Grades 7–12

biomass

Lesson Plans on Alternative Fuels

An innovative, hands-on approach to learning designed to supplement and reinforce your students' preparedness for higher education goals

Biomass

- is any organic matter – wood, crops, seaweed, animal wastes – that can be used as an energy source.
- is our oldest source of energy.
- is a renewable energy source because its supplies are not limited.
- offers pro-environmental opportunities for a sustainable, cleaner future for our planet.
- is a growing field for higher education focus.
- provides economic advantages as public awareness and implementation grows.

Introduction

Biomass as a source of energy is gaining greater attention as the world's leaders seek alternatives to reliance on petroleum-based fuels. This important industry sector is expanding to meet anticipated needs for the future and addressing serious concerns of today's energy-greedy society.

***Ag* in the Classroom** is a comprehensive program designed to foster among our state's young people a greater appreciation of agriculture and related industries, such as Biomass. Sponsored by the South Carolina Farm Bureau Federation, ***Ag* in the Classroom** provides teachers with professionally developed curricula materials featuring relevant industries, emphasizing the importance of agriculture, environmental effect and economic consequences.

These Biomass lessons take into account the developmental stages of the student and can be used at the teacher's discretion. To minimize planning time and maximize efficiency, all materials are designed to integrate with and supplement existing classroom curricula. Standards prescribed by the South Carolina Curriculum Standards are stated wherever possible and met to enhance students' understanding of the subject matter.

Teachers may look to the South Carolina Energy Office for additional support for the Biomass course. SCEO can be contacted at **energy.sc.gov**.

Other valuable resources can be found in the **Resources** section at the end of this publication.

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Using This Packet

Biomass has been specially designed for clear organization and appeal to young minds. We hope you'll find the format motivational and easy-to-use. The packet is divided into three sections, each with a unique tab: **Standards**, **Lesson Plans** and **Resources**.

The **Standards** section lists the curriculum standards which are covered in the lessons.

The **Lesson Plans** section is divided into lesson plan groups, each of which is comprised of a single numbered lesson and a series of related activities, hand-outs and teacher aids labeled "a," "b," "c" and so forth. The number of each lesson plan is displayed on the side tab for quick reference. Tabs at the right margin facilitate finding any individual lesson group when the packet is placed on its side in a book bag or filing cabinet, and a table of contents is provided following this page so that you can quickly look up the exact page you seek. The subject matter of each Activity is also indicated, similarly speeding recognition of a desired worksheet.

Biomass lesson plans are not meant to be exclusive; feel free to add your own materials to our lesson plan suggestions as new information on this constantly growing field makes itself available. We would appreciate your input on these discoveries to help make future materials even better.

Throughout the lesson plans in this packet, teaching strategies may include the use of one or more of Dr. Spencer Kagan's Cooperative Learning Structures*. ***Ag* in the Classroom** extends thanks to Kagan Inc. for granting permission to adapt the various structures for this use.

In addition, ***Ag* in the Classroom** appreciates the assistance of contributing agencies in providing information for use in various lesson plans. Contact information for these agencies is provided in the **Resources** section, along with multi-referenced resources.

*Kagan, Spencer. (1994). *Cooperative Learning*. San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
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Table of Contents

*Kagan, Spencer. (1994). *Cooperative Learning*. San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
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Table of Contents, cont'd.

Glossary

abiotic Having an absence of life or living organisms.

acid A solution that has an excess of hydrogen ions (H+).

acid rain Acid precipitation falling as rain.

agricultural wastes Waste products resulting from agricultural processes that can be reused for other purposes.

alcohol An organic compound with a carbon bound to a hydroxyl group. Examples are methanol (CH_3OH) and ethanol (CH_3CH_2OH).

alternative fuel vehicle (AFV) Vehicle that operates using alternative fuel/s.

alternative fuel As defined in the Energy Policy Act of 1992 (EPACT): methanol, denatured ethanol and other alcohols, separately or in blends of at least 10 percent by volume with gasoline or other fuels; compressed natural gas; liquefied natural gas; liquefied propane gas; hydrogen; coal-derived liquid fuels; fuels other than alcohols derived from biological materials; electricity; biodiesel; and any other fuel determined to be substantially not petroleum and yielding potential energy security benefits and considerable environmental benefits.

antioxidants 1. A chemical compound or substance that inhibits oxidation; 2. A substance, such as vitamin E, vitamin C or beta carotene, thought to protect body cells from the damaging effects of oxidation.

aromatic A chemical that has a benzene ring in its molecular structure (benzene, toluene, xylene). Aromatic compounds have strong, characteristic odors.

B-20 A mixture of 20 percent biodiesel and 80 percent petroleum diesel based on volume.

bacteria A small single-cell organism. Bacteria do not have an organized nucleus, but they do have a cell membrane and protective cell wall. Bacteria can be used to ferment sugars to ethanol.

bacterial decay The process for changing garbage in landfills to methane gas.

base A solution that has an excess of hydroxide ions (OH-) in an aqueous solution.

benzene A toxic six-carbon aromatic component of gasoline, which is a known carcinogen (cancer-causing agent).

benzene ring A six-sided ring of carbon atoms containing alternating single and double-bonded carbon atoms.

biodegradable Capable of decomposing rapidly under natural conditions.

biodiesel A biodegradable transportation fuel produced through transesterification, a process in which organically derived oils are combined with alcohol (ethanol or methanol) in the presence of a catalyst to form ethyl or methyl ester. The biomass-derived ethyl or methyl ester can be blended with conventional diesel fuel in engines or used as a neat fuel (100 percent biodiesel). Biodiesel can be made from soybean or rapeseed oils, animal fats, waste vegetable oils or microalgae oils.

biodiversity The relative abundance and variety of plant and animal species and ecosystems within particular habitats.

bioenergy Renewable energy produced from organic matter, through conversion of the complex carbohydrates in organic matter to energy. Organic matter may either be used directly as a fuel or processed into liquids or gases.

biofuel/s Liquid or gaseous fuels made from biomass. Biofuels include ethanol, biodiesel, hydrogen, methane, and methanol.

biogas A combustible gas derived from decomposing biological waste. Biogas normally consists of 50 to 60 percent methane gas.

biomass A renewable energy resource derived from organic matter, including wood, agricultural crops, residue and waste, and other living cell material that can be burned to produce heat energy. Algae, sewage and other organic components of municipal and industrial wastes may also be used to make energy through chemical processes, so are therefore considered biomass resources.

biomaterials A synthetic material used to replace part of a living system or to function in intimate contact with living tissue.

biotic Pertaining to life or living organisms.

by-product Material, other than the principal product, generated as a consequence of an industrial process or as a breakdown product in a living system.

calorie A unit of measurement defined as 4.184 absolute joules or the amount of energy it takes to raise the temperature of one gram of water from 15 to 16 degrees Celsius (or 1/100th the amount of energy needed to raise the temperature of one gram of water at one atmospheric pressure from 0 degrees C to 100 degrees C). Food calories are actually equal to 1,000 calories (1 food calorie = 1 kilocalorie).

carbohydrate A class of organic compounds including sugars and starches. Many (but not all) carbohydrates have the basic formula CH_2O.

carbon dioxide (CO_2) A colorless, odorless gas produced by respiration and combustion of carbon-containing fuels. Plants use it as a food in the photosynthesis process.

carbon monoxide (CO) A colorless, odorless, poisonous gas produced by incomplete combustion.

cash crop Any crop sold for money.

catalyst A substance that increases the rate of a chemical reaction, without being consumed or produced by the reaction. Enzymes are catalysts for many biochemical reactions.

cellulase A family of enzymes that breaks down cellulose into glucose molecules.

cellulose A carbohydrate that is the principal component of wood. It is made of linked glucose molecules that strengthen the cell walls of most plants.

Celsius A unit of temperature named after the Swedish astronomer Anders Celsius (1701–1744), who first proposed it in 1742. The Celsius temperature scale was designed so that the freezing point of water is 0 degrees and the boiling point is 100 degrees at standard atmospheric pressure.

cesspool A covered cistern; waste water and sewage flow into it.

cofiring Mixing a modest amount of clean, dry sawdust with coal and burning the sawdust coal mixture in the existing coal-firing equipment of a large, coal-burning, utility boiler, thereby reducing coal usage and lowering carbon dioxide emissions from fossil fuels.

combustion A chemical reaction between a fuel and oxygen that produces heat and, usually, light.

commodity An article of trade or commerce, especially an agricultural or mining product that can be processed and resold.

compression engine An engine that works on the basis of compression, in which the working substance in a heat engine, such as the vapor mixture in the cylinder of an internal-combustion engine, is compressed.

conservation tillage Minimal cultivation of the soil.

conversion 1. Something that is changed from one use, function or purpose to another; 2. The expression of a quantity in alternative units, such as length or weight.

corporation A business organization owned by a group of stockholders, each of whom enjoys limited liability.

cover crop Green temporary crop grown to prevent or reduce erosion and to improve the soil by building up its organic content.

decomposition A chemical reaction type in which a large compound is broken down into smaller, simpler compounds.

denatured Ethanol that has had a substance added to make it unfit for human consumption.

desertification The degradation of land in arid, semi-arid and dry sub-humid areas into desert, resulting from various factors including climatic variations and human activities.

diesel engine A compression-ignition piston engine in which diesel fuel is ignited by injecting it into air that has been heated (unlike a spark-ignition engine).

digestion The breaking down of large organic molecules into smaller ones.

E-10 A mixture of 10 percent ethanol and 90 percent gasoline based on volume.

E-85 A mixture of 85 percent denatured ethanol and 15 percent gasoline based on volume.

energy The ability to do work.

energy crop A crop grown specifically for its fuel value, including food crops such as corn and sugarcane, and nonfood crops such as poplar trees and switchgrass.

environment The external conditions that affect organisms and influence their development and survival.

enzyme A protein or protein-based molecule that speeds up chemical reactions occurring in living things. Enzymes act as catalysts for a single reaction, converting a specific set of reactants into specific products.

EPA Environmental Protection Agency

EPACT Energy Policy Act of 1992.

erosion General term for the processes by which the surface of the earth is constantly being worn away; the displacement of solids (soil, mud, rock, and so forth) by the principal agents of wind, running water, ice (mostly glaciers), near-shore waves, or other movement in response to gravity.

ester An ester is a compound formed from the reaction between an acid and an alcohol.

ethanol (CH_3CH_2OH) Ethyl alcohol, a colorless, flammable liquid, produced by sugar fermentation and distillation by yeast. Ethanol is used as a fuel oxygenate. Ethanol is the grain alcohol found in alcoholic beverages.

exothermic Releasing heat.

Farm Bureau A resource for agricultural learning and solutions.

fatty acid A carboxylic acid (an acid with a -COOH group) with long hydrocarbon side chains.

feedstock Any material that can be converted to another form of fuel or energy product.

fermentation A biochemical reaction that breaks down complex organic molecules (such as carbohydrates) into simpler materials (such as ethanol, carbon dioxide and water). Bacteria or yeasts can ferment sugars to ethanol.

fertilizer Organic or inorganic material containing one or more of the nutrients — mainly nitrogen, phosphorus and potassium, and other essential elements required for plant growth. Added to the soil or other medium, fertilizers provide plant nutrients that are naturally lacking or that have been removed by harvesting or grazing, or by physical processes such as leaching or erosion.

field crops Agronomic crops such as corn, soybeans and wheat.

firelog Cost-effective wood substitute for burning.

flexible fuel vehicle (FFV) Also known as flex fuel vehicle, a vehicle with a single fuel tank designed to run on varying blends of unleaded gasoline with either ethanol or methanol.

forage Herbaceous plant material (mainly grasses and legumes) eaten by grazing animals.

fossil fuel/s Solid, liquid or gaseous fuels formed in the ground after millions of years by chemical and physical changes in plant and animal residues under high temperature and pressure. Oil, natural gas and coal are fossil fuels.

fungi Plant-like organisms with cells with distinct nuclei surrounded by nuclear membranes, incapable of photosynthesis. Fungi are decomposers of waste organisms and exist as yeast, mold or mildew.

geothermal Of or relating to the internal heat of the earth.

geothermal energy Energy derived from the natural heat of the Earth contained in hot rocks, hot water, hot brines or steam.

ginning To separate the seeds from a commodity or product, such as cotton.

global warming A term used to describe the increase in average global temperatures due to the greenhouse effect. Scientists generally agree that the Earth's surface has warmed by about 1 degree Fahrenheit in the past 140 years.

glucose ($C_6H_{12}O_6$) A six-carbon fermentable sugar.

glycerin ($C_3H_8O_3$) A liquid by-product of biodiesel production used in the manufacture of dynamite, cosmetics, liquid soaps, inks, and lubricants.

grain crops Crops for which standards have been established under the United States Grain Standards Act; namely, wheat, oats, corn, barley, rye, flaxseed, soybeans, grain sorghum, and mixed grains, and other crops yet to be determined.

gram A unit of measurement of mass, defined in the SI system of units as one one-thousandth of a kilogram (i.e., $1x10^{-3}$kg).

greenhouse effect The heat effect due to the trapping of the sun's radiant energy, so that it cannot be reradiated. In the earth's atmosphere, radiant energy is trapped by greenhouse gases produced from both natural and human sources.

greenhouse gas A gas, such as water vapor, carbon dioxide, tropospheric ozone, methane, and low-level ozone, which contributes to the greenhouse effect.

hydrocarbon (HC) An organic compound that contains only hydrogen and carbon. In vehicle emissions, these are usually vapors created from incomplete combustion or from vaporization of liquid gasoline. Emissions of hydrocarbons contribute to ground-level ozone.

hydrolysis A chemical reaction that releases sugars, which are normally linked together in complex chains. In ethanol production, hydrolysis reactions are used to break down the cellulose and hemicellulose in the biomass.

hydropower The harnessing of the energy of moving or falling water, usually in the form of hydroelectricity from a dam, but it can be used directly as a mechanical force. The term refers to a number of systems in which flowing water drives a water turbine or waterwheel.

joule (J) A unit of electrical energy equal to the work done when a current of one ampere passes through a resistance of one ohm for one second. Also called newton metre, or coulomb volt, this SI unit of energy and work, pronounced to rhyme with "tool," is named in honor of the physicist James Prescott Joule (1818–1889). One joule is the work required to exert a force of one newton for a distance of one metre.

landfill gas Gas that is generated by decomposition of organic material at landfill disposal sites. Landfill gas is approximately 50 percent methane.

landfill An area designated to receive solid wastes, such as municipal solid waste (household trash), construction debris and sludge from sewage treatment and other processes.

legislature An officially elected or otherwise selected body of people vested with the responsibility and power to make laws for a political unit, such as a state or nation.

lignin An amorphous polymer that, together with cellulose, forms the cell walls of woody plants. Lignin acts as the bonding agent between cells.

linen Fabric, yarn or paper made from the fiber of flax, probably the first vegetable fiber known to people.

linseed oil A yellowish drying oil derived from the dried ripe seeds of the flax plant (*Linum usitatissimum*, *Linaceae*). It is obtained by pressing, followed by an optional stage of solvent extraction. Its uses include: animal feeds; putty; sealants; caulking compounds; brake linings; linoleum; textiles; foundry products; leather treatment; polishes, varnishes and oil paints; animal care products; wood preservation; synthetic resins. The linoleic acid in linseed oil is used as a dietary supplement.

lubricity The quality or condition of being lubricious, which is slippery or smooth.

malting The process of steeping a grain (usually barley) in water, partially germinated, then drying and curing it. The end product is used in brewing to convert cereal starches to sugars by means of the enzymes (chiefly diastase) produced during germination. Its high carbohydrate and protein content make it a valuable nutrient.

mass In physics, the quantity of matter in a body regardless of its volume or of any forces acting on it.

methane An odorless, colorless, flammable gas with the formula CH_4 that is the primary constituent of natural gas.

milliliter A unit of volume equal to one thousandth (10^{-3}) of a liter.

moisture absorbent The property of a substance being able to absorb moisture.

monomer Small molecules that join in repeating patterns to form larger molecules (polymers).

mulch A protective covering, usually of organic matter such as leaves, straw or peat, placed around plants to prevent the evaporation of moisture, the freezing of roots and the growth of weeds.

municipal solid waste (MSW) Any organic matter, including sewage, industrial and commercial wastes, from municipal waste collection systems. Municipal waste does not include agricultural and wood wastes or residues.

natural gas A mixture of gaseous hydrocarbons, primarily methane, occurring naturally in the earth, used as fuel.

natural resource Resources (actual and potential material) supplied by nature.

nitrogen oxides (NOx) A product of photochemical reactions of nitric oxide in ambient air and the major component of photochemical smog.

nonrenewable resources An energy resource that cannot be replaced as it is used. Although fossil fuels, such as coal and oil, are in fact fossilized biomass resources, they form at such a slow rate that, in practice, they are nonrenewable.

no-till A system for planting crops without plowing, using herbicides to control weeds and resulting in reduced soil erosion and the preservation of soil nutrients.

nuclear energy 1. The energy released by a nuclear reaction, especially by fission or fusion; 2. A source of power, also called atomic energy.

oilseed crops Oilseed crops are a very important component of semi-tropical and tropical agriculture, providing easily available and highly nutritious human and animal food. Many also have industrial uses and are relatively easy to incorporate into locally manufactured products. Oilseed crops include castor, groundnut, safflower, sesame, soya and sunflower, crambe, niger and jojoba.

organic compound Contains carbon chemically bound to hydrogen. Organic compounds often contain other elements (particularly O, N, halogens, or S).

organic matter Organic matter in soil consists of plant and animal material that is in the process of decomposing. When it has fully decomposed, it is called humus. This humus is important for soil structure because it holds individual mineral particles together in clusters.

oxygenate A compound which contains oxygen in its molecular structure. Ethanol and biodiesel act as oxygenates when they are blended with conventional fuels. Oxygenated fuel improves combustion efficiency and reduces tailpipe emissions of CO.

ozone A compound formed when oxygen and other compounds react in sunlight. In the upper atmosphere (stratosphere), ozone protects the earth from the sun's ultraviolet rays. Though beneficial in the upper atmosphere, at ground level, ozone is called photochemical smog, and is a respiratory irritant and considered a pollutant.

ozone depletion The phenomenon of reductions in the amount of ozone in the stratosphere.

particulate/s A fine discrete mass of solid or liquid matter that remains individually dispersed in gas or liquid emissions. Particulates take the form of aerosol, dust, fumes, mist, smoke, smog or spray, found in air or emissions. Each of these forms has different properties.

pectin An organic molecule found in the walls of plant cells.

petroleum Any petroleum-based substance comprising a complex blend of hydrocarbons derived from crude oil through the process of separation, conversion, upgrading, and finishing, including motor fuel, jet oil, lubricants, petroleum solvents, and used oil.

photosynthesis A complex process used by many plants and bacteria to build carbohydrates from carbon dioxide and water, using energy derived from light. Photosynthesis is the key initial step in the growth of biomass and is depicted by the equation: $CO_2 + H_2O$ + light + chlorophyll = $(CH_2O) + O_2$.

plant residue The result of decaying plant matter which provides nutrients and organic matter to soil.

polymer A large molecule made by linking smaller molecules ("monomers") together.

polysaccharide A carbohydrate consisting of a large number of linked simple sugar, or monosaccharide, units. Examples of polysaccharides are cellulose and starch.

potential energy Energy that is stored in matter as a function of that matter's position.

