changing environment (1700 to the present) on its watersheds, concentrating on how these original watersheds influenced people and how people affected the watersheds.

For the Teacher: Assessment Rubric

– Expected Science Content for Project –

Time Period	Main Concept of Time Period
1700 –	98% forested, mature forest managed by Native Americans.
1740 –	Forests cut down, wildlife disappearing, water quality getting worse
1850 –	80% fields, 20% forest. Farms being abandoned, top soil worn out or eroded away, water quality bad, almost no wildlife, many young Vermonters leaving to go west.
1915 –	Succession occurs – fields then pines then hardwoods
TODAY –	Forests have returned, yet not old... 80% forest, 20% field – much wildlife returned
Other criteria	Appealing placement of pictures and text

Vermont Standards – Grades 9-12

7.13.ccc. Describe, model and explain the principles of the interdependence of all systems that support life (e.g. flow of energy, ecosystems, life cycles, cooperation and competition, and human population impacts on the world ecological system) and apply them to local, regional and global systems.

Vermont Science Grade Expectations

S9-12:49 Students demonstrate their understanding of processes and change within natural resources by choosing a Vermont ecosystem, tracing its succession before and after a damaging event and showing how the ecosystem has been restored through control of the water cycle, disposal of wastes and recycling of nutrients.

– Science Career Opportunities –

Resource list compiled by Vermont Genetics Network (VGN), a NIH/NCRR grant funded program located at the University of Vermont.

National Resources

American Association for the Advancement of Science (AAAS)

AAAS is an international non-profit organization dedicated to advancing science around the world by serving as an educator, leader, spokesperson and professional association.

AAAS Career Support – www.aaas.org/careercenter/undergraduates.html

AAAS Advice-filled Articles – http://sciencecareers.sciencemag.org/career_development/previous_issues/articles/2007_07_06/caredit_a0700094

Association for Women in Science (AWIS)

The Association for Women in Science is dedicated to achieving equity and full participation for women in science, mathematics, engineering and technology.

www.awis.org/

Biomedical Sciences

Listing of opportunities for undergraduates and recent college graduates

http://people.clarkson.edu/~woodwort/opportunities.htm

BNET Business Network

Information for undergraduates leaving the classroom for research

http://findarticles.com/p/articles/mi_qn4188/is_20070213/ai_n17221038

Brigham and Women's Hospital (BWH)

BWH is a teaching affiliate of Harvard Medical School.

www.brighamandwomens.org/

Bristol-Myers Squibb Pharmaceutical Company

Listing of career opportunities

www.bms.com/career/data/

Careers.md

Information on various healthcare careers

www.careers.md/

Dartmouth-Hitchcock Medical Center

Dartmouth-Hitchcock is New Hampshire's only academic medical center and is affiliated with Dartmouth College.

www.dhmc.org/

Duke University Career Center

Duke University Career Center provides career services to undergraduates and graduate students.

http://career.studentaffairs.duke.edu/undergrad/get_advice/career_staff/industry_insights/engin_tech.html

Environmental Protection Agency (EPA) Careers

Information about student opportunities and programs

www.epa.gov/careers/stuopp.html

Forensic Science Service

Listing of forensic science courses offered at universities

www.forensic.gov.uk/forensic_t/inside/career/c_faq.htm

Howard Hughes Medical Institute (HHMI)

HHMI is a non-profit medical research organization whose mission is to advance biomedical research and science education in the U.S.

www.hhmi.org/

Johns Hopkins University

Part of the mission of Johns Hopkins University is to foster independent and original research.

www.jhu.edu/

Mathematical Association of America (MAA)

MAA is the largest mathematical society in the world that focuses on mathematics for students, faculty and all who are interested in the mathematical sciences.

www.maa.org/students/undergrad/

Mayo Clinic

The Mayo Clinic is the world's first and largest integrated non-profit group medical practice.

www.mayo.edu/

National Institutes of Health (NIH)

NIH is part of the U.S. Department of Health and Human Services and is the primary federal agency for conducting and supporting medical research.

General information – www.nih.gov/

Listing of Career Opportunities – http://grants.nih.gov/training/resources.htm

National Science Foundation (NSF)

NSF is an independent federal agency created by Congress in 1950 to promote the progress of science; to advance the national health, prosperity and welfare.

General information – http://nsf.gov/

Career Opportunities – www.nsf.gov/about/career_opps/

New Scientist Jobs

Search for jobs in the field of science

www.newscientistjobs.com/jobs/default.aspx

PhDs.org

Lists jobs and advice on getting into graduate school

www.phds.org/

Pfizer Pharmaceutical Company

Listing of career opportunities

www.pfizer.com/careers/

Robert Wood Johnson Foundation

The mission of the Robert Wood Johnson Foundation is to improve the health and health care of all Americans.

www.rwjf.org/

Science Careers From the Journal *Science*

Search engine for science careers

http://scjobs.sciencemag.org/search/jobs.aspx

University Medical Center at Princeton

University Medical Center at Princeton, a unit of Princeton HealthCare System, has been a leading teaching hospital for more than 30 years.

www.princetonhcs.org/page3942.aspx

Weill Medical College of Cornell University

Weill Medical College of Cornell University is among the top-ranked clinical and medical research centers in the country.

www.med.cornell.edu/

Woods Hole Oceanographic Institution (WHOI)

WHOI is the largest non-profit oceanographic institution in the world.

www.whoi.edu/