power In physics, the amount of energy put out or produced in a given amount of time. The unit of power based on the English units of measurement is "horsepower," devised for describing mechanical power by James Watt, who estimated that a horse can do 550 ft-lb of work per sec; a foot-pound is the work done when a weight (force) of 1 lb is moved through a distance of 1 ft. The unit of power in the metric system is the watt, named in honor of James Watt and equal to 1 joule per second; the watt is used for measuring electric power in most countries, even those still using English units for other quantities. In common usage, the terms power and energy have become synonymous; for example, electrical energy is usually referred to as electric power.

raw material/s 1. An unprocessed natural product used in manufacturing; 2. Unprocessed material of any kind.

reaction A chemical reaction is a dissociation, recombination or rearrangement of atoms.

recycle The process of recovering and reusing waste products — from household use, manufacturing, agriculture, and business — and thereby reducing their burden on the environment.

renewable Any commodity or resource that can be renewed, such as solar energy or firewood, that is inexhaustible or replaceable by new growth.

renewable energy All sources of energy that are captured from ongoing natural processes, such as solar power, wind power, water flow in streams (hydro power), biomass, biodiesel, and geothermal heat flows. Most renewable forms of energy, other than geothermal and tidal power, come from the sun.

renewable resources An energy resource that is replenished continuously in nature or that is replaced after use through natural means. Renewable energy resources include solar, wind, geothermal, hydro, and biomass. Municipal solid waste (MSW) is also considered to be a renewable energy resource.

replace 1. To substitute a person or thing for another that is broken or inefficient or lost or no longer working or yielding what is expected; 2. Take the place or move into the position of; 3. Put in the place of another; switch seemingly equivalent items; 4. Put something back where it belongs.

reuse To use again, especially after salvaging or special treatment or processing.

seed pieces Portions of plants from which new plants can be grown, such as potatoes.

silica A white or colorless crystalline compound, SiO_2, occurring abundantly as quartz, sand, flint, agate, and many other minerals, and used to manufacture a wide variety of materials, especially glass and concrete. A usable material from the ash of rice hulls.

solar energy 1. Energy in our solar system; 2. In recent years, refers to any form of energy radiated by the sun, including light, radio waves and X rays.

starch A molecule composed of long chains of glucose molecules. Many plants store the energy produced in the photosynthesis process in the form of starch.

thermal energy Kinetic energy due to disordered motions and vibrations of microscopic particles such as molecules and atoms.

toxics As defined in the 1990 Clean Air Act Amendments, toxics include benzene, 1,3 butadiene, formaldehyde, acetaldehyde, and polycyclic organic matter.

transesterification A chemical process which reacts between an alcohol with the triglycerides contained in vegetable oils and animal fats to produce biodiesel and glycerin.

triglyceride A triglyceride is an ester of glycerol and three fatty acids. Most animal fats are composed primarily of triglycerides.

volatile A solid or liquid material that easily vaporizes.

volume A quantification of how much space an object occupies. The SI unit for volume is the cubic metre.

waste-to-energy plants Produce electricity in ways similar to a regular power plant, except WTE plants use a different fuel, burning waste as fuel to make electricity.

watt The common base unit of power in the metric system. One watt equals one joule per second. It is the power developed in a circuit by a current of one ampere flowing through a potential difference of one volt. One watt = 3.413 Btu/hr.

wind energy The energy present in the flow of air around the earth. The wind is driven by the temperature and pressure differences in the atmosphere arising from heating of the earth by the sun and it is further guided by topography. The energy stored in the atmosphere is in three forms: kinetic, potential and thermal. They all play a part in the motion of wind, but the main interest is in the kinetic energy from the wind's motion. The term "wind energy" is most often used to refer to the generation of useful energy from wind. This can be electrical, as in wind turbines, or mechanical, as used in wind pumps for simple agriculture. The kinetic energy of the wind is harnessed, initially by conversion to a rotation; this rotation can be used in a generator, or directly for a mechanical task such as pumping or milling.

yeast Any of various single-cell fungi capable of fermenting carbohydrates.

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Wikipedia online, the leading user-contributed encyclopedia

Standards

SC Farm Bureau
AG in the classroom

SOUTH CAROLINA
Energy Office

Curriculum Standards

Language Arts, Grade 7 through 12

W1 The student will apply a process approach to writing.
W2 The student will write for a variety of purposes.
W3 The student will respond to texts written by others.
W4 The student will create legible texts.
C1 The student will use speaking skills to participate in large and small groups in both formal and informal situations.
C2 The student will use listening skills to comprehend and analyze information he or she receives in both formal and informal situations.
C3 The student will comprehend and analyze information he or she receives from nonprint sources.
R1 The student will integrate various cues and strategies to comprehend what he or she reads.
R3 The student will use a knowledge of semantics, syntax and structural analysis to determine the meaning of unfamiliar words and read texts with understanding.
RS1 The student will select a topic for exploration.
RS2 The student will gather information from a variety of sources.
RS3 The student will use a variety of strategies to prepare and present selected information.

Sciences, Grades 7 and 8

IA7b Create drawings, diagrams, charts, tables, and graphs to communicate data.
IA7c Interpret and describe patterns of data on drawings, diagrams, charts, tables, graphs and maps.
7–**IB2b** / 8–**IC2b** Communicate ideas with drawings and simple models.
7–**IC2a /** 8–**ID2a** Describe examples of contributions people have made to science and technology. (H, N)
7–**IIIA4c** Analyze ways air pollution can be reduced.
7–**IIIA5b** Describe ways that humans may be influencing or contributing to global warming. (P)
7–**IIIA6a** Describe how sunlight, through photosynthesis, is transferred by producers into chemical energy.
7–**IIIA7e** Distinguish between renewable and nonrenewable resources and examine the importance of their conservation. (P)
7–**IIIA7f** Evaluate the effects of human population on air, water and land. (P)
7–**IIIA7g** Analyze the benefits of solid waste management (reduce, reuse, recycle). (T, P)

Physical Science, Grade 9 through 12

I Inquiry

II Physical Science (Chemistry)

- **IIB6a** Demonstrate an understanding of how carbon atoms bond to one another as simple hydrocarbons.
- **IIB6b** Describe the formation of polymers.
- **IIB6d** Determine the uses of polymers in everyday life.
- **IIC1c** Explain the sources and environmental effects of some inorganic and organic toxic substances, such as heavy metals and PCBs. (P)
- **IIC3a3** Explain how acid rain is formed and discuss its effects on the environment. (P)
- **IIC3a4** Demonstrate an understanding of the significance of pH as related to consumer products.
- **IIC4b** Apply reaction rate concepts to real-life applications such as food spoilage, storage of film and batteries, digestive aids, and catalytic converters. (P, T)

III Physical Science (Physics)

- **IIIA4b** Compare and contrast the environmental impact of power plants that use fossil fuels, water or nuclear energy to produce electricity. (P, T)

Science, Grade 9 through 12

I Inquiry

II Life Science

- **IID1a** Analyze how organisms interact with the biosphere as part of the geochemical cycles (carbon, nitrogen, phosphorous, and water cycles).
- **IID2b** Assess the value of the carbon cycle to the flow of energy through the ecosystems.
- **IID3b** Evaluate how interrelationships and interdependencies of living things contribute to the homeostasis of ecosystems.
- **IID4b** Give examples and explain how limiting factors such as water, food, oxygen, and living space play a role in the stability of ecosystems.
- **IID4e** Evaluate dynamic equilibrium as a result of checks and balances within populations, communities and ecosystems.
- **IID5a** Identify events that lead to awareness of environmental concerns such as fish kills, destruction of the ozone layer, global warming, and decline of the bald eagle. (H)
- **IID5d** Assess the consequences of acid rain on ecosystems. (P)
- **IIE4b** Analyze energy in biological systems in terms of transformation, conservation and efficiency.

III Earth Science

- **IIIB1b** Analyze how the use and recovery of fossil fuels impacts the environment. (T, P)

IIIB1c Evaluate the importance of limiting consumption of nonrenewable resources. (T, P)

IV Physical Science (Chemistry)

IVB6b Describe polymers as molecules bonded together.

IVB6c Determine uses of aromatic compounds and polymers in everyday life. (P)

IVC1b Describe how metabolism is an interrelated collection of chemical reactions.

IVC2c Classify reactions as energy-absorbing (endothermic) or energy-releasing (exothermic) based on temperature measurements.

IVC4b Analyze the effects of temperature, particle size, stirring, concentration, and catalysts on reaction rates.

IV Physical Science (Physics)

IVB2a Classify energy types as potential, kinetic or electromagnetic.

IVB4a Compare and contrast the environmental impact of power plants that use fossil fuels, water or nuclear energy to produce electricity. (P, T)

Biology, Grade 9 through 12

I Inquiry

II Biology

IID1a Demonstrate an understanding of how organisms interact with the biosphere as part of the geochemical cycles (e.g., carbon, nitrogen, phosphorous, water cycles).

IID1b Identify important nutrient cycles and evaluate how they affect ecosystems.

IID2a Demonstrate an understanding of the flow of energy, beginning with the sun, through various trophic levels.

IID2b Assess the value of the carbon cycle to the flow of energy through the ecosystems.

IID3a Relate the concepts of cooperation and competition to organisms within an ecosystem.

IID3b Evaluate how interrelationships and interdependencies of living things contribute to the homeostasis of ecosystems.

IID3c Demonstrate an understanding of how living things maintain their high level of order at the expense of increasing the disorder of their physical surroundings.

IID4b Give examples and explain how limiting factors such as water, food, oxygen, and living space play a role in the stability of ecosystems.

IID4e Evaluate dynamic equilibrium as a result of checks and balances within populations, communities and ecosystems.

IID5a Identify events that lead to awareness of environmental concerns such as fish kills, destruction of the ozone layer, global warming, and the decline of the bald eagle. (H)

IID5e Assess the consequences of acid rain on ecosystems. (P)
IIE2a Analyze bond energy as it relates to food molecules.
IIE2b Discuss the importance of ATP and how it is cycled.
IIE4a Demonstrate an understanding of the dynamics of energy and entropy as they apply to biological systems.
IIE4b Analyze energy in biological systems in terms of transformation, conservation and efficiency.

U.S. and South Carolina Studies, Grade 8
IV Production, Distribution and Consumption: Economics

Social Studies — Economics, Grade 9 through 12
ECON-1 The student will demonstrate an understanding of how scarcity and choice impact the economic activity of individuals, families, communities, and nations.
ECON-2 The student will demonstrate an understanding of markets and the role of supply and demand in determining price and resource allocation.
ECON-8 The student will demonstrate an understanding of the principles of trade and economic development.

Standards for Agricultural and Environmental Sciences, Grade 9 through 12
A1 Identify and explain the major areas of agricultural and environmental sciences and career opportunities available to a student preparing for agricultural and environmental sciences occupations.
B4 Explain the impact of soil management on the environment and economy of our state.
E1 Name and explain at least three reasons for man to conserve natural resources.
F11 List the basic steps in problem solving/decision making.

Key:
H=History of Science
N=Nature of Science
P=Science in Social and Personal Perspectives
T=Technology — major categories of the National Science Education Standards that have been integrated in content areas.

Some text contained herein is excerpted directly from the National Science Education Standards.

The term *investigate* is defined as an opportunity for students to explore questions and develop content knowledge by making observations and inferences, collecting and interpreting data, and drawing tentative conclusions through the use of active learning strategies.

All curriculum standards for the state of South Carolina may be viewed online at myscschools.com/offices/cso.

Lesson Plans

Vital Terms for Biomass

Purpose

While the usage of the word "biomass" itself is relatively new, many of the terms used to explore the sciences involved are familiar to students and others reflect new developments and discoveries in this rapidly developing field. It is important to understand these terms, which are becoming mainstream as steppingstones to some of the important critical thinking required to include biomass in the overall picture of our planet's future.

Standards

Language Arts, Grade 7 through 12

C1, C2, R3

Vocabulary

alternative fuel vehicle (AFV)	cesspool	Farm Bureau	lignin
antioxidants	co-firing	feedstock	lubricity
biodegradable	corporation	fermentation	particulates
biodiesel	EPA	firelog	recycle
biomass	ethanol	legislature	silica

Materials Provided

Glossary

"Wordsearch" Activity Hand-out (1a)

Materials Needed

copies of Wordsearch puzzle

Teaching Strategies

1. Introduce this lesson by explaining that some terms will seem familiar, other terms are new but vital to the study of biomass. Use the glossary to introduce some of the unfamiliar words and their meanings, as well as their importance and derivation.
2. Provide each student with a copy of the Wordsearch puzzle (1a).
3. Divide the students into groups of two to complete the Wordsearch puzzle.
4. When one student locates a word, the other student in the group gives the definition, then reverse roles.
5. Collect the Wordsearch puzzles when they are done.

Answer to Wordsearch

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
S	P	A	R	T	I	C	U	L	A	T	E	S	+	L	1
+	T	+	F	+	S	I	L	I	C	A	+	+	+	E	2
+	+	N	+	V	+	+	+	+	+	+	B	+	+	G	3
E	L	B	A	D	A	R	G	E	D	O	I	B	N	I	4
C	+	C	+	D	+	E	T	+	Y	+	O	E	O	S	5
K	O	+	O	+	I	H	L	T	+	F	M	P	I	L	6
C	N	R	+	F	A	X	I	C	A	+	A	A	T	A	7
O	I	+	P	N	I	C	O	R	Y	+	S	+	A	T	8
T	N	+	O	O	I	R	M	I	+	C	S	+	T	U	9
S	G	L	+	R	R	B	I	+	T	+	E	+	N	R	10
D	I	+	B	+	U	A	+	N	+	N	+	R	E	E	11
E	L	U	+	R	+	+	T	+	G	+	A	+	M	+	12
E	L	+	E	L	E	S	E	I	D	O	I	B	R	+	13
F	+	A	C	E	S	S	P	O	O	L	+	+	E	+	14
+	U	G	O	L	E	R	I	F	+	N	+	+	F	+	15

(Over, Down, Direction)

AFV (3,1,SE)
ANTIOXIDANTS (12,12,NW)
BIODEGRADABLE (13,4,W)
BIODIESEL (13,13,W)
BIOMASS (12,3,S)
CESSPOOL (4,14,E)
CO-FIRING (3,5,SE)
CORPORATION (1,5,SE)
EPA (13,5,S)
ETHANOL (9,4,SW)
FARM BUREAU (11,6,SW)
FEEDSTOCK (1,14,N)
FERMENTATION (14,15,N)
FIRELOG (9,15,W)
LEGISLATURE (15,1,S)
LIGNIN (2,12,N)
LUBRICITY (2,13,NE)
PARTICULATES (2,1,E)
RECYCLE (13,11,NW)
SILICA (6,2,E)

Background Information

The United States is faced with energy supply-and-demand problems. One way in which we can help address these problems is through the proper use of biomass. We all need to be knowledgeable about terms relating to biomass. This activity will provide students with a beginning framework of vital terms.

Wordsearch

S	P	A	R	T	I	C	U	L	A	T	E	S	Y	L
N	T	X	F	O	S	I	L	I	C	A	E	F	C	E
V	Y	N	Z	V	F	E	P	N	U	L	B	C	Y	G
E	L	B	A	D	A	R	G	E	D	O	I	B	N	I
C	M	C	B	D	S	E	T	W	Y	G	O	E	O	S
K	O	H	O	V	I	H	L	T	R	F	M	P	I	L
C	N	R	L	F	A	X	I	C	A	W	A	A	T	A
O	I	J	P	N	I	C	O	R	Y	Z	S	P	A	T
T	N	E	O	O	I	R	M	I	H	C	S	Q	T	U
S	G	L	U	R	R	B	I	B	T	X	E	U	N	R
D	I	M	B	Q	U	A	G	N	K	N	J	R	E	E
E	L	U	W	R	J	P	T	D	G	Y	A	S	M	N
E	L	V	E	L	E	S	E	I	D	O	I	B	R	J
F	X	A	C	E	S	S	P	O	O	L	O	W	E	V
Q	U	G	O	L	E	R	I	F	A	N	J	L	F	B

AFV
ANTIOXIDANTS
BIODEGRADABLE
BIODIESEL
BIOMASS
CESSPOOL
CO-FIRING

CORPORATION
EPA
ETHANOL
FARM BUREAU
FEEDSTOCK
FERMENTATION
FIRELOG

LEGISLATURE
LIGNIN
LUBRICITY
PARTICULATES
RECYCLE
SILICA

Getting to Know Pioneers in Energy

Purpose
To help students understand the contributions of various people who were pioneers in the field of energy.

Standards
Language Arts, Grade 7 through 12
W2, RS1, RS2, RS3

Sciences, Grade 7 and 8
7–IC2a / 8–ID2a, 7–W21 / 8–W21, 7–W22 / 8–W22, 7–C12 / 8–C11, 7–W42 / 8–W42

Vocabulary
biomass	municipal solid waste (MSW)	petroleum
ethanol	natural gas	solar energy
geothermal	nuclear energy	wind energy

Materials Provided
"Significant Events in the History of Energy for Each Century" Hand-out (2a)
"List of Pioneers in Energy" Activity Guide for copying and assignment (2b)

Materials Needed
computer access with PowerPoint software
Internet access
encyclopedia
biography books or other books from the library
clip art or pictures cut out of magazines

Teaching Strategy
1. Begin by introducing the students to "Significant Events in the History of Energy for Each Century" (2a). For more comprehensive information, use the Web site: **eia.doe.gov/kids/history/index.html**. Using "Significant Events in the History of Energy for Each Century" (2a), as well as the Web site **eia.doe.gov/kids/history/timelines/index.html**, the teacher can create multiple questions with pre-researched answers.
2. Read the article to students and ask various questions of the students, such as:
   a) What energy sources are used today?
   b) Who was important in the history of energy?
   c) Who might have contributed to various energy inventions and discoveries?
   d) What are the various types of energy?
   e) What types of energy will be available for the future?

3. Ask students who was the most important person(s) in the history of energy. Assign each student a name from the “List of Pioneers in Energy” (2b). Students will do a research project on one of these pioneers of energy history. With access to a computer lab, this project is ideally suitable to be created in PowerPoint.
4. Students will research the person given to them. They can begin their research on the following Web sites: **eia.doe.gov/kids/history/people/pioneers.html** or **ask.com**. Students need to create a presentation on their person that includes the following information in the following suggested format:
   a) Where and when born, where lived and when died;
   b) Family background;
   c) Education;
   d) Who or what influenced the person?;
   e) What is the person best known for?;
   f) Did this person’s accomplishment/s lead to someone else’s work?;
   g) Something interesting about this person; and
   h) Sources/references for the information.
5. If students do not have computer access, assign them a written report which includes pictures or graphic representations. Depending on the grade level of your students, they may do their research in pairs and work together.
6. If your school has a computer lab, inquire about having your class visit the lab over several days to work on this project. The students can then present their projects to the whole class, so that students can learn about other pioneers in energy.
7. If students create a PowerPoint project, they will need to create a title slide that contains their name, class period, date, pioneer’s name, and picture. Each subsequent slide should provide the information outlined in 4a–h above, with a title, information and visual appeal, including pictures and animation if appropriate.
8. Grading for the PowerPoint project will be based on the following:

   Each slide is worth 10 points: 2 points each for the title and adherence to the format for information, 6 points for visual appeal including background, pictures and animation. This will add up to 90 points.

   The other 10 points will be based on the presented information itself:

   Was it accurate?
   Was it written grammatically correct?
   Was thought put into the presentation?
   Was the information logical?
   How was the overall presentation?
9. If the students write this report or work within another software application, the grading can be the same. For visual appeal, students could create a border on their pages and include timelines, graphic representations of patent information and line drawings of inventions or technologies influenced by the pioneer.

Background Information

Energy has a long history. Before people could read and write, fire was discovered to be good for cooking, heating and scaring away wild animals. Fire was possibly civilization's first great energy discovery, and wood was the main fuel for a long time. Many exciting developments in energy over the past 500 years have caused an impact on every facet of civilized development, reflecting creativity, scientific knowledge and genius on the part of contributors to our ongoing search for safe and practical energy sources.

The information for this lesson plan originated from the Energy Information Administration Web site which has links to many other energy topics. Depending on the specific form of energy the teacher wants the students to study, the teacher may choose from several topics.

eia.doe.gov/kids/history/index.html
eia.doe.gov/kids/history/people/pioneers.html
eia.doe.gov/kids/history/timelines/index.html

Significant Events in the History of Energy for Each Century

1600s

Isaac Newton was one of the world's great scientists because he took his ideas, and the ideas of earlier scientists, and combined them into a unified picture of how the universe works. Newton explained the workings of the universe through mathematics. He formulated laws of motion and gravitation which progressed in the future to measurements and predictions of all things scientific. The development of the steam engine by James Watt was one of the most significant technologies in history.

1700s

After eons of superstitious imaginations about electricity, Ben Franklin figured out that static electricity and lightning were the same. His correct understanding of the nature of electricity paved the way for the future.

1800s

The mathematical theory of electromagnetic fields was published. James Clerk Maxwell created a new era of physics when he unified magnetism, electricity and light. One of the most significant events, possibly the most significant event, of the 19th century was Maxwell's discovery of the four laws of electrodynamics ("Maxwell's Equations"). This led to electric power, radios and television.

1900s

The special theory of relativity was written. Albert Einstein created a new era of physics when he unified mass, energy, magnetism, electricity, and light.

One of the most significant events of the 20th century was Einstein's writing of the formula of $E=mc^2$: energy = mass times the square of the speed of light. This led to nuclear medicine — and a much longer life span, astrophysics and commercial nuclear electric power.

List of Pioneers in Energy

George Edward Alcorn Jr. (1940)
Anders Celsius (1701)
David Crosthwait (1898)
Marie Curie (1867)
John Dalton (1766)
Rudolf Diesel (1858)
Edwin Laurentine Drake (1819)
Thomas Edison (1847)
Albert Einstein (1879)
Michael Faraday (1791)
Henry Ford (1863)
Benjamin Franklin (1706)
Robert Goddard (1882)
Meredith C. Gourdine (1929)
Frederick M. Jones (1892)
James Prescott Joule (1818)
Roscoe L. Koontz (1922)
Lewis Latimer (1848)
Guglielmo Marconi (1874)
James Clerk Maxwell (1831)
Lise Meitner (1878)
Isaac Newton (1642)
Georg Simon Ohm (1787)
J. Robert Oppenheimer (1908)
Nicolaus Otto (1832)
Michael Pupin (1858)
Louis Roberts (1913)
William Stanley (1858)
Rufus Stokes (1924)
Nikola Tesla (1856)
Granville Woods (1856)

(above list adapted from **eia.doe.gov/kids/history/people/pioneers.html**)

Investigating Issues Related to Fossil Fuel Utilization and Alternative Energy Sources

Purpose

The student will research an environmental issue related to biomass utilization, alternative fuel sources or environmental problems that result from the utilization of traditional fossil fuels. The student will present his or her information to the class in the form of a poster, model or diorama.
Time required includes two days for research of the project topic plus one day for presentation.

Standards

Language Arts, Grade 7 through 12
W2, W4, W1, RS2, RS3

Biology, Grade 9 through 12
IB9, IC2, ID1, IE2, IF2, IG1b, IG5, IG6, IID5a, IID5e

Vocabulary

acid rain
alternative fuel vehicle (AFV)
biomass
biodiesel
desertification
EPA
ethanol
firelog
fossil fuel
geothermal energy
global warming
hydrogen fuel
hydropower
landfill gas
natural gas
nuclear energy
ozone depletion
petroleum/oil
recycle
solar energy
soybeans
wind energy

Vocabulary Specific to this Lesson Plan (not in Glossary)

air pollution
hybrid cars
poultry litter
water pollution
wood and wood waste
yellow grease

Materials Provided

"Biomass Environmental Issues Project" Activity Hand-out (3a)
"Grading Sheet for Biomass Environmental Issues Project" Teacher Aid (3b)
"Topics List" Activity Hand-out (3c)
"Student Assignment Record" Teacher Aid (3d)

Materials Needed

Access to library and Internet resources. Class time should be scheduled for utilization of the media center and the computer lab.
Materials for presentation as required for the students' chosen method. (Materials are provided by the student.)

Teaching Strategy

1. The six vocabulary phrases not found in the provided Glossary should be researched and defined in classroom discussion, noting their relevance to the purposes of this project.
2. The project is assigned after students have completed instruction on the negative effects of fossil fuel emissions on the environment (including acid rain, ozone depletion and global warming) and alternative sources of energy (including substitute fuels and alternative methods of generating energy). Use the Web sites listed in the "Resources" section if any research is required.
3. Cut the "Topics List" into strips and fold. Place folded strips into a container for the students to pick from. Students enjoy this because they get to "pick" their topic.
4. Distribute the "Biomass Environmental Issues Project" Activity Hand-out which includes a place for the student's name and the topic selected.
5. After the student selects a topic, he or she fills in the topic on the hand-out. The student then writes his or her name on the topic slip and returns the topic slip to the teacher for recording on the "Student Assignment Record" sheet.
6. Students are allotted two days for research in the library and use of the computer lab. Any further time needed for research is done outside of class time.
7. On the assigned due date, student projects are turned in and graded according to the rubric on the "Biomass Environmental Issues Project" Activity Hand-out.
8. For the presentation portion of the project, divide the students into equal numbers in groups labeled 1 through 4 in this adaptation of "Inside-Outside Circles*." Have the students in groups 1 and 2 form circles in different parts of the room facing outwards with their shoulders almost touching. These are the "inside circles." Have the students in group 3 form a circle facing the students in group 1, and have the students in group 4 form a circle facing the students in group 2. The students of groups 3 and 4 are the "outside circles." Leave a blank position in each circle. This is called the teacher space and, as each student faces the teacher space, they must present their project to the teacher for grading.
9. At a signal from the teacher, the student in the outside circle presents his project to the student facing him on the inside circle. The student on the inside circle listens attentively. The listener must formulate a question to ask the presenter when he has finished. When the presenter has finished sharing, the listener thanks him for sharing and asks his question. The presenter answers the question and thanks the listener for listening. This procedure is repeated with students switching roles, so the student on the inside circle presents his project to the student on the outside circle who listens.
10. Students on the outside circle move one student to the right, and the procedure in step 9 is repeated until all members of both circles have shared their project

*Kagan, Spencer. (1994). *Cooperative Learning*. San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
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with each other and with the teacher. If time permits, the members of the outside circles can switch places, giving the students the opportunity to listen to more projects. If this is the case, there is no need for a teacher space.

Background Information

The most common methods to obtain energy currently in use involve the combustion of fossil fuels. Not only are fossil fuels a limited and nonrenewable resource, but the oxidation of fossil fuels also contributes to environmental pollution and serious problems such as acid rain and global warming. The development of alternative energy sources and alternatively fueled vehicles has the two-fold advantage of reducing environmental damage and decreasing dependence on a dwindling nonrenewable resource.

Biomass Environmental Issues Project

Name: ____________________

Your project will involve doing research on an environmental issue (randomly selected) related to biomass utilization, alternative fuel sources or environmental problems resulting from the utilization of traditional fossil fuels. For your project you will prepare a poster, a model or a diorama that reflects the problem or solution associated with your issue and familiarize yourself with the issue so that you can contribute insight that expands on the overall subjects of biomass and the environment.

We will be going to the library on____________________.

I. You are to gather information from at least **three** different sources. These may be Internet sources (be sure these are reliable sources), books, magazines, or encyclopedias. Do not use more than one general reference encyclopedia.
II. Be sure your project thoroughly addresses your environmental issue.
III. Your project is to be turned in on____________________.
IV. You will be graded on the following criteria.
   1. Quality and appearance of your work — 65 points
      a. neat
      b. complete and informative
      c. colorful
   2. Presentation of project to the class — 20 points
      a. speak so you can be heard
      b. present your information (don't just read from poster)
      c. give your opinion of your findings
   3. Quality of your 3 sources — 15 points
      a. Turn in a list of the sources you used with your project (either typed or in black ink). For books, magazines or encyclopedias, include the title of the source, title of the article you referenced, date of publication or issue, and page numbers.
      b. For Internet sources, give the complete Internet address. Be very careful copying this address as I will check all Internet sources. Remember that a search engine (such as **google.com**) is not a sufficient address.

Remember: Your project counts as two major grades. Do a good job. You may earn extra credit for an especially well-done project and/or presentation.

V. If your project is one day late, 10 points will be deducted. If your project is two days late, 30 points will be deducted. **NO PROJECTS WILL BE ACCEPTED AFTER ____________________ (the second late day).**

Assigned Issue:____________________

Grading Sheet for Biomass Environmental Issues Project

PROJECT GRADE:__________________

NAME:____

DATE TURNED IN:__________________

TITLE:____

GRADING:

Project (65) ____________

Presentation (20) ____________

Sources (15) ____________

Extra Credit ____________

Penalties ____________

TOTAL ____________

PENALTIES:

On Time (0) ____________

1 Day Late (-10) ____________

2 Days Late (-30) ____________

PROJECT GRADE:__________________

NAME:____

DATE TURNED IN:__________________

TITLE:____

GRADING:

Project (65) ____________

Presentation (20) ____________

Sources (15) ____________

Extra Credit ____________

Penalties ____________

TOTAL ____________

PENALTIES:

On Time (0) ____________

1 Day Late (-10) ____________

2 Days Late (-30) ____________

Topics List

Acid Rain

Air Pollution

Alternative Fuel Vehicles

Biomass

Biodiesel

Coal

Corn

Desertification

Firelogs (enviro-log.net)

EPA

Ethanol

Fossil Fuel Depletion

Geothermal Energy

Global Warming

Hybrid Cars

Hydropower

Topics List, Cont'd.

Hydrogen Fuel

Landfill Gas

Natural Gas

Nuclear Energy

Ozone Depletion

Petroleum/Oil

Poultry Litter

Recycling

Solar Energy

Soybeans

Water Pollution

Wind Energy

Wood and Wood Waste

Yellow Grease

Student Assignment Record

TOPIC	STUDENT
Acid Rain	
Air Pollution	
Alternative Fuel Vehicles (AFVs)	
Biomass	
Biodiesel	
Coal	
Corn	
Desertification	
Firelogs (enviro-log.net)	
EPA	
Ethanol	
Fossil Fuel Depletion	
Geothermal Energy	
Global Warming	
Hybrid Cars	
Hydropower	
Hydrogen Fuel	
Landfill Gas	
Natural Gas	
Nuclear Energy	
Ozone Depletion	
Petroleum/Oil	
Poultry Litter	
Recycling	
Solar Energy	
Soybeans	
Water Pollution	
Wind Energy	
Wood and Wood Waste	
Yellow Grease	

Introduction to Biomass: From Potential Raw Materials to End Products and Resulting Impacts

Purpose

At the end of this lesson, students will be able to understand biomass concepts, including related vocabulary. Biomass/biomass process will be studied from beginning to end by identifying potential raw materials, discussing the necessary processing steps, and exploring the resultant biomass products or impacts.

Standards

Language Arts, Grade 7 through 12
W1, W2, W4, C1, C2

Sciences, Grade 7
IIIA7e

Science, Grade 9 through 12
IIIB1c

Vocabulary (Basic)

alternative fuels
biodiesel
biomass
ethanol
flexible fuel vehicle (FFV)
raw materials
renewable resources

Depending on grade level, offer appropriate words and phrases as provided in the Glossary.

Materials Provided

"Each One Teach One" Activity (4a)

Materials Needed

A Day with Captain Soybean book, available from the SC Soybean Board, (803) 734-1767
index cards with various vocabulary words and their definitions written on them
several different school menus
"Where Can You Find Corn After It Leaves the Farmers' Field?" poster*
"Where Can You Find Soybeans After They Leave the Farmers' Field?" poster*

*Available from Indiana Farm Bureau. To order, send a check for $2.00 per poster with quantity needed and contact information to: Women's Division, Indiana Farm Bureau Inc., PO Box 1290, Indianapolis IN 46206. Please include 6 percent sales tax and $4.00 shipping and handling.

Teaching Strategy

1. To provide an overview of biomass raw materials, introduce posters to identify corn and soybeans. Discuss other potential raw materials.
2. Read *A Day with Captain Soybean* and discuss the beginning and end process for converting soybeans into final biodiesel products.
3. Review and reinforce vocabulary words using “Each One Teach One” (4a) activity.
4. Students will look at school menus to identify agricultural products that can be used in biomass. Examples include corn, foods that contain soybeans, etc. Students will also maintain a week-long log of potential products from home and school that could be used in biomass. Examples include food items, food waste, cooking oil, etc.
5. Plan appropriate field trips and/or speakers to reinforce biomass concepts and impacts. Field trip possibilities include United Energy in Aiken, South Carolina and an automotive dealership that sells FFVs, such as a Ford dealership. Potential speakers include the South Carolina Energy Office and South Carolina Department of Health and Environmental Control’s Bureau of Air Quality. Students will write brief reports describing what was learned from these field trips and/or speakers. For example, if a dealership that sells FFVs is visited, students would report the number, types and approximate costs of such available vehicles. If applicable data is available, students should draw conclusions about the sales and advantages/disadvantages between FFVs and traditional vehicles.

Background Information

Biomass and the impacts from biomass are currently a topic of interest among various groups. From a fuel perspective, gasoline prices are elevated and the nation’s dependence on foreign oil supplies is critical and often times on “shaky ground.” Biomass products are also derived from domestically produced materials. Therefore, the use of biomass and biomass products benefits our economy, national security, and the protection of health and the environment. Perhaps most importantly, its use recognizes the vital role of agriculture and farmers in our society.

Each One Teach One

1. "In this activity, you will have two groups: teachers and learners."
2. "You will receive a card which has one vocabulary word and definition printed on it. Your job is to teach that one fact to everyone else in the group. Use whatever teaching strategies you wish to use to help your classmates learn. At the same time you are teaching your word, you will be learning as many words as possible. Your goal is to be a good teacher and a good learner."
3. "There will be an evaluation at the end of the activity in which the good teachers and the good learners will be recognized."
4. "Any questions?" Distribute index cards, one to teach student. "You may begin." The less instructions you give at this point the better. Different groups will approach the activity differently. That's fine. Students like to talk and move; this activity incorporates both.
5. Walk among the students to observe methods being used and have materials ready to record to review the newly learned vocabulary words.
6. When it is obvious that it is time to stop, have everyone return to their seats. Recommended time is 5–10 minutes.
7. "Now it is time for group evaluation. Place the card with your word on it in the center of the table." The teacher should collect the cards. "Also, any notes taken during the exercise should be turned face down."
8. "Think of a word someone else taught you. Raise your hand and I will call on you to share." As students share the words, record on the board or other appropriate material. Ask the student who taught the word to stand and take a bow. Doing so will recognize the good teachers.
9. After all words have been discussed or no one else can think of other words, have everyone stand up and take a bow. Doing so will recognize the good learners.

Too Much Garbage!

Purpose

This lesson plan will increase students' awareness of the amount of waste generated by individuals and populations over various time spans. The students will identify the various waste materials and amounts generated by people in the U.S. Students will gather data, make predictions, categorize garbage, construct data tables and/or graphs, and participate in discussions that will emphasize the enormity of the problem and the need to identify solutions for upcoming generations.

Standards

Language Arts, Grade 7 through 12
RS2

Science, Grade 7
Inquiry, IIIA5b, IIIA7e, IIIA7g

U.S. and South Carolina Studies, Grade 8
IV

Science, Grade 7 through 12
Inquiry, IIIB1c, IVB4a

Social Studies, Economics, Grade 9 through 12

Agricultural and Environmental Sciences, Grade 9 through 12

Vocabulary

environment
landfill
mass
recycle
replace
reuse
volume

Materials Provided

"Biomass Facts" for copying and distribution (in "Resources" section, 1a and 1b)

Materials Needed

teacher- or student-collected garbage (paper, plastic, metal, glass, rubber, organic, other)
large paper bags (13 per group — 2 labeled: #1 & #2 and 11 labeled: paper, plastic, metal, glass, rubber, organic, other, recycle, replace, reuse, landfill)
science journal
chalkboard (dry erase board)
graph paper
weight (mass) scales
masking tape
rulers

Teaching Strategy

1. The teacher or students will collect trash for several days or weeks (paper, plastic, glass, metal, rubber and organic).
2. Separate the class into groups of 4 to 6 students.
3. Have each group weigh their total amount of trash (apportioned or collected on their behalf) and record the findings.
4. Have each group form a square out of their trash in a bag labeled #1 and marked with group number; secure with tape, measure and record findings.
5. Regroup the entire class and record the findings on the board and discuss the possible environmental effects.
6. Use the information to make predictions about the trash in the U.S. and how much land is needed to hold the amount of trash in the classroom (amount/person).
7. Provide the class with the solid waste fact and the acre fact, then have the class revise their predictions about the amount of land needed per person.
8. Have each group or student construct a data table and/or graph.
9. Have each student write a one-paragraph summary in their science journal.
10. Separate again by groups and have each group separate their trash by paper, plastic, glass, metal, rubber, organic, other and place in labeled bags with group number.
11. Have each group record the items by categories.
12. Have each group weigh each bag of trash (provide a weight for organic if using pictures) and record the findings.
13. Have each group form a square out of their organic and other trash in a bag labeled #2 and with group number, secure with tape, measure and record findings.
14. Regroup the entire class and record the findings on the board. Discuss the possible environmental effects.
15. Use information to make predictions about the trash in the U.S., how much land is needed to hold the amount of trash in the organic and other bags (amount/person) and what could be done to the trash in the paper, plastic, glass, metal and rubber bags.
16. Provide the class with the solid waste fact and the acre fact, then have the class revise their predictions about the amount of land needed per person.
17. Have each group or student construct a data table and/or graph.
18. Have each student write a one-paragraph summary in their science journal.
19. Provide each group with the solid waste fact and the acre fact, then have the group predict the amount of land needed per person in a week, in a month, in six months, in a year and in several years (give specific numbers of multiple years).
20. Record the findings on the board.

21. Discuss the environmental and health consequences based on the findings.
22. Have each group or student construct a data table and/or graph.
23. Have each student write a one-paragraph summary in their science journal.
24. Separate again by groups and have each group separate the trash in their bags again by recycle, replace, reuse, landfill, and place in labeled bags with group number.
25. Have each group record the items by category.
26. Have each group weigh only the landfill bag and record the weight.
27. Have each group form a square out of their bag labeled “landfill” with the group number, secure with tape, measure and record findings.
28. Regroup the entire class and record the findings on the board.
29. Use information to make predictions about the trash in the U.S., how much land is needed to hold the amount of trash in the landfill bag (amount/person) and what could be done to the trash in the recycle, replace and reuse bags.
30. Discuss the environmental and health consequences based on the findings.
31. Have each group or student construct a data table and/or graph.
32. Have each student write a one-paragraph summary in their science journal.
33. Compare and contrast the differences found from totally grouped trash to sorted by recycle, replace and reuse.
34. Review the “Biomass Facts” pertinent to waste materials (in “Resources” section, 1a and 1b) with students and the implications of these facts on the need to recycle, replace and reuse.
35. Have each student write a one-page essay explaining the environmental benefits to recycling, replacing and reusing trash, and how they can make a difference in the future.
36. Some students may choose to act on their enhanced awareness of the impact of waste on the planet. If initiative is shown by these students, consider assigning extra credit to encourage activities school-wide, community-wide or in their homes, such as paper recycling programs or aluminum can recycling, providing these are outcomes from this lesson plan.

Background Information

Responsible generation and handling of waste materials throughout a community can change a recognized liability into an asset. Solutions for recycling waste, energy creation and reuse of trash require creative thinking and a solid background in science, with the potential of changing the future in a positive and dynamic way for upcoming generations.

Energy is Garbage!

Purpose

Students will gain knowledge in the meaning of biomass, how it is made and its positive effects on our environment.

Standards

Language Arts, Grade 7 through 12
C1, C2, C3, RS2

Sciences, Grade 7 through 12
Inquiry

Sciences, Grade 7 and 8
7–IIIA6a, 7–IIIA7e, IIIA7f

Science, Grade 9 through 12
IID4e, IIE4b, IIIB1c

Social Studies — Economics, Grade 9 through 12
ECON-1

Agricultural and Environmental Sciences, Grade 9 through 12
B4, E1

Vocabulary

bacterial decay	ethanol	landfills	renewable
biomass	fermentation	methane	waste-to-energy plants
conversion	fossil fuels	photosynthesis	

Materials Provided

Glossary
"Waste-to-Energy Fact Sheet" Hand-out (6a)
"Each One Teach One" Activity (in "Introduction to Biomass" lesson, 4a)
"Biomass Facts" (in "Resources" section, 1a through 1f)
"Inside-Outside Circles*" Activity (6b)
"Energy from Garbage" Activity (6c)

Materials Needed

Apple Film (available online at **farmland.org/#**, scroll to bottom of page and click on "**film**")
permanent marker
white index cards (any size) for "Each One Teach One" (4a)
colored paper for "Biomass Facts" to be used in the "Inside-Outside Circles*" (6b) activity
overhead transparency and marker

*Kagan, Spencer. (1994). *Cooperative Learning*. San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
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Teaching Strategy

1. Present the Apple Film to demonstrate to students the earth's capabilities for agricultural production. The presentation shows how much actual land we have to produce our food and how important it is to protect and conserve our land.
2. Distribute copies of the "Waste-to-Energy Fact Sheet" (6a) to students to provide them with appropriate background, more specific vocabulary in context, and a good overview of some of the steps already in place that are helping to preserve and further agricultural production. After a quick review, ask content-specific questions to determine the level of comprehension as to the scope of the problem and the solutions outlined in the fact sheet.
3. Prepare "Each One Teach One" index cards in advance, with one vocabulary word and its definition per card. Follow directions for "Each One Teach One" (4a). Teacher should walk around to monitor.
4. Teacher should prepare cards for "Inside-Outside Circles*" (6b) in advance using different colored index cards. Follow directions for "Inside-Outside Circles*" (6b). Teacher should walk around to monitor.
5. Have students tell their facts from fact cards. Teacher will write them on the overhead until all facts are listed.
6. Divide the class into groups for the "Energy from Garbage" (6c) activity to conclude this lesson plan. Inform students that they will be analyzing dried peas or beans to determine if they will produce gas, with the organic matter representing waste material, or garbage. Distribute "Energy from Garbage" (6c) hand-out and materials to each group. Read directions together and instruct the groups to follow the directions. Teacher should walk around to monitor. Students should be encouraged to anticipate the eventual outcome by discussing the proposed hypotheses and to record their predicted result. While the procedure for the experiment will not take long, the observation should continue for a week. Predictions, observation notes and conclusions should be recorded in the students' science journals.

Background Information

Land use is already at a premium. Biomass utilization means that our landfill usage could decrease and more land could be used to grow crops for food or other needs. Not only will the land be used more effectively, our energy supply would not have to be dependent on foreign countries. If we educate our students on these issues, hopefully they will understand the need to respect the environment and sustain the agricultural future of our planet.

*Kagan, Spencer. (1994). *Cooperative Learning.* San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
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Fact Sheet

WASTE-TO-ENERGY: Clean, Reliable, Renewable Power

What is "waste-to-energy"?

Waste-to-energy facilities produce **clean, renewable energy through the combustion of municipal solid waste in specially designed power plants equipped with the most modern pollution control equipment to clean emissions**. Trash volume is reduced by 90% and the remaining residue is regularly tested and consistently meets strict EPA standards allowing reuse or disposal in landfills. There are 89 waste-to-energy plants operating in 27 states managing about 13 percent of America's trash, or about 95,000 tons each day. Waste-to-energy generates about 2,500 megawatts of electricity to meet the power needs of nearly 2.3 million homes, and the facilities serve the trash disposal needs of more than 36 million people. The $10 billion waste-to-energy industry employs more than 6,000 American workers with annual wages in excess of $400 million.

Why is waste-to-energy clean?

America's waste-to-energy facilities meet some of the most stringent environmental standards in the world and employ the most advanced emissions control equipment available. The EPA announced that America's waste-to-energy plants produce "dramatic decreases" in air emissions, and produce electricity "with **less environmental impact than almost any other source of electricity**." The "**outstanding performance**" of pollution control equipment used by the waste-to-energy industry has produced "dramatic decreases" in emissions. EPA data demonstrate that dioxin emissions have decreased by more than 99% in the past ten years, and represent less than one-half of one percent of the national dioxin inventory. Mercury emissions have declined by more than 95% and now represent two percent of the national inventory of man-made mercury emissions. Additionally, EPA estimates that waste-to-energy technology annually avoids 33 million metric tons of carbon dioxide, a greenhouse gas, that would otherwise be released into the atmosphere.

Communities served by these facilities recycle an average of 35% of their trash as compared with the national recycling rate of 30%. Waste-to-energy annually removes for recycling nearly 700,000 tons of ferrous metals and more than three million tons of glass, metal, plastics, batteries, ash and yard waste at recycling centers located on site.

June 2004

INTEGRATED WASTE SERVICES ASSOCIATION

1401 H Street N.W., Suite 220 • Washington, DC 20005 • 202-467-6240 • FAX: 202-467-6225

Why is waste-to-energy renewable?

For more than twenty years, waste-to-energy has been recognized as a source of renewable energy under existing law. **Waste-to-energy is a "clean, reliable, renewable source of energy," according to the U.S. EPA.** The Federal Power Act, the Public Utility Regulatory Policies Act, the Federal Energy Regulatory Commission's regulations, and the Biomass Research and Development Act of 2000 all recognize waste-to-energy power as renewable biomass, as do fifteen states that have enacted electric restructuring laws. EPA estimates 75% of trash contains biomass on a Btu-output basis. Turning garbage into energy makes **"important contributions to the overall effort to achieve increased renewable energy use and the many associated positive environmental benefits,"** wrote Department of Energy Assistant Secretary for Energy Efficiency and Renewable Energy David Garman.

What makes waste-to-energy reliable?

Waste-to-energy plants **supply power 365-days-a-year, 24-hours a day**. Facilities average greater than 90% availability of installed capacity. Waste-to-energy plants generally operate in or near an urban area, easing transmission to the customer. Waste-to-energy power is sold as "base load" electricity. There is a constant need for trash disposal, and an equally constant, steady, and reliable energy generation. Waste-to-energy promotes energy diversity while helping cities meet the challenge of trash disposal.

How does waste-to-energy produce clean energy from dirty garbage?

Waste-to-energy facilities achieved compliance in 2000 with new Clean Air Act pollution control standards for municipal waste combustors. More than $1 billion was spent to upgrade waste-to-energy facilities, leading EPA to write that the "**upgrading of the emissions control systems of large combustors to exceed the requirements of the Clean Air Act Section 129 standards is an impressive accomplishment**." In addition to combustion controls, waste-to-energy facilities employ sophisticated pollution control equipment.

- A "bag house" works like a giant vacuum cleaner with hundreds of fabric filter bags that clean the air of soot, smoke and metals.
- A "scrubber" sprays a slurry of lime into the hot exhaust. The lime neutralizes acid gases, just as a gardener uses lime to neutralize acidic soil. Scrubbing also can improve the capture of mercury in the exhaust.
- "Selective Non-Catalytic Reduction" or "SNCR" converts nitrogen oxides – a cause of urban smog – to harmless nitrogen by spraying ammonia or urea into the hot furnace.
- "Carbon Injection" systems blow charcoal into the exhaust gas to absorb mercury. Carbon injection also controls organic emissions such as dioxins

Ash residue from waste-to-energy facilities represents about 10% by volume of the original trash. The **ash is tested in accordance with strict state and federal leaching tests and is consistently shown to be safe for land disposal and reuse**. Ash makes good cover in landfills because it exhibits concrete-like properties causing it to harden once it is placed and compacted in a landfill, reducing the potential for rainwater to leach contaminants from trash landfills into the ground.

Inside-Outside Circles*

This material has been adapted from the following book with permission from Kagan Publishing & Professional Development: Kagan, Spencer. *Cooperative Learning*. San Clemente, CA: Kagan Publishing, 1994. (800) 933-2667; www.KaganOnline.com/. Kagan, 1994.

This activity is used to facilitate sharing between individual students. Students may be sharing a paragraph they have written, a completed project, a recollection or opinion, or any other type of assignment. For this lesson plan's activity, you can use the "Biomass Fact Sheets" prepared for copying in the "Resources" section, 1a through 1f. This activity can be adapted for most of the lesson plans in this textbook.

1. Divide class into four equal groups. Tell two of the groups to form separate circles in two locations in the room. After the circles are formed, have students face outwards with shoulders almost touching. These are the two "inside circles."
2. Have each of the remaining two groups form a circle around one of the other circles. These are the "outside circles" and each student in the outside circles should be facing a student from the inside circle. If there is an odd number of students, have one set of two students on an outside circle partner with one student on the inside circle.
3. Tell students that members of the inside circles will be referred to as "a"s, and members of outside circles are "b"s. Have "a"s begin to share their information with "b"s when the teacher says "Go." "B"s are to actively listen and think of a question to ask after "a"s are finished. When time is called (usually 30 seconds to one minute is sufficient), "b"s ask their question and "a"s answer. "B"s thank "a"s for sharing and "a"s thank "b"s for listening.
4. Next have all "b"s rotate one position to the right. Repeat step 4, but this time "b"s share and "a"s ask the question.
5. Now have "a"s rotate one position to the left and share. Continue this pattern until the circles have moved through one full rotation.

*Kagan, Spencer. (1994). *Cooperative Learning*. San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
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Energy from Garbage Directions

Materials

packet of dried peas or beans (soak overnight before using)
six airtight clear plastic bags
water

Procedure

1. Soak the peas or beans in water overnight.
2. Place 10 peas or beans into each bag and squeeze out all the air before you seal the bag.
3. Put two bags in a warm sunny place, two bags in a warm shady place, and two bags in a totally dark place for a week and observe what happens.
4. Record your observations in your science journal on a regular basis and add your conclusions at the end of the week.

Questions

1. Can you produce a gas from decaying garbage?
2. Can you control the amount of gas produced from decaying garbage?

Possible Hypotheses

A gas is/is not produced when garbage decays.
The amount of gas from decaying garbage can/cannot be controlled.

Sell That Resource

Purpose
Students will familiarize themselves with the attributes and benefits of renewable or nonrenewable resources. Summarizing the information will help them to evaluate the qualities of that resource and decide which qualities are the most important. Technology is an integral factor to making better use of renewable resources, but occasionally technological solutions have intended benefits and unintended consequences. The process of researching a specific resource will provide students with both positive and negative aspects to that resource's viability in the future of biomass.

Standards
Language Arts, Grade 7 through 12
C1, C2, C3, W1, W2, W3, W4, RS1, RS3
Sciences, Grade 7 through 12
Inquiry, 7–IIIA4c, 7–IIIA7e, IID2a, IID3b, IID4e, IIIB1c
Social Studies — Economics, Grade 9 through 12
ECON-1
Agricultural and Environmental Sciences
E1

Vocabulary
biodiesel	energy	fossil fuels	renewable resources
biomass	ethanol	nonrenewable resources	

Materials Provided
"Web Site" resources — one copy per student (in "Resources" section, 3)

Materials Needed
Energy Factbook, A Resource for South Carolina — one copy for each student obtained through the South Carolina Energy Office at 1-800-851-8899 or online at **energy.sc.gov**, under K–12 Education.
computer with Internet access
samples of various brochures, including both three-fold and four-fold design
construction paper for the students to design a brochure persuading people to use a particular resource

Teaching Strategies
1. Ask media specialist to prepare materials pertaining to renewable and nonrenewable resources.
2. Distribute *Energy Factbook* and copies of "Web Site" resources.

3. Discuss pertinent terms in glossary.
4. Using the *Energy Factbook* and the “Web Site” resources for background information, discuss the advantages and disadvantages of the various resources.
5. Explain that the research will help students learn about the attributes and benefits of each resource.
6. Students individually will choose a resource that they would like to further explore.
7. Show the students various types of brochures and explain that their assignment is to prepare a brochure selling their chosen resource. This brochure must persuade the general public to purchase and use their chosen resource.
8. Take the students to the media center and have the media specialist provide instruction on how to access information about their chosen resource.
9. Using their notes, students should choose persuasive/descriptive phrases for the text of their brochure.
10. Students will design the title page.
11. Students should bring rough draft to teacher for approval.
12. After the rough draft has been approved, have the student complete the final brochure.
13. Have the students display their brochures in a prominent place in the school.

Background Information

The sun is a major source of energy for changes on the earth’s surface. It is one of several energy sources that are not being fully utilized today to balance our use of nonrenewable resources. For the earth to survive in the future, it is important that people — indeed, all organisms — be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

Renewable Energy Resources

Purpose
Students will investigate a variety of renewable energy resources, as well as the benefits and drawbacks of each.

Standards
Language Arts, Grade 7 through 12
C1, C2, W1, W2, W3, W4, R1, RS2, RS3

Sciences, Grade 7 through 12
Inquiry, 7–1B2b, 8–IC2b, 7–IIIA7e, IIB1c, IID3b, IID4e, IIE4b

Social Studies — Economics, Grade 9 through 12
ECON-1, ECON-8

Agricultural and Environmental Sciences, Grade 9 through 12
E1, F11

Vocabulary
biomass	nonrenewable sources	solar
geothermal	renewable energy	
hydropower	renewable sources	

Materials Provided
"Renewable Energy Resources" Activity Hand-out (8a)

Materials Needed
computer with Internet access
pencil
paper

Teaching Strategy
Students will go online and read articles (keywords: **renewable** + **energy** + **resources** + **community**) to answer the following questions related to renewable energy sources:

1. What are the environmental benefits of renewable energy?
2. How much would it cost a household to adapt to using or installing renewable energy strategies?

After students have read the articles, the teacher will ask them questions such as the following:

1. Why do these reports suggest that communities should begin to look at alternative energy resources?
2. There were [five] sources of energy described on [this site]. What are they?
3. What are the benefits of using renewable energy technologies?

4. Why aren’t some renewable resources widely accepted today?
5. What is meant by “environmental costs”? “Social costs”? What are examples of each?
6. What energy resource is cheapest in the short run? In the long run?

Divide students into teams of four or five. Each team will be responsible for researching one of the following: solar; wind; geothermal; biomass; or hydropower systems.

The teacher will distribute the activity hand-out and explain the entire scope of the lesson to students. Explain the final product (the vote), as well as all steps leading up to that. Be sure that the due dates are clear and recorded on the student sheets. If they aren’t known yet, be sure to remind students to record them as they are determined.

Background Information

In this lesson, students will use Internet resources to investigate renewable sources of energy.

The students should already have a basic understanding of energy and know several examples of renewable and nonrenewable sources from a previously taught lesson.

It’s important to be aware of common misconceptions associated with energy. For example, students may believe energy is associated only with humans or movement, is a fuel-like quantity which is used up or is something that makes things happen that is expended in the process. In addition to not readily understanding the conservation of energy, students do not understand that once energy is converted, it is not necessarily in a usable form.

This lesson is designed to help students investigate and evaluate renewable energy sources. Most students can name several renewable resources, but have little understanding of them.

It’s also important for students to examine controversial issues associated with renewable energy sources from multiple perspectives. By exploring benefits, drawbacks and social ramifications, students will develop a deeper appreciation for these complex issues.

Renewable Energy Resources

Name: ______________________________

Research Partners: ______________________________

In this activity, you will investigate various alternative energy sources and, at the conclusion of the lesson, vote on a new type of energy to be adopted by the "town." There will be several steps, with the following guidelines and due dates.

1. You will be placed into a group of 4 or 5 members to research one of the following energy sources as assigned: **solar**; **wind**; **geothermal**; **biomass**; or **hydropower**. As a group, you will write a one-page summary of the energy source and prepare a presentation for the class.

   The following ideas should be included in your summary/presentation:
   - How does this technology work?
   - How could this energy source be used?
   - What are some examples of its current use?
   - What are apparent environmental impacts associated with this?
   - Are there hidden environmental and social costs?
   - Is this technology widely accepted today? Why or why not?
   - Do the costs of this technology make it prohibitive for common use? Why or why not?

   The due date for the summary is ____________________, and the due date for the class presentation is ________________ .

2. After listening to all class presentations, you will write a "community news article" in which you choose the type of alternative energy you feel would be the easiest to implement in widespread use. You will use persuasive writing, for you will ultimately be trying to persuade other members of the community to adopt this alternative energy source. You should defend your choice using information learned in this lesson.

   The due date for the article is __________________.

3. Then you will participate in a mock town hall meeting in which students will be advocates for particular energy sources. You will discuss and debate the various alternative energy sources and, at the end, participate in a class vote to determine what type of alternative energy the "town" will adopt.

   The town hall meeting and vote will be held on______________________ .

Energy is Energy

Purpose

Students will use their own body heat to generate energy, and calculate the dollar value of that energy in today's market (it should be very, very small), and will then investigate the chemical energy stored in a marshmallow.

Standards

Language Arts, Grade 7 through 12
C3, R1, RS2

Sciences, Grade 7 through 12
Inquiry, 7–IIIA6a

Science, Grade 9 through 12
IID2b, IVC2c, IVB2a

Biology, Grade 9 through 12
IID1a, IId1b, IID2a, IID2b, IID3a, IID3c, IIE2b, IIE4a, IIE4b

Vocabulary (found in Glossary)

calorie	glucose	photosynthesis	power
enzyme	joule	potential energy	watt

Vocabulary Specific to this Lesson Plan (refer to "Background Information")

activation energy
adenosine diphosphate (ADP)
adenosine triphosphate (ATP)
alcohol dehydrogenase
anabolism
carbon
catabolism
cellular respiration
chemical energy
chlorophyll
electricity
endergonic
entropy
exergonic
First Law of Thermodynamics
gas
heat
hydrogen
insulin
kinetic energy
lactase
light
liquid
matter
metabolism
molecule
oxygen
plasma
protease
rennilase
Second Law of Thermodynamics
solid
substrate

Materials Provided
"Laboratory Safety Review" (in "Resources" section, 2)
"Student-generated Power" Hand-out (9a)
"How Many Calories are in Marshmallows?" Hand-out (9b)

Materials Needed
test tubes
thermometers
marshmallows
calculators

Teaching Strategy
1. After discussing Energy and the First Law of Thermodynamics (see "Background Information" below and on the following pages), begin this activity. Remind students that energy comes in many forms, and that it can change forms. The same energy that leaves a student's forehead as heat can be converted into electrical energy — this is the basic idea in using biomass as an alternative energy source. Then give the students "Student-generated Power" (9a). This is a good activity that comes as close to playing in a lab as a student can hope for. The math is difficult, but approached in this cookbook form, any student with a calculator can handle it.
2. Now that students have a basic understanding that energy can change forms, they can investigate the use of biomass as a source of heat energy by burning a marshmallow and collecting its energy. Give the students "How Many Calories are in Marshmallows?" (9b). Obvious safety precautions will need to be followed, so be sure to review the "Laboratory Safety Review" provided in the "Resources" section, 2.

Background Information
I. The universe is made of two things: Matter and Energy

Matter is anything that has mass and takes up space. Everything you've ever touched, seen, tasted or smelled is composed of matter. Matter is said to take several different forms, and can change from one form into another. Depending on conditions such as temperature and pressure, matter can be either:

- **Solid** — tightly packed molecules that retain their own shape.
- **Liquid** — less tightly packed molecules that slide around and take on the shape of their container.
- **Gas** — molecules that bounce off each other, fill their container and can be compressed.
- **Plasma** — electrically charged, glowing particles (stars and flames are plasma).

Energy is the ability to do work. Energy can't be seen directly, but it is every bit as real as matter. Energy also comes in different forms, and can change from one form into another. Some common forms of energy are:

- **Light** — a form of energy which travels in waves at a very high rate of speed.
- **Heat** — a form of energy which always travels into a colder area.
- **Electricity** — a flow of electrons.
- **Potential Energy** — energy that is stored in matter as a function of that matter's position. A bowling ball at the top of a staircase has more potential energy stored in it than a bowling ball at the bottom of a staircase, and that energy can be released as it rolls down the stairs.
- **Kinetic Energy** — energy of movement. Kinetic energy is the energy that can be transferred from a falling bowling ball onto your toe. The bowling ball is ***unchanged*** from such a collision; the energy it has transferred onto your toe, however, is unmistakably real.
- **Chemical Energy** — energy that is stored inside chemical bonds. Chemical reactions rearrange these chemical bonds, and so change the amount of energy stored. Two things can result from a chemical reaction:
  - The reaction can **release** energy — heat, light or noise is released. These reactions are called **exergonic**. If it gets hot, it's exergonic.
  - The reaction can **absorb** energy — heat, light or noise is absorbed. These reactions are called **endergonic.** If it gets cold, it's endergonic.

With very few exceptions, **all energy on planet earth comes originally from the sun,** the star closest to our planet. Sunlight energy is captured by photosynthetic plants and converted into the **chemical energy** of sugar, which can then be converted into other forms of energy. Even electric light comes originally from the sun.

1. **Electricity** is made from burning the **chemical energy** of **coal**.
2. **Coal** comes from **plants**.
3. **Plants** capture the energy from **sunlight.**

Thermodynamics is the study of energy.

First Law of Thermodynamics: **Energy can be changed from one form to another, but it cannot be created or destroyed.** The total amount of energy and matter in the universe remains constant, merely changing from one form to another.

Second Law of Thermodynamics: Nature really hates organized things, and seems to prefer low energy messes. This is commonly referred to as **"entropy."** A watch will always run down, but a watch will never wind itself back up (it will always move from high energy to low energy). You can keep your room clean only by constantly attending to it, otherwise, it gets disorganized (it will always move from high energy to low energy). Likewise, unless energy is constantly added to an organism to maintain it, the organism runs out of energy, and begins to literally fall apart (this is what happens when an organism dies). Entropy is a measure of disorder. The flow of energy maintains order and life. Entropy wins when organisms cease to take in energy and die.

II. Chemical Reactions and Enzymes:

Metabolism is the sum total of all the chemical reactions inside an organism. We say that a very thin person has a ***high metabolism***, which means that person does all his chemical reactions very fast, like a nervous hummingbird, and so he burns calories very fast. A person with a ***slow metabolism*** would burn calories more slowly, and might tend to put on weight.

Metabolism is of two types:

- **Anabolism** — these are chemical reactions that **build up molecules** in the organism. Your body needs to manufacture some of the things it needs, like eye color proteins and hair molecules. **Anabolic reactions** build up molecules.
- **Catabolism** — these are chemical reactions that **tear down molecules** in the organism. When you digest food, your body is doing **catabolic reactions**.

Most chemical reactions happen much faster at higher temperatures than at lower temperatures. This is why we refrigerate our food. Entropy is trying desperately to turn our food into rotten mush, but the low temperatures of a refrigerator slow that process down. A living organism has to be able to do millions of chemical reactions all at the same time, and it would be easy to do that many reactions at a very high temperature. Unfortunately, living organisms are destroyed at high temperatures.

"**Enzymes"** are special proteins made by living things which allow chemical reactions to occur fast, but at the low temperatures of living organisms. Enzymes function as biological catalysts. A catalyst is a chemical that speeds up chemical reaction the same way heat does, but without raising the temperature. Many enzymes function by lowering the **activation energy** of reactions (the energy needed to get the reaction started).

There are ***thousands*** of different enzymes. Each one acts to speed up a particular chemical reaction. Some important enzymes are:

- **Insulin** — this enzyme helps people break down sugars to use for energy. **Diabetics** don't make very much insulin, so they have lots of physical problems.
- **Lactase** — breaks down lactose, a milk sugar. People who are **lactose intolerant** just don't make enough lactase, and tend to throw up when they drink milk.
- **Alcohol dehydrogenase** — breaks down alcohol. People who get drunk really easily don't make much alcohol dehydrogenase. The more people drink, the more of this enzyme they make, so the more it takes to get drunk, and so on.
- **Protease** — breaks down proteins.
- **Rennilase** — is an enzyme that is removed from deep inside a cow's stomach, and is added to milk to turn it into cheese.

As you can see, many enzyme names end with the suffix "**-ase.**" The substance the enzyme works on is called the **substrate.** For example, the substrate of insulin is sugar. To recap:

Name of Enzyme	Name of Substrate
Insulin	Sugar
Lactase	Lactose
Alcohol Dehydrogenase	Alcohol
Protease	Protein
Rennilase	Milk

III. Glucose and Adenosine Triphosphate

Glucose is the sugar from which living things get most of their energy. When an organism eats ***anything***, enzymes within a cell break that food down into glucose, and the energy of glucose is released in small bits that the cell can use.

Thirty-six molecules of **Adenosine triphosphate (ATP)** store the energy from one glucose molecule in chemical bonds that the cell can use one at a time. The energy is put into a chemical bond that glues a phosphate molecule to **ADP** (**Adenosine diphosphate**), making it **ATP** (Adenosine **tri**phosphate). By breaking that chemical bond and releasing the extra phosphate, the energy is released.

Energy is stored:

ADP (Adenosine diphosphate) **+ energy + Phosphate** / **ATP**

Energy is released:

ATP / **ADP** (Adenosine diphosphate) **+ energy + Phosphate**

ATP is like a rechargeable battery. The energy of ATP gets used, making ADP, then more energy is put in, recharging ADP back into ATP.

IV. An Important Anabolic Reaction and an Important Catabolic Reaction

As you know, **anabolic reactions** are chemical reactions that **build up molecules** in an organism. One very important anabolic reaction is **photosynthesis**, the anabolic reaction in which green plants use the energy from sunlight to *build up* molecules of glucose (which store chemical energy).

You also know that **catabolic reactions** are chemical reactions that **tear down molecules** in the organism. One very important catabolic reaction is **cellular respiration**, the catabolic reaction in which organisms *break down* molecules of glucose to release their chemical energy.

A. **Photosynthesis: All food on the planet comes from photosynthesis.** Plants (and a few other organisms) use a pigment called **chlorophyll** to capture the energy of sunlight and store it in the chemical bonds of glucose (**$C_6H_{12}O_6$**). In order to accomplish this, plants need not only sunlight and chlorophyll, but also the following things:

Carbon — plants get **C**arbon from the **C**O_2 in the atmosphere.

Hydrogen — plants get **H**ydrogen from **H**$_2$O. This is why you have to water plants!

Oxygen — plants get **O**xygen from the C**O**$_2$ in the atmosphere.

The general formula for photosynthesis is:

$$6CO_2 + 6H_2O + \text{energy (sunlight)} > C_6H_{12}O_6 + 6O_2$$

Plants release oxygen as a waste product. The oxygen is left over from removing Hydrogen from H_2O.

B. **Cellular Respiration: Food made by photosynthesis is *used* in cellular respiration.** Almost all organisms (including plants) do cellular respiration, breaking the chemical bonds of glucose (**$C_6H_{12}O_6$**) to release energy and to store it temporarily in molecules of ATP.

The general formula for **cellular respiration** is exactly opposite to **photosynthesis**:

$$C_6H_{12}O_6 + 6O_2 > 6CO_2 + 6H_2O + \text{energy (ATP)}$$

Organisms that do cellular respiration release CO_2 as a waste product.

The waste products of **photosynthesis** are the product raw materials of **cellular respiration.**

The waste products of **cellular respiration** are the product raw materials of **photosynthesis**.

Student-generated Power

We can measure energy in ***calories***, but the electric company sells energy by the ***kilowatt hour.*** In this lab, we will burn calories, convert them to ***kilowatt hours*****,** then calculate the cost of the energy we generated at today's prices.

Procedure:

1. Add 20 ml of water to a test tube.
2. Measure and record the **starting** temperature of the water.
3. When the signal is given, begin doing whatever you wish to warm up the test tube. You can shake it, rub it, sit on it, etc., as long as you only use your body to warm it.
4. After five minutes, measure and record the **final** temperature.

Calculations:

a. **Starting** Temperature of Water:	
b. **Final** Temperature of Water:	
c. Change in Water Temperature:	
d. Water Volume:	20 ml
e. Water Mass:	
f. Time (in seconds):	

1. How many **calories** of heat did your water absorb? **(Change in Water Temperature/Water Mass)** — **1. ____________ calories**

2. The **work** done in raising the temperature of water can be found by multiplying the number of calories (which you just found) times **4.19 joules** (joules is a unit of work). — **2. _____________ joules**

3. **Power** is defined as work divided by time (joules/sec), and is expressed in **watts**. Your answer from #2, divided by time (in seconds) will tell you how much **power** you generated. — **3. ______________ watts**

4. Now take the **answer from #3**, *divide it by 1,000*, then **multiply it by 0.0833.** This is the number of **kilowatt hours (kWh)** you produced. — **4. _______________ kWh**

5. A typical power utility company charges about $0.08 per kWh. To find out how much money your power was worth, take the **answer from #4** and **multiply it by 0.08.** — **5. _____________ cents**

How Many Calories are in Marshmallows?

Name:____

By burning different foods and measuring the heat, we can estimate the number of calories in the food. Be sure to follow the safety measures in the Laboratory Safety Review provided (“Resources” section, 2).

Procedure

1. Put **20 ml (.02 L) of water** into a test tube.
2. Measure and record the **temperature** of the water.
3. Measure and record the **mass** of the marshmallow you intend to burn.
4. Measure and record the **mass** of the stand the marshmallow will sit on, in case the marshmallow melts onto the stand and can’t be removed. ____________ g
5. Ignite the marshmallow and allow it to burn completely while heating the water.
6. Measure and record the **new temperature** of the heated water.
7. Measure and record the **new mass** of the burned (or partially burned) marshmallow.

	Before Burning	After Burning
Water Temperature in Celsius		
Mass of Marshmallow		

8. Calculate the **change in mass** of the marshmallow. 8. ____________
9. Calculate the **change in temperature** of the water. 9. ____________
10. Calculate the marshmallow **energy in calories** (change in water temperature x 0.02 Liters). 10. ____________
11. Calculate the **number of calories per gram** of marshmallow (**energy in calories/change in mass** of the marshmallow). 11. ____________
12. The marshmallow label says that marshmallows have about **3.5 calories per gram**. Your measurements are probably a lot lower than that. Why do you think that is?

____

____

____

____

____

____

Alternative Fuels vs. Gasoline: Knowing is Half the Battle

Purpose

Students will compare the differences between diesel engines and gasoline engines. Students will also view traditional gasoline and diesel fuels, and determine the benefits of using alternative fuels.

Standards

Language Arts, Grade 7 through 12
C1, C2, C3, R1, RS2

Science, Grade 7 through 12
Inquiry, 7-IIIA7e

Science, Grade 9 through 12
IIIB1b, IIIB1c

Social Studies — Economics, Grade 9 through 12
ECON-2

Vocabulary

biomass	compression engine	E-85
biodiesel	diesel engine	flexible fuel vehicle (FFV)

Materials Provided

"Biomass: Nature's Most Flexible Energy Resource" SECO Fact Sheet 15 Hand-out (10a)
"Get Revved Up: Engine Discussion Points" Hand-out (10b)

Materials Needed

visual schemata of diesel engine and compression engine
dried corn (on cob or kernels)
soybeans/soybean plant
laboratory grade ethanol
empty gasoline can
paper
pencil
notes from field experience activity

Teaching Strategy

This lesson should be covered in a three-day unit. The field trip should be scheduled first and in a manner that the activities occur chronologically.

1. Begin discussion with determining how each student arrived at school. Create headings and make a tally on the board of how many students traveled by each

mode. Show students the gasoline can and explain that this is today's fuel. Then show them corn and soybeans and explain, "Can you imagine putting this into your gas tank as fuel?" Have students brainstorm as to how this can possibly happen.

2. Divide the class into four groups and distribute SECO Fact Sheet 15 "Biomass: Nature's Most Flexible Energy Resource" (10a) to each student. Within groups, students should address the following questions:
   - What are three sources of biomass other than wood?
   - Why aren't fossil fuels considered renewable?
   - Why do negative environmental effects occur as the result of burning fossil fuels?
   - How are corn and soybeans utilized to produce vehicle fuels?

   Once the class has convened, pose one of the questions to each student group. Have students add input where necessary.
3. Distribute "Get Revved Up: Engine Discussion Points" (10b). While students are viewing the schemata of the engines, explain the operation of the engines and note the differences between each engine.
4. Students will participate in a field experience where they will see the operation of a diesel engine vs. a combustion engine (suggest auto shop, bus maintenance shed or farming equipment manufacturer). Discuss the pros and cons of using alternative fuels. Have students pose questions about how alternative fuels affect the operation of the engine.
5. Students will respond to all activities by providing a critique and will be asked to verbally describe the differences between the diesel engine and the combustion engine.

Background Information

With an increased focus on environmental protection, alternative fuels are slowly being recognized as a way to lessen detrimental environmental effects. Alternative fuels pack a dual benefit — there are less adverse effects and the natural wastes produced through agricultural processing can be recycled. With increased vehicle use, haste to seek more nonrenewable oil sources to meet the demand for more petroleum and a decrease in waste storage space, alternative fuels may be the ideal future fuel.

Biomass: Nature's Most Flexible Energy Resource

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SECO FACT SHEET **NO. 15**

HIGHLIGHTS

- **Biomass fuels can be used in place of fossil fuels**
- **Wood and wood wastes are already a significant energy source in the United States**
- **Biomass can provide extra income to farmers, ranchers, and industries with abundant waste materials**
- **New technologies are expanding opportunities for biomass**

SOURCE: BAYLOR UNIVERSITY

Airplane powered by biomass. *Versatile biomass materials can be converted into fuels capable of just about any energy service, from powering airplanes and cars to making electricity to heating the family living room.*

SUMMARY

Biomass, the chemical energy stored in plant and animal materials, is among the most precious and versatile resources on earth. It provides food as well as building materials, paper, fabrics, medicines and chemicals. Biomass has been used for energy purposes ever since man discovered fire. Today, biomass fuels can be utilized for tasks ranging from heating your home to fueling your car and running your computer.

WHAT IS BIOMASS?

Wood may be the best-known example of biomass. Through photosynthesis, trees convert the radiant energy of the sun and combine it with carbon dioxide and water to create plant tissue. When burned, the wood releases the energy the tree captured from the sun's rays. But wood is just one example of biomass. Rice hulls, waste straw, animal manure, surplus corn, peanut shells and any other abundant, low cost organic material can also be used as an energy source.

All of the fossil fuels we consume – coal, oil and natural gas – are simply ancient biomass. Over millions of years, the earth has buried ages-old

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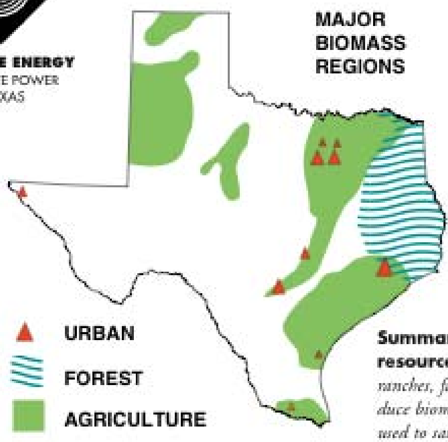
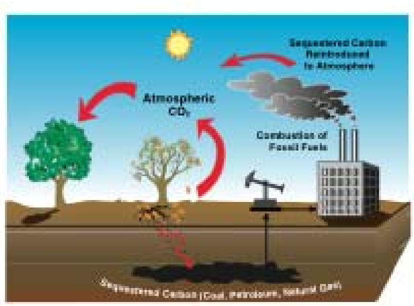


Summary of Texas energy resource areas. *Texas' forests, ranches, farms and even cities produce biomass materials that can be used to satisfy many energy needs.*

plant material and converted it into these valuable fuels. But while fossil fuels contain the same constituents as those found in fresh biomass – hydrogen and carbon – they are not considered renewable because they take such a long time to create.

Environmental impacts pose another significant distinction between biomass and fossil fuels. When a plant decays, it releases most of its chemical matter back into the atmosphere. In contrast, fossil fuels are locked away deep in the ground and do not affect the earth's atmosphere unless they are dug up and burned. The negative environmental impacts of burning fossil fuels is a good reason to consider biomass and other clean renewable resources.



Simplified carbon cycle. *Unlike fossil fuels, biomass does not increase atmospheric greenhouse gases when burned.*

HOW BIOMASS IS USED

HEAT

Burning wood in your fireplace to heat your home may be the most recognizable use of biomass. Businesses and factories can use advanced systems to create heat with biomass fuels.

STEAM, ELECTRICITY AND MARKETABLE GASES

For many years, mills and factories have burned biomass waste (especially wood waste) to produce steam for heat or electricity on-site. Gradually decaying biomass materials, such as garbage in landfills, produce methane similar to natural gas. It can be captured and burned to generate electricity at the landfill or sold as pipeline quality gas. New processes may soon allow biomass to be turned into usable gases even more rapidly.

VEHICLE FUELS

New processes will allow alcohol production from practically any biomass material. Gasoline often includes a small amount of ethanol – around 10% – to increase performance and reduce pollution. Ethanol fuels are made primarily from corn. Over 2 million vehicles known as flex-fuel vehicles (FFVs), capable of running on E-85 (85% ethanol) or gasoline, have been sold in the U.S. in recent years. In addition, diesel engines with minor modifications can use fuel called biodiesel made from waste vegetable oils or crops such as soybeans.

BIOMASS RESOURCES IN TEXAS

Texas has an abundance of materials suitable for biomass energy use. From its vast forests to its huge grain and fiber farms, the state is richly endowed with biomass. Perhaps the best sources are concentrated waste materials. If just half of the available biomass wastes were utilized for electricity production, they could supply 10% of the state's needs. Here are the most promising resources:

FORESTS

The highly productive forests of east Texas yield many cost effective biomass opportunities. The sawdust and waste wood from saw mills and pulp mills are already being used to generate steam and electricity at many Texas timber processing plants.

AGRICULTURE

Large quantities of waste materials remain after processing crops such as cotton, rice, peanuts and sugar cane. These crop wastes, manure from feed lots and dairies, and stalks and stubble remaining in the field after harvest may all be practical to use as fuel.

URBAN SOURCES

All large cities have concentrated biomass sources that may prove suitable for biomass energy projects. Examples of these sources include sewage treatment facilities, landfills, furniture factories, breweries, and food packaging plants.

ENERGY CROPS

Farming fast-growing crops like switchgrass and cottonwood trees for use as fuel would greatly expand the potential of biomass. Perhaps 25% or more of Texas' transportation and electricity needs could be provided from these types of energy crops if their production becomes widespread.

ADDING VALUE IN RURAL COMMUNITIES

Small biomass energy projects can provide many needed benefits in rural agricultural communities. For example, a feedlot operation could solve its manure disposal problem, reduce odors, provide jobs and increase the local tax base by installing a waste-to-energy generator on site.

WASTE SOURCES	(Quads)
Agricultural Wastes	
Harvest residues	0.081
Processing residues	0.028
Woody Wastes	
Logging residues	0.084
Mill residues	0.066
Biogas	
Animal manure	0.026
Municipal sewage	0.025
Urban	
Landfilled biomass	0.150
TOTAL	**0.46**

Energy potential from Texas biomass waste resources. *Waste resources from food and lumber processing facilities are low cost sources of biomass fuel. Examples include rice hulls, cotton boll stems, sugar cane stalks, sawdust and wood chips. (Quad = 1 quadrillion BTUs, 1 kWh = 3,412 BTUs)*

InfinitePower.org

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ORGANIZATIONS

American Bioenergy Association
314 Massachusetts Ave. N.E., Suite 200
Washington, DC 20002
(202) 467-6540
www.biomass.org/

Governor's Ethanol Coalition
3118 Emerald Lane, Suite 100
Jefferson City, MO 65109
(877) 485-8595
www.e85fuel.com/

National Biodiesel Board
3337-A Emerald Lane
Jefferson City, MO 65110-4898
(573) 635-3893
www.biodiesel.org/

New Uses Council
295 Tanglewood Dr.
East Greenwich, RI 02818-2210
(401) 885-8177
newuses.org/

Renewable Fuels Association
One Massachusetts Ave., Suite 820
Washington, DC 20001
(202) 289-3835
www.ethanolrfa.org/

Western Regional Biomass
Energy Program
P. O. Box 95085
Lincoln, NE 68509-5085
(402) 471-3526 or 2867
www.westbioenergy.org

RESOURCES

FREE TEXAS RENEWABLE ENERGY INFORMATION

For more information on how you can put Texas' abundant renewable energy resources to use in your home or business, visit our website at **www.InifinitePower.org** or call us at 1-800-531-5441 ext 31796. Ask about our free lesson plans and videos available to teachers and home schoolers.

ON THE WORLD WIDE WEB:

Thorough **Oak Ridge National Laboratory** guide to biomass related information of all types; excellent place to start research.
bioenergy.ornl.gov/

Click on BIOMASS for information on a range of energy uses and technologies.
solstice.crest.org.renewables/index.shtml

The National Corn Growers Association site, focusing primarily on ethanol production from corn.
www.ncga.com/04growers/ethanol/index.htm

Environmental Protection Agency site, a wealth of information on landfill gas energy.
www.epa.gov/landfill/products.htm#4

The U. S. Department of Energy's Energy Efficiency & Renewable Energy Network site on bioenergy
www.eren.doe.gov/RE/bioenergy.html

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Get Revved Up: Engine Discussion Points

(adapted [with permission] from GA Ag Curriculum Physical Science Applications Unit 5, Lesson 6 "Diesel Engine Theory and Principles")

1. What is the main difference between a diesel and a gasoline engine?
   a. The method of ignition.
   b. Gasoline engines require a spark plug to ignite the fuel and air in the cylinder.
   c. The diesel engine does not have spark plugs to ignite the fuel in the cylinder; it uses high compression to ignite the fuel.
2. A diesel injection system uses a high-pressure mechanical injection pump to force fuel through an injector nozzle and into the combustion chamber.
   a. A diesel injector opens when fuel is forced into the injector body.
   b. With a two-stroke diesel engine, air enters the engine through the ports in the side of the cylinder.
   c. An injection pump is the main control for engine speed, power and efficiency on most diesel engines.
   d. A unit injector uses the engine camshaft to push down on the injector follower to produce high fuel pressure.
   e. A governor is used to help control the speed and power output of a diesel engine.
3. What are the diesel engine components?
   a. The cylinder block.
   b. The size of the cylinder is called the bore.
   c. The amount of air that can be compressed by the piston in the cylinder is called the displacement.
   d. One trip of the piston from the bottom to the top or from top to bottom of the cylinder is called a stroke.
   e. The crankshaft of a diesel engine is normally made of forged steel.
   f. The head gasket seals the contact surface area between the block and the head of a diesel engine.
   g. The source of movement for a diesel engine's valve train is the camshaft.
   h. Lifters transfer the motion from the camshaft lobes to the push rods. A third rocker arm is needed for large diesel engines that use unit injectors.
   i. Glow plugs are used on some smaller diesel engines to help start the engine during cold weather.
   j. Filters are used on all major systems of a diesel engine to prevent dirt from damaging the precision parts.
   k. A thermostat is used to control coolant flow and engine temperature.

What is Ethanol and How Does It Make a Car Run?

Purpose

Students will gain knowledge of ethanol and its use as an alternative fuel. Students will also gain knowledge of the fermentation process of corn to make ethanol and other substances.

Standards

Language Arts, Grade 7 through 12
C1, C2, C3, W1, W2, W3, W4, R1, RS1, RS2

Science, Grade 7 through 12
Inquiry, 7–IB2b, 8–IC2b, 7–IIIA4c, 7–IIIA7e

Physical Science, Grade 9 through 12
IIB6a, IIC3a4, IIIA4b

Science, Grade 9 through 12
IIE4b, IIIB1c, IVC4b, IVB4a

Biology, Grade 9 through 12
IIIE4b

U.S. and South Carolina Studies, Grade 8
IV

Social Studies — Economics, Grade 9 through 12
ECON-1, ECON-2, ECON-8

Agricultural and Environmental Sciences, Grade 9 through 12
E1, F11

Vocabulary

by-product	E-10	feedstock	renewable energy
carbon dioxide	enzyme	fermentation	respiration
carbon monoxide	ethanol	nitrogen oxide	yeast

Materials Provided

"Ethanol Fact Sheet" Teacher Aid (11a)
"Ethanol Fact Sheet" Hand-out (11b)
"Energetic Debate" Activity (11c)
"Pick a Project" Activity Hand-out (11d)
"Laboratory Safety Review" (in "Resources" section, 2)
"What Types of Food are Easiest to Ferment?" Activity (11e)

Materials Needed

access to computer lab and Internet

Teaching Strategy

1. Familiarize yourself with the “Ethanol Fact Sheet” teacher aid (11a), then distribute “Ethanol Fact Sheet” (11b) to students to provide them with a comprehensive overview of ethanol. Discuss with the students some of the other types of energy sources that are considered renewable energy.
2. Arrange a field trip to a local farm, research laboratory, factory, or any other location where ethanol products and by-products are used, such as a transportation/fleet maintenance facility that uses ethanol to run its vehicles.
3. Students will go online and research fuel consumption figures for city or school buses. Compare the bus efficiency to a Ford Taurus with a 31-mile-per-gallon rating. If the Ford Taurus carries four passengers, then it gets 124 passenger-miles per gallon. If it carries just one passenger, it gets only 31 passenger-miles per gallon. How many passengers does a bus have to carry to be more efficient than individual cars for transportation? Ask students the following questions:
   a) What type of gasoline does your family put in your car?
   b) Does it contain any additives?
   c) Do you think the additives make a difference in how the car runs?
   d) Do they make a difference in the amount of pollution cars produce?
4. Organize the students according to the instructions for each of the two debates in “Energetic Debate” (11c) and provide mediation for the debates.
5. Distribute the “Pick a Project” (11d) activity hand-out, permitting the students to select their own assignment from the list to be turned in on a specific date after presentation to the class.
6. Students will do an activity about fermentation — “What Types of Food are Easiest to Ferment?” (11e). Caution students: “This process produces materials unfit to consume.” The students should answer the following questions in this activity and record their observations in their science journals:
   a) What is the evidence that reactions are going on in any of the containers?
   b) How are these observations related to fermentation?
   c) Can you draw any conclusions about which of the substances tested was most helpful to yeast fermentation?
   d) Were there any conditions under which the fermentation didn’t seem to proceed or went only very slowly? What were they? Can you think of explanations for these results?
   e) Can you draw any conclusions about what temperature is best for yeast-flour-sugar fermentation? Try many different combinations of yeast and food and temperatures. What is the optimum mixture for fermentation?

Background Information

As the number of people in the world keeps growing, so does our need for energy. Some energy sources — specifically fossil fuels such as coal and oil — are in limited supply. Once we use up what's in the ground, they will be gone forever. Other energy sources, such as wind and water power and solar energy, are called renewable energy, because they will regenerate over and over again as we use them.

Ethanol is one form of renewable energy that is becoming widely used. Ethanol is a form of alcohol that can be burned in engines just like gasoline. But unlike gasoline, which is made by distilling crude oil, ethanol is made from the starchy parts of plants. Ethanol is made from farm-produced raw materials which are chronically in surplus. In 1992, 400 million bushels of grain were used to produce ethanol. Most ethanol in this country, however, is created though fermentation of corn, the preferred feedstock in ethanol production. Ethanol production creates new domestic markets for corn and adds four to six cents a bushel for each 100 million bushels used. (The amount used in 1992, for example, was responsible for a 16- to 24-cent gain in the price of corn.) Better prices mean less reliance on government subsidy programs and more income and independence for farmers.

In addition to being a renewable fuel, ethanol helps to reduce air pollution. Gasoline is a substance made of carbon and hydrogen. When ethanol burns with gasoline, its "extra" oxygen atoms combine with the "extra" carbon atoms to reduce or even eliminate carbon monoxide (CO) in the exhaust gases.

In some parts of the U.S., ethanol is mixed with gasoline at one part ethanol to nine parts gasoline to help reduce air pollution. No adjustment is needed for a car's engine to burn this mixture. Some new cars are designed to burn fuel blends of up to 85 percent ethanol.

Ethanol costs more to make than gasoline. New production technologies may bring the price of ethanol down in the coming years.

Fact Sheet Background:
Ethanol and Its Use as a Motor Vehicle Fuel

(Adapted [with permission] from the Illinois Corn Growers Association and Illinois Corn Marketing Board, **ilcorn.org/Ethanol/ethanol.html***)*

A renewable energy source made from corn, ethanol appears to have advantages as a fuel for motor vehicles, especially when used as a blend with gasoline. It is also associated with issues which can serve as excellent opportunities for engaging students in problem-solving and issue-clarification activities. Ethanol is an excellent scientific/technological/societal topic, for it illustrates that science and technology provide new products and new uses for products from our abundant production that improve living standards.

Use of this fact sheet requires little outside preparation on the part of the teacher. It may be taught as a unit or its elements may be integrated into other teaching units. Sections include:

a) Introduction to Ethanol
b) Ethanol Chemistry and Technology

Goals and Objectives

The Ethanol Fact Sheet was written to aid those teaching in middle school and higher grades to meet state Curriculum Standards. It should also be useful to vocational, agriculture and driver education teachers. As a result of using this material, students should develop a better understanding of:

a) the conversion of corn to ethanol and its use as fuel for motor vehicles;
b) the pros and cons of encouraging increased quantities of ethanol to be used as vehicle fuel;
c) the energy relationships between agriculture, science and technology, and society.

Students should also improve skills in interpretation, analysis, problem solving, and personal decision making. Any portion of or the entire fact sheet may be reproduced.

Use of the Fact Sheet should help provide teachers and students with the background needed to understand the production and use of ethanol, and to decide which of these claims and counterclaims are valid. They can then arrive at their own conclusions about whether or not to use ethanol in their own vehicles and whether it is in the national interest to encourage its use as a fuel.

The "Ethanol and Its Use as a Motor Vehicle Fuel Fact Sheet" was developed at the request of the Illinois Advisory Board on Conservation Education in response to the need for instructional materials on forms of alternative energy, especially ethanol, the only renewable, clean-burning, alternate liquid energy. The Illinois Corn Growers Association and the Illinois Corn Marketing Board supplied the funds for the development and original printing of this fastback.

Fact Sheet:
Ethanol and Its Use as a Motor Vehicle Fuel

Introduction to Ethanol

The Search for Energy

There is growing concern about having enough energy to heat our homes and power our transportation systems, and the extent to which energy sources now in use harm the environment.

Much effort has gone into the development of alternative energy sources which are renewable, less polluting and more dependable. Of significant importance is ethanol which is alcohol made by fermenting corn. It is presently blended with gasoline to enhance octane levels and stretch the supply of petroleum products.

What is Ethanol?

Ethanol is a liquid which can be used as a fuel in neat form or blended with gasoline and as a raw material in industrial and technological processes. Over one billion gallons are produced annually in the United States. Each bushel of corn processed yields 2-1/2 gallons of ethanol and several valuable by-products. When used as an automobile fuel, one unit of ethanol is usually mixed with nine of gasoline to provide what is often referred to as an E-10 blend.

History

Ethanol has been known and used throughout history, moving from use as an intoxicating drink in ancient times to an important chemical for transportation and industry in this century. At the time of Edwin Drake's discovery of oil in Pennsylvania in 1859, sales of alcohol for lamp fuel exceeded 25 million gallons per year. A heavy tax on ethanol during the Civil War almost destroyed the industry in the United States. In Europe, where crude oil resources were scarce, alcohol was widely used as a fuel well into the 1900s. When the federal tax was removed in 1906, alcohol fuel again did well until price competition from big oil interests greatly reduced its use.

Some early automobiles, such as Henry Ford's Model T, were originally designed to run on alcohol fuels. During the early and mid-1900s, several attempts were made to promote ethanol as a substitute for gasoline. Low oil prices after World War II (often as low as $3 per barrel) caused interest in fuel ethanol to dwindle until the oil crisis of the 1970s.

In 1973, the Organization of Petroleum Exporting Countries (OPEC) increased oil prices and even blocked shipments of crude oil to the United States. This alerted our country to its dependence on foreign oil and its vulnerability to sudden price increases and supply shocks. Attention was once again focused on corn ethanol and other alternative fuels. The federal and some state governments have provided incentives similar to tax breaks offered to the oil industry to encourage ethanol production for use as part of America's liquid fuel supply.

Why the Increased Interest in Ethanol Now?

Despite efforts by the oil industry to discourage its use, low oil prices on the world market, and some who believe that it damages fuel systems, ethanol production and use as a fuel increased at an astonishing rate during the 1980s. Use of ethanol as a fuel increased from 40 million gallons in 1980 to 430 million gallons in 1984 to one billion gallons in 1992. One gallon of ethanol is usually mixed with nine gallons of gasoline to make ten gallons of the 10 percent ethanol/gasoline blend (E-10). Therefore, ten times as many gallons of E-10 blend are used as the amount of fuel ethanol produced.

This rapid growth in the use of the E-10 blend is accounted for because the fuel performs well in automobile engines and is priced competitively with "straight" gasoline.

Ethanol proponents set forth additional reasons for more ethanol to be produced and used:

- It is in our state and national interest. Less oil needs to be imported, trade deficits are reduced and the risk of having needed oil supplies cut off by unfriendly governments is reduced.
- Farmers gain because of increased stability in the price and demand for corn.
- Environmental quality improves. Carbon monoxide emissions from autos are reduced and lead and other carcinogens (cancer-causing substances) are replaced as octane enhancers in gasoline.
- Motorists gain increased octane in gasoline, reduced engine knock, cleaner engines, and a new source of liquid fuel.

Those who doubt or challenge the use of ethanol as a fuel and oppose these incentives argue that:

- It is inappropriate to burn a food grain as a fuel when one considers worldwide food conditions.
- Ethanol should compete equally with gasoline and not receive favorable treatment or more incentives than other fuels.
- Ethanol damages fuel system components in some vehicles and causes operational problems such as vapor lock in hot weather.
- Ethanol use does little to reduce oil imports or improve environmental quality.
- Waiving portions of the motor fuel taxes for ethanol blend users reduces monies available for highway construction and repairs.

Elsewhere

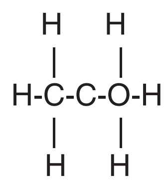
In other countries, ethanol is being produced and used in large quantities as a fuel for automobiles. As a result of the worldwide increases in oil prices in the l970s, Brazil initiated a program to produce major quantities of ethanol for use in automobiles in order to reduce its petroleum imports. Visitors to Brazil report that filling stations provide pure or neat alcohol or a blend of gasolines containing as much as 22 percent ethanol. Brazil currently exports large quantities of ethanol, much of which is made from sugar cane grown on land once covered by rain forests.

Ethanol Chemistry and Technology

Ethanol and How It is Made

Ethanol is just one of a large group of substances called alcohols. They contain one or more “carbinol” groups in their makeup, often shown as: C-O-H or C-OH.

What is attached to the carbon at the three remaining locations or bonds determines the kind of alcohol. Hydrogen is present at these three sites in the closely related methanol; but, in the case of ethanol, two of the sites hold hydrogen atoms, and the remaining site holds a second carbon atom. It, in turn, holds three more hydrogen atoms. It may be shown as:



or C_2H_5OH

In its pure or neat form, ethanol is a colorless, waterlike liquid with a mild odor which boils at 78°C (172°F) and freezes at -112°C (-170°F). When burned it produces a pale blue flame with no soot and much energy, making it an ideal fuel. Ethanol mixes readily with water and is frequently used as a solvent and as an ingredient when making hundreds of other chemicals.

Ethanol is a product of fermentation, a process by which many organisms derive energy from sugar. This process is comparable to the respiration of food nutrients in many animals and plants. In fermentation, however, energy is obtained when sugar is changed to ethanol and carbon dioxide.

Because of the way the hydroxide (OH) is bonded to the carbon, ethanol has no basic or acidic properties. When dissolved in water it is neutral and has a pH of 7.

From Corn (Starch) to Ethanol by Fermentation

Changing corn to ethanol by fermentation involves several distinct steps. Starch in corn, primarily *amylose amylopectin* (80%), is built from thousands of complex sugar molecules. These must be broken down into simple sugars or *monosaccharides* before fermentation can occur. In earlier times, this was accomplished by chewing the corn and allowing the saliva enzymes to naturally break down the starch. Today, this is achieved by cooking the corn and adding the enzymes *alpha amylase* and *gluco amylase*. New and improved methods are being explored to more effectively do this conversion, a process often referred to as saccharification.

Once a simple sugar is obtained, a single-celled plant yeast, *Saccharomyes sp*., is added, which then grows and brings about fermentation. The process of releasing the energy from the sugar is similar to that of cellular respiration, except for the final two steps of the process as outlined below:

- In fermentation, yeast release ethanol and carbon dioxide. In respiration, continuation of the breakdown yields carbon dioxide, water and energy.
- In fermentation, the ethanol retains much of the energy that was originally present in the sugar which, while inefficient for yeast, explains why ethanol is an excellent fuel.

Although ethanol can also be produced from ethylene (C_2H_4) from the petroleum industry, the fermentation of food grains is still the primary source. At this point, corn is considered the most practical product in the United States to ferment.

The Commercial Production of Ethanol

Although ethanol production takes various forms (including the fermentation of sweet fruit juice to wine, for instance), most of the United States' production is in large industrial plants located in the Midwest.

Changing the sugars and starches in corn kernels to ethanol is a complex process and has become well-established as a mix of technologies which includes microbiology, chemistry and engineering. Greatly simplified, it involves:

a) mechanically grinding the corn as finely as practical;
b) stirring while adding water and an enzyme to create a slurry (while maintaining a pH of 7 by adding sodium hydroxide or sulfuric acid);
c) adding additional enzymes and heat to convert starch molecules to complex sugars (dextrins);
d) cooling and adding other enzymes to break down the complex sugars into simple sugars;
e) adding yeast to convert the sugars to ethanol through fermentation;
f) removing the ethanol from the mash by distillation or evaporation.

At every step, specific acidity levels, pressures and temperatures must be maintained. In industry this takes place in huge factories under carefully controlled conditions using highly developed technologies.

Ethanol Technology

Ethanol production, in which an agricultural product is used as a material from which to produce fuel which improves living standards, is an illustration of how science, technology, agriculture, and industry are interwoven. The ethanol plants receive the vast quantities of corn they need by truck, rail or barge (whichever is least costly). Here the corn is cleaned, finely ground and blown into gigantic tanks where it is mixed into a slurry of cornmeal and water. Enzymes are added to the slurry and precise acidity levels and temperatures are maintained, causing the starches in the corn to break down, first into complex sugars and finally into simple sugars.

New technologies have greatly changed the fermentation process. Until recently several days were required for the yeast to work in each batch to produce ethanol. A new, faster and more cost-efficient technology, continuous fermentation, now alleviates many of the problems of the batch system.

Geneticists and other plant scientists are also involved. They have successfully developed strains of yeast which can convert even greater percentages of the starch to ethanol.

After fermentation, the ethanol is removed from the resulting mix of ethanol, water, yeast and residue, and purified by distillation, a process which takes advantage of ethanol's low boiling point, 78°C. When the mix is heated to a temperature a bit higher than this, the ethanol evaporates and is subsequently recaptured as a gas and condensed. Additional chemicals, redistillation processes and molecular sieves are used to further purify the ethanol.

Although distillation uses large amounts of energy (much of which comes from coal) technological advances are being made which greatly reduce the amount of energy needed for this stage. These advances help to further reduce the costs of producing ethanol.

That's Not All…

Ethanol is not the only valuable product that comes from this process. Most of the substance of the corn kernel remains and has great value in the production of food for people, livestock feed and various chemicals. A bushel of corn (56 lb) used in ethanol manufacture yields the following co-products:

1.6 lb corn oil

3.0 lb corn gluten meal

13.0 lb corn gluten feed

12.5 lb carbon dioxide

The first of these co-products are used in producing food for human consumption and high-protein livestock feed. For instance, the 1.6 lb of corn oil from a bushel of corn is equivalent to 2 lb of margarine. The carbon dioxide is used as a refrigerant, in carbonated beverages, to help vegetable crops to grow more rapidly in greenhouses, and to flush oil wells. In effect, only the starch of the corn (carbon, hydrogen and oxygen) goes into the ethanol.

Energy In — Energy Out

Much energy is required at each step of the way in the production of ethanol, beginning with seedbed preparation for planting the corn and ending with that energy needed to transport the ethanol to the place where it is blended with gasoline.

Although the net amount of energy that is actually gained as a result of ethanol production is hotly debated, a big advantage results from having a liquid which is readily used in automobiles as the end product.

Economics and Politics

At present, it costs $.57 to $1.50 to produce one gallon of ethanol. The price at the gas pump, however, reflects federal and state tax exemptions, loan guarantees and other government subsidies.

Balancing the cost of these special tax incentives is a significant reduction in farm subsidies and the generation of additional tax revenues. A 1985 study by Purdue University found that the use of 240 million bushels of corn by the ethanol industry saved U.S. taxpayers more than $623 million in government farm program expenditures.

The fledgling oil industry began receiving federal support (subsidies) in 1916 to promote development of an energy industry. The oil industry became very profitable decades ago, yet these promotional funds have become part of the industry's profit structure, rather than being reallocated to provide support to new energy sources and technologies as the federal government originally intended. In 1984, the oil industry received more than $8.5 billion in federal subsidies (which does not include $20 billion for military protection of Middle East petroleum sources). In that same period, renewable energy industries — alcohol fuels, solar, wind, photovoltaics, wood, hydropower, and geothermal — received subsidies of only $1.7 billion. This imbalance conceals real commercial energy costs, eliminates fair competition, and creates the illusion of lower energy prices, which leads to overconsumption.

Most experts agree that U.S. and worldwide petroleum supplies are being consumed faster than new discoveries are being made and that during the next decade domestic oil supplies could be depleted. Conservation and renewable fuels (e.g., ethanol) can extend our domestic supplies and reduce our imports. Since foreign oil imports are the largest component of our multi-billion-dollar trade deficit, using ethanol can decrease our dependence on foreign oil imports and contribute to our economic and national security.

Environment

According to U.S. Environmental Protection Agency documents, the use of E-10 blends will reduce carbon monoxide emissions by 25 percent or more. Used in the pure or neat form, ethanol reduces most forms of air pollution (carbon monoxide and ozone emissions) coming from automobiles.

Ethanol doesn't pose the health and air pollution problems that lead does, yet it is both a fuel extender and an effective octane enhancer in gasoline.

Denver, Las Vegas and Phoenix, as well as other cities throughout the U.S., have alleviated serious carbon monoxide problems during the winter months by mandating the use of oxygenated fuels, one of which is the E-10 blend.

EPA studies suggest that the use of E-10 blends may slightly increase nitrogen oxide (NOx) emissions, but the extent and effects of this are uncertain.

Ethics

Ethanol production does not divert food to fuel. Only the starch in corn is utilized in making ethanol. The protein-rich and edible oil coproducts of ethanol production provide food for people and feed for livestock both here in the United States and overseas.

Each 100 million bushels of corn used to produce ethanol creates 2,250 new rural jobs, including construction, support and operations jobs, plus many more jobs in research, transportation and exports.

Testing

Over the past 12 years, 50 billion gallons of E-10 blends (equivalent to one trillion miles driven) have been used in the United States. Drivers who have used ethanol blends over a period of years report little or no change in vehicle performance.

A two-year, multi-vehicle study by Ashland Petroleum Company showed no fuel-related maintenance or driveability problems with ethanol-blended gasoline.

Texaco ran a fleet of company cars on E-10 blend gasoline for the fleet's entire useful life. At the end of the study, inspectors examined the engines and found them to be cleaner than those from other cars that had run on straight gasoline.

In 1975, Brazil adopted a national policy of replacing gasoline with alcohol fuel to the maximum extent possible. By 1980, it had replaced 20 percent of its gasoline consumption with ethanol. Then, to increase alcohol use even further, the government reached agreements with automobile manufacturers (e.g., Ford, Volkswagen) to produce car engines designed to run on "straight" alcohol. Now, most new cars manufactured for use in Brazil run on 100 percent ethanol.

Transportation

Ethanol is a grain alcohol. Scientific testing shows that ten percent ethanol/gasoline (E-10) blends can be used safely in existing car engines. It does not clog fuel injectors or carburetors. Some problems may result, however, when other alcohols such as methanol or wood alcohol are used in excess of five percent. Don't confuse them with ethanol!

There have been some extensive public relations efforts to mislead the public with slogans such as "No alcohol in our gas!" This kind of negative advertising aims to give the impression that there is something wrong with fuel which does contain alcohol. Studies show, however, that ethanol blends have no negative effects on engines or their performance. In fact, ethanol tends to improve engine performance and eliminate pinging and engine run-on.

Use of leaded gasoline may result in the formation of corrosive salts which foul spark plugs and corrode exhaust systems. Over a period of time, regular gasoline will leave a deposit of varnish-like residue in the fuel system. E-10 blends with detergent help clean out these deposits.

Ethanol has proven itself to retailers, motorists and auto manufacturers. Use of E-10 blends is approved under the warranties of every auto manufacturer (U.S. and foreign). In fact, auto companies have already developed engines that run on 100 percent ethanol. This technology, now being used in Brazil, could easily be used in the U.S.

Energetic Debate

Debate No. 1

Divide the class into transportation groups such as:

1. Fossil (gasoline, diesel, methanol)
2. Renewable (fermentation ethanol)
3. Electric (mass transit, battery power)
4. Solar vehicles
5. Nuclear vehicles
6. Wind-powered vehicles

Allow one class period for groups to research and list the advantages and disadvantages of their fuel source.

Assign each group a number from 1 to 6, and draw Figure 1 on a chalkboard or whiteboard.

Figure 1

8	W	I	N	N	E	R
7						
6						
5						
4						
3						
2						
1	S	T	A		R	T
	1	2	3	4	5	6

Roll dice or use a spinner to determine which group gets to speak. A spokesperson identifies the group and its intention, then states a fact (e.g., "I'm from fossil fuels. I'd like to move up a step as there is no harmful radiation released when using gasoline"). The group moves up a step.

Assume the next spin allows the nuclear group to speak. They might respond: "I'm from nuclear vehicles. I wish to move fossil fuels down because the SO_2 emissions result in acid rain." The fossil fuels group is moved down one step.

Continue until a group reaches the top.

Penalize a group a step down for repeating or giving a wrong fact.

Decisions by the judge (teacher) are final!

Evaluation:

Were students able to research, evaluate, list, and analyze the advantages and disadvantages of various fuel sources? In a follow-up discussion, deal with questions such as:

1. Did any fuel source make it to the top? Why? Why not?
2. Was any group driven to the bottom? If so, do we now have a fuel source with so many disadvantages that it would fail?
3. Did any group not get to speak? Where did they finish? Could this really happen?
4. Do the final positions truly reflect the nation's energy mix?

Debate No. 2

"The National Government should act to encourage the use of E-10 blends in motor vehicles."

Designate teams of 2 or 3 students to research and argue both sides of the issue. Let the class or audience judge:

a) which team did the best job;
b) which side of the argument had the best case.

Pick a Project

Let each student pick one of the following projects to complete:

1. Use a map of your community to:
   a) mark the location of filling stations;
   b) circle stations that sell E-10 blends;
   c) underline those that do not.

   Record the prices and octane ratings of fuel at each station and determine the average price. If there is a difference in price between those selling E-10 blends and those that do not, find the reason.

2. What are the coproducts of ethanol production? Obtain samples and interview the users of these products in your own community.

3. Interview a farmer about ethanol and its use as a fuel. Does s/he use it in her/his own vehicles?

4. Use various resources (Internet, interviews, agencies) to determine how many acres (or square miles) in South Carolina are used to produce corn. Mark an area this size on a South Carolina map. Shade the portion going into the production of:
   a) ethanol
   b) livestock feed
   c) food for people (including sweet corn, popcorn, etc.)

5. Design a logo for ethanol. Collect other logos and discuss why they are important and what makes them effective or ineffective.

6. Discuss the use of bumper stickers as promotional tools. What makes them effective or ineffective? Point out that some are positive and some negative. Design a bumper sticker about the use of corn, ethanol or a related topic.

7. Design a mural or cover for a booklet, showing relationships between natural resources, farms, technology, transportation and people.

8. Respond to the following questions, in written or keyboarded format, basing your answers on the “Ethanol Fact Sheet” (11b), classroom discussions and your research in supplementary materials.
   a) Who or what groups stand to gain the most if:
      1. greater use is made of ethanol/gasoline (E-10) blend fuels in automobiles?
      2. ethanol/gasoline (E-10) blend fuels are rejected by motorists?
   b) What are the positive and negative environmental impacts of gradually replacing straight gasoline with ethanol/gasoline (E-10) blend fuels?
   c) What are the effects of using ethanol/gasoline (E-10) blend fuel in automobiles?
   d) What are the effects of large-scale use of ethanol/gasoline (E-10) blend fuels on:
      1. national security?
      2. roads and highways?
      3. cost and availability of food?
   e) Where do the funds come from for the tax credits or incentives governments offer to the ethanol and petroleum industries?
   f) What reasons might a farmer use to convince another farmer to use or not to use ethanol/gasoline (E-10) blend fuel?
   g) What reasons can you set forth to convince a driver who lives in an urban area to use or not use ethanol/gasoline (E-10) blend fuel?

9. List all of the objects in your home (or school) that use purchased energy inputs. Remember appliances that are not obvious, such as water heaters. Then tell how each object is powered; i.e., the type of fuel used to produce the power.

What Types of Food are Easiest to Ferment?

Directions

In this activity, you will test different substances to see what you can learn about fermentation. Before proceeding, make sure students are familiar with the "Laboratory Safety Review" in "Resources" section, 2.

Materials Needed

8 (or more) packets of yeast
4 clear glass, half-liter containers
stirrers
measuring spoons
flour
salt
sugar
vinegar
heating element
pencil
paper/science journal

Procedure

Part One — Fermenting Foods

1. Empty one packet of yeast into each of four half-liter (one pint) beakers of warm water. Stir for one minute.
2. Add 10 ml (2 tsp) of flour to each beaker. Stir again.
3. Add 5 ml (1 tsp) of salt to the first beaker, 5 ml of sugar to the second beaker, 5 ml of vinegar to the third, and leave the fourth alone. Stir again.
4. Wait 5 minutes. What do you observe? Record your observations.
5. Wait 15 minutes. What do you observe? Record your observations.
6. Let the solutions sit overnight. What do you observe? Record your observations.

Questions

1. What is the evidence that reactions are going on in any of the containers? How are these observations related to fermentation?
2. Can you draw any conclusions about which of the substances tested was most helpful to yeast fermentation?

Part Two — Changing Temperatures

1. In this part of the activity, you will observe the effect of different temperatures of water on fermentation. The teacher will prepare boiling water for the first beaker. Fill the second beaker with warm water — just a little warmer than skin

temperature. Fill the third beaker with cold tap water. Fill the fourth beaker with ice water.

2. Empty one packet of yeast into each beaker. Stir to dissolve. Add 10 ml of flour and 5 ml of sugar to each jar. Stir again.
3. Wait 5 minutes. What do you observe? Record your observations.
4. Wait 15 minutes. What do you observe? Record your observations.

Questions

1. Were there any conditions under which the fermentation didn't seem to proceed or went only very slowly? What were they? Can you think of explanations for these results?
2. Can you draw any conclusions about what temperature is best for yeast-flour-sugar fermentation? Try many different combinations of yeast and food and temperatures. What is the optimum mixture for fermentation?

Grain, Oil and Field Crops

Purpose

Students will identify certain grain, oil and field crops. They will determine the uses for the crops and note where they are grown. They will explain soil management practices and cite natural resources. This unit may require 5 days of classroom time.

Standards

Language Arts, Grade 7 through 12
C1, C2, C3, RS2

Sciences, Grade 7 through 12
Inquiry, 7–IIIA7a, 7–IIIA7f

Science, Grade 9 through 12
IID2b, IID4b, IIIB1c

Biology, Grade 9 through 12
IID1b, IIID3b, IIID4b

U.S. and South Carolina Studies, Grade 8
IV

Social Studies — Economics, Grade 9 through 12
ECON-1, ECON-2, ECON-8

Agricultural and Environmental Sciences, Grade 9 through 12
A1, B4, E1

Vocabulary

biodiesel	erosion	grain crops	natural resource	seed pieces
biomass	fertilizer	linen	no-till	
cash crop	field crops	linseed oil	oilseed crops	
conservation tillage	forage	malting	organic matter	
cover crop	ginning	mulch	plant residue	

Materials Provided

"South Carolina Statistics" Overhead 1 Original (12a)
"Soil Management Practices" Overhead 2 Original (12b)
"Natural Resources" Overhead 3 Original (12c)
"Inside-Outside Circles*" Activity (6b)
"Natural Resources" Activity Hand-out (12d)

*Kagan, Spencer. (1994). *Cooperative Learning.* San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
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Materials Needed

crop samples
water
plowed garden spot
hoe
South Carolina Commodities placemat, available from SC Farm Bureau by calling (803) 936-4409
South Carolina Agricultural Statistics census book*
LCD projector and computer

*Available through SC Agricultural Statistics Service, 1835 Assembly St, PO Box 1911, Columbia SC 29202-1911, (803) 765-5333, nass.usda.gov/sc/.

Teaching Strategy

1. Introduce the lesson by asking students to name some important crops grown in their county and in South Carolina. Distribute the South Carolina Commodities placemat. Have them take note of the crops grown in their county and surrounding ones. Use the most current *South Carolina Agricultural Statistics* census book for more detailed information in conjunction with Overhead 1, "2003 Census of Agriculture, State Profile" (12a).
2. Use the PowerPoint presentation found at **aged.ces.uga.edu/** (click on "Disk 3" then "Crop and Soil Science," then "Grain, Oil, and Specialty Field Crop Production" or **aged.ces.uga.edu/2004cds/cd3/PowerPoints%20A%20%2D%20G/Crop%20and%20Soil%20Science/**) which gives more detail on the following crops: corn, wheat, barley, oats, rye, rice, sorghum, soybeans, peanuts, safflower, flax, sunflowers, cotton, sugar beets, sugar cane, and tobacco. Choose the ones most common in your area to discuss. Point out ways to identify the crops. Have samples available to show. Discuss how each crop is used for humans as well as animals. (Note the use of biodiesel — from soybeans or sunflowers — in tractors used to harvest and plant crops.)
3. Divide students into groups. Give groups different samples to plant depending on what is available. Know in advance which crops can be planted at the time of year you are teaching the unit. Have students mark off and plant samples in straight rows. Be sure to identify each row with some type of marker. *Water as needed*. (If the time of year you will be teaching does not match up with the crops to be planted, have crops planted in advance so the samples will be growing when the unit is taught.)
4. Discuss the importance of managing the soil, especially where crops are planted. Review soil terms listed above, using Overhead 2, "Soil Management Practices" (12b). Explain biomass and how animal litter and crop residue are forms of biomass. Get animal litter (chicken, turkey) from a nearby farm. If you have pets in your classroom, their litter could likely be used instead. Spread around the crops when they are well-established. Maintain the "garden" spot throughout the course.
5. Discuss natural resources found in agriculture. Explain that biomass is a

renewable natural resource. Have students explain why resources should be conserved, using Overhead 3, “Natural Resources” (12c).

6. Review and apply the “Inside-Outside Circles*” activity (6b), tailored appropriately to this lesson plan.
7. A field trip could be taken to any row crop farm in your county if time allows.
8. When finished teaching this lesson plan, distribute “Natural Resources” activity hand-out (12d) as an assignment to be completed and assessed for subject comprehension.

Background Information

Cultivating land and growing crops began about 10,000 years ago, with a gradual change from hunters to farmers. Years ago people watched animals to see what was safe for them to eat. Trial and error has led to the crops we grow today. New types and varieties are being developed even today in demand for the growing population. In the U.S., grain, oil and specialty crop production occupies 450+ million acres. This represents 20% of the land mass in the U.S. We are among the most efficient agriculturalists in the world.

More than food is now produced from crops, such as plastics from vegetable oils and biodiesel fuel from sunflower and soybean seed. It is up to us to manage the land where crops are grown and to conserve our natural resources so that food and products can be produced for years to come.

*Kagan, Spencer. (1994). *Cooperative Learning*. San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
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Overhead 1

South Carolina Statistics
Cash Receipts for Crops

Farm Marketings Top Ten Commodities, SOUTH CAROLINA, 2003 Preliminary, with Rank

Commodity	Cash Receipts	Percent of Total 1/	Rank in State	
			2003	2002
	-- Thou. Dollars --			
Broilers	389,266	23.4	1	1
Greenhouse, Nursery, & Floriculture	289,887	17.4	2	2
Turkeys	172,900	10.4	3	3
Tobacco	125,503	7.5	4	4
Cattle and Calves	123,938	7.4	5	5
Vegetables	88,531	5.3	6	6
Eggs	87,186	5.2	7	7
Cotton / Cottonseed	64,161	3.9	8	9
Soybeans	62,604	3.8	9	--
Milk Production	42,840	2.6	10	8
Other Crops 2/	143,762	8.6	--	--
Other Livestock and Livestock Products 3/	73,871	4.4	--	--
STATE	1,664,449	--	--	--

1/ Total may not add to 100 percent due to rounding. 2/ Peanuts, hay, oats, wheat, corn, sorghum, peaches, pecans, apples, other fruits and nuts, tea, minor seed crops, miscellaneous field crops, and forest products. 3/ Hogs, farm chickens, other poultry, sheep and wool, goats and goats' milk, aquaculture, honey and beeswax, horses, lambs, and miscellaneous.
SOURCE: Economic Research Service -USDA.

Tobacco is the 4th largest agricultural commodity in S.C.
Horry County is the leading producer.

Cotton is the 8th largest commodity in S.C.
Darlington County is the leading producer.

Soybeans are the 9th largest commodity in S.C.
Florence, Dillon, Horry, and Darlington counties are the leading producers.

Overhead 2

Soil Management Practices

Based on…

1. reducing raindrop impact;
2. reducing or slowing wind speed or water moving across land;
3. securing soil with plant roots;
4. increasing absorption of water;
5. carrying runoff water safely away;

…recommended practices:

- keep soil covered with growing plants, mulch;
- no till;
- use contour practices;
- use strip cropping on hilly land;
- rotate crops;
- increase organic matter in soil;
- provide correct balance of lime & fertilizer;
- establish permanent grass waterways;
- construct terraces;
- avoid overgrazing;
- establish a conservation plan.

Natural Resources

Natural resource examples:
soil, air, water, wildlife, crops

Why conserve?

1. Land provides us solid foundations for buildings, nutrition and support for plants, and space for work and play.
2. Water is an essential nutrient for all plant and animal life.
3. Air is essential for life!

Natural Resources

PART 1

Directions: List as many natural resources as you can on the lines provided.

PART 2

Directions: When your teacher says to begin, write a paragraph (a minimum of 5 sentences) explaining why we should conserve natural resources. Give at least 3 examples. You will present your paragraph to other classmates. Put some thought into it and write neatly!

Biomass Laboratories

Purpose
The purpose of each of the following three experiments is presented at the beginning of each laboratory activity.

Standards
Language Arts, Grade 7 through 12
C1, C2, C3, W1, W2, W3, W4, R1, RS1, RS2, RS3
Science, Grade 7 through 12
Inquiry, IA7b, IA7c, 7–IB2b, 8–IC2b, 7–IIIA4c, 7–IIIA5b, 7–IIIA6a, 7–IIIA7e, 7–IIIA7f
Physical Science, Grade 9 through 12
IIB6a, IIB6b, IIB6d, IIC3a3, IIC3a4, IIC4b, IIIA4b
Science, Grade 9 through 12
IID1a, IID2b, IID3b, IID4b, IID4e, IID5a, IIE4b, IIIB1b, IIIB1c, IVB6b, IVB6c, IVC4b, IVB4a
Biology, Grade 9 through 12
IID1a, IID2b, IIID2a, IIID2b, IIID3a, IIID3b, IIID3c, IIID4b, IIID4e, IIID5a, IIIE2a, IIIE4a, IIIE4b
U.S. and South Carolina Studies, Grade 8
IV
Agricultural and Environmental Sciences, Grade 9 through 12
A1, B4, E1, F11

Vocabulary

agricultural wastes	calorie	gram	pectin
alternative fuels	Celsius	lignin	polymer
benzene ring	decomposition	milliliter	potential energy
biomass	digestion	moisture absorbent	silica
biomaterials	exothermic	monomer	thermal energy

Materials Provided
"Laboratory Safety Review" (in "Resources" section, 2)
"Biomass Utilization" Hand-out (13a)
Laboratory 1: "Food Energy" Overview (13b)
Laboratory 1: "Food Energy" Hand-out (13c)
Laboratory 2: "Useful Products from Rice Hulls" Overview (13d)
Laboratory 2: "Useful Products from Rice Hulls" Hand-out (13e)
Laboratory 3: "Production of Pectin from Soybean Hulls" Overview (with answer key) (13f)
Laboratory 3: "Production of Pectin from Soybean Hulls" Hand-out (13g)

Materials Needed

Each laboratory has its own list of required materials to be provided in the classroom.

Teaching Strategy

Each laboratory has a teaching strategy tailored to the experiment, as well as directions and procedures. Each laboratory will benefit from reviewing the "Laboratory Safety Review" (in "Resources" section, 4) and "Biomass Utilization" hand-out (14a) before commencing the experiment.

Background Information

A bio-based revolution is quickly emerging in the U.S. which could present new business opportunities for farmers and others, allowing them to participate and profit from the production of bioenergy and biomass products.

Biomass generally refers to materials that are or were once connected with any living materials, including all natural organic carbon-containing materials. This represents an enormous amount of stored energy and endless by-product possibilities.

Biomaterials produced from biomass are called "green," since they are produced from a renewable resource. Some of these biomaterials include phenol, glues, softeners, biodegradable plastics, antifreeze, food thickeners, and gels.

Agricultural products from biomass have enormous potential to provide a healthier future for our planet. Soybean hulls, along with many other often-discarded plant parts, can produce phenols, silica and antioxidants, along with other by-products.

Plants such as soybeans and corn produce plenty of oils that will readily burn. If we can use this oil and mix it with, say, diesel, then we can cut down on our petroleum dependency. Who knows? Before long, you may be driving a car or truck that runs on plant oils.

Whatever the future holds, you can be confident that biomass will play a vital part.

Biomass Utilization

What are Biomass Products?

In a broad sense, biomass refers to all materials that were/are associated with any living materials that existed/currently exist in the biosphere — the thin surface layer of the earth. This includes all natural organic carbon-containing material. Biomass can be considered as an enormous store of energy. Solar energy is trapped and stored in the biomass. Solar energy is converted to chemical energy by plants and stored in the form of carbohydrates. This chemical energy recycles naturally through soil, atmosphere and living matter, by chemical and biological process. Due to the conducive environment which existed a long time ago, some of the biomass converted into fossil fuel. Fossil fuel is not renewable within a reasonable period of time. As we use fossil fuel continuously, it will soon be depleted.

Today, mankind is affecting the energy recycling process by producing huge amounts of waste, yet this waste can be a valuable energy source. Biomass such as household garbage, agricultural and industrial waste is of major concern due to disposal limitations. Although any form of biomass can be a source of bioenergy, discussion here is focused on agricultural products and wastes, and the ways in which these biomasses can be converted to useful energy or matter — an asset instead of an environmental liability.

Origin of Bioenergy

Plants absorb water from the soil and carbon dioxide from the air and convert these into sugars using light energy from the sun. In essence, plants convert light (or solar) energy into chemical energy. This process is called photosynthesis.

Photosynthesis
Carbon dioxide + Water —> Glucose + Oxygen

Glucose is a simple sugar. Different plants store the sugar produced by photosynthesis in different forms. Sugar canes and sugar beets store the energy as simple sugars. Plants such as rice, corn, wheat, and potatoes store the energy as more complex sugars called starch. In addition to sugars and starches, plants also produce very complex sugar polymers called cellulose. Sugars, starches and cellulose are the energy source of biomass.

Why Biomass?

Currently we depend on fossil fuel, a nonrenewable resource, as our major energy source, because it is abundant, relatively cheap and convenient. The more we use, the faster it will be depleted so, as the world population increases, we need to determine more reliable and renewable energy sources to meet the ever-increasing demand for energy.

What are the renewable sources available to us? Geothermal, solar power, wind energy, hydropower, and nuclear energy are abundantly available and will not deplete. Utilization of these energies requires high technology and the complexities in using these technologies make them inconvenient. Among these, nuclear energy seems to be very efficient and attractive. The cost, technological aspects, safety risks, and challenges regarding nuclear waste disposal, however, make nuclear energy utilization questionable. Biomass energy utilization requires very simple inexpensive technologies. Biomass, a natural and renewable resource, seems to be one of the promising sources to meet the world's growing energy demand.

Bioenergy from Biomass

The energy stored in biomass is called bioenergy. This bioenergy can be utilized by transforming the biomass into suitable biofuels. Biomass can be converted into solid, liquid or gaseous biofuels by various processes. Bioethanol is currently produced from corn. Ethanol-based fuel can supplement or replace gasoline in automobiles. Some new cars and trucks are produced to run on E-85 — a fuel containing 15% gasoline and 85% ethanol. When it is burned, fossil fuel releases carbon dioxide into the atmosphere, while ethanol is produced from an agricultural product that consumes carbon dioxide.

Bioethanol

Ethanol production from biomass is a biochemical process and involves three major steps:

1. Converting biomass into a suitable intermediate material.
2. Fermenting the intermediates.
3. Separation of the ethanol from other by-products.

Hydrolysis by acids or enzymes is used to break down starchy material into simple sugar, a more suitable form for ethanol production. This sugar intermediate is fermented into alcohol. Fermentation is an anaerobic biological process. In this process, sugars are converted into ethanol by the action of yeast or other micro-organisms. Ethanol is then separated from other by-products using a simple distillation process.

Biodiesel

Biodiesel can be made from vegetable oil, animal fat or recycled cooking oil. Oils and fats are triglycerides — esters formed by the reaction of fatty acids with glycerol. When the triglycerides undergo hydrolysis, the reverse reaction occurs. This leads to the formation of fatty acids. As a result, oils usually contain small amounts of fatty acids. Biodiesel is a mixture of fatty acids — alkyl esters. In biodiesel, the glycerol portion of the esters is replaced by simple alkyl groups such as methyl or ethyl groups. Biodiesel is generally used as a fuel blend, consisting of 20% biodiesel and 80% petroleum diesel.

Biodiesel production involves the following basic process:

1. *Acid esterification*

   If the oil contains more than 4% fatty acids, the fatty acids are first converted into esters by treating the oil with an alcohol. A catalyst such as sulfuric acid is used to aid this conversion.

2. *Transesterification*

   Triglyceride esters react with alcohol and convert into alkyl esters by this process. A base (potassium hydroxide) is used as a catalyst for this reaction.
3. *Recovery* of biodiesel and by-products.

Gasification of Biomass

There are other ways to obtain direct energy or fuel from biomass. One method is direct combustion. This is a simple process, but very inefficient. For example, direct combustion of biomass can be used in a boiler to produce steam. The steam is used to turn the turbine to generate electricity. Generally, the thermal efficiency of direct combustion is 10 to 30%. The second process is gasification. In this process, solid biomass is reacted with hot steam and oxygen in the air to produce liquid or gaseous fuel. Gasification efficiency of agricultural wastes ranges from 60 to 90%. By controlling the gasification conditions, synthesis gas can be produced. Synthesis gas is a mixture of carbon monoxide, carbon dioxide, hydrogen, and methane. This synthesis gas can be used to produce hydrocarbons. Hydrocarbons are also the major components in the fossil fuels. Synthesis gas can also be converted into methanol — a liquid fuel. However, the efficiency of this conversion is about 20%. In industry, catalysts are used to improve the efficiency. Another process called pyrolysis can be used to convert biomass into charcoal or a liquid called pyrolysis oil. This process involves heating the biomass in the absence of air at a temperature in the range of 300 to 500^{o}C until it chars.

Are Biofuels Harmful or Beneficial for the Environment?

All fossil fuels are mixtures of hydrocarbons of varying length and structures. Hydrocarbons are molecules that contain carbon and hydrogen atoms. These molecules contain no oxygen atoms. Combustion of these fuels requires oxygen. An air supply provides oxygen for this purpose. The carbon-containing materials release carbon monoxide and carbon dioxide into the atmosphere as a result of combustion. We all know that carbon dioxide is one of the greenhouse gases that traps solar energy and causes global warming. As noted earlier in this section, however, biofuels are derived from plants, which consume carbon dioxide. Therefore, the carbon dioxide content of the atmosphere is better balanced by a biomass-based recycling process. Since burning fossil fuel releases carbon dioxide that was captured billions of years ago, causing an environmental imbalance, producing biofuels from plant materials as a substitute for fossil fuel could substantially reduce the harmful net greenhouse gas emission.

Further, petroleum fuels contain various types of hydrocarbons with chemical additives that are included to improve combustion, intended to enhance vehicle performance. Some of the components in the fuel and the additives are toxic and highly volatile, and are responsible for health hazards associated with vehicle emissions due to combustion. The use of biofuels as additives to petroleum fuel can reduce these harmful emissions. In fuel blends such as E-10 and B-20, ethanol and biodiesel are added to the gasoline and diesel, respectively. While the E-10 blend has 10% ethanol and 90% gasoline, the B-20 blend has 20% biodiesel and 80% petroleum diesel. These fuel-blends burn more completely than petroleum, producing less carbon monoxide and hydrocarbons. It is possible to use a higher percent of biofuels to further improve the emission quality.

Economical Benefits

In the previous sections, we learned that the use of bioethanol and biodiesel can have a positive impact on environmental quality issues. Improving the quality of our environment saves money and encourages economic expansion. Further, producing and using biofuels might reduce or even eliminate our dependence on foreign oil. Most agricultural waste can be used to produce biofuels. The production of biofuels would not only create value from this waste, it would minimize waste disposal problems and associated expenses. We also can develop and grow crops specifically for biofuel production. We refer to these crops as "energy crops." Growing energy crops would diversify farming and provide more farmers with a stable income. Research is necessary to develop economical energy crops and the necessary technology to efficiently convert biomass into biofuel.

Can We Produce Useful Chemicals from Biomass?

So far we have focused on converting biomass into biofuels to generate energy. Biomass utilization, however, is not limited to generating bioenergy. A variety of useful materials can be produced from biomass. These materials, generally referred to as biomaterials, range from simple chemicals to more complex polymers. It is unfortunate that we depend on fossil materials for most of the organic chemicals as they are derived from petroleum-based materials. Chemicals derived from petroleum are called petrochemicals. Can we replace petrochemicals with chemicals derived from biomass?

Biomaterials

Biomaterials produced from biomass are also called green chemicals. This means that they are produced from a renewable resource. Some important biomaterials include phenol, glues, softeners, biodegradable plastics, antifreeze, food thickeners, and gels.

What are the chemicals in biomass? The most common chemicals are carbohydrates. Carbohydrates include simple sugars such as glucose, fructose and sucrose, and more complex polymers of sugars such as starches and cellulose. Simple sugars can be readily converted to chemicals using a biological process such as fermentation followed by chemical conversions. Complex sugars can also be converted in the same way after breaking them down into simple sugars using acid or enzymatic hydrolysis. Chemicals that can be produced from glucose by fermentation are: ethanol, acetic acid, acetone, propanol, glycerin, and lactic acid. These chemicals can be converted to a variety of other useful chemicals. For example, ethanol can be dehydrated to ethylene. Ethylene is the starting material for polyethylene. Plastic shopping bags are made out of polyethylene.

Lignin
Plants also have lignins. Lignin can be considered a natural adhesive, as it holds together all the cells to form fibers. Lignins are polymers containing phenols. Phenols can be separated from lignin and converted to useful chemicals. Phenol-based adhesives are used to bond wood panels to form plywood boards.

Oils from oil seeds
Vegetable oils are produced from oilseeds from plants such as canola, soybeans, sunflowers, and peanuts. The chemicals that form the oil are triglycerides. The triglycerides are esters, a type of chemicals formed from fatty acids and glycerol. As we learned earlier, these triglycerides can be easily split into fatty acids and glycerol using a process called hydrolysis. Fatty acids are widely used in personal care products and cleaners. These fatty acids also can be converted to a variety of useful chemicals.

Other Useful Chemicals

Antioxidants

Antioxidants are used in a variety of skin care products and food products that contain fats and oil. Some chemicals are oxidized in the presence of oxygen and sunlight. This oxidation damages cells in the body. Oxidation of fats and oil in foods makes the foods deteriorate and unsuitable for consumption. Antioxidants are used to prevent this oxidation damage. Prunes, blueberries, grapes, spinach, garlic, and soybeans are some of the natural sources that are rich in antioxidants. Research conducted at Claflin University in South Carolina indicated that phenolic antioxidants can be produced from soy hull. Soy hull is removed from soybeans before oil extraction, and disposed of as a waste product. In fact, soy hull is rich in phenolic antioxidants and other chemicals such as pectin and lignin.

Silica-based Chemicals

In the rice industry, raw rice is milled to remove rice hull from rice grain. Rice hull is separated from the milled rice and disposed of as a waste product. Research conducted at the University of Arkansas showed that pure silica can be produced from rice hull. Silica-based materials are used in adhesives, detergents, thermal insulators, and ceramics.

Future of Biomass

If we learn how to use biomass efficiently and how to develop cost-effective technology for producing fuels and chemicals, there will be less waste generated by industry and consumers. Biomass utilization is necessary to protect our environment. We also need to develop new energy crops, just for producing fuels and chemicals. We must not rely only on fossil fuel for our future.

Laboratory 1 Overview: Food Energy

Purpose

Students will determine the amount of energy in the oils of some types of beans/seeds and food snacks by igniting the foods and measuring the change in water temperature, then determine which is the most valuable in terms of alternate energy sources.

Materials Needed

100 mL graduated cylinder
Celsius thermometers
lab apron
lab goggles
bag of Cheetos™
bag of marshmallows
various bags (small) of dry beans — lima beans, etc.
bag of dry-roasted nuts — peanuts, cashews, etc.
wire clothes hanger (1 for each group)
matches (long wooden are best)
small plastic cups (for seeds/nuts/foods)
needles (large stickpin types)
pliers
aluminum foil
balls of clay (for each group — small golf ball size)
water
clean metal can with label and top removed

Teaching Strategy

1. Start the lesson with this question: "What would happen to us and our country if we were no longer able to purchase or supply petroleum for our fuel needs?" Discuss the possibilities of alternative fuels (solar, electric, along with biomass fuels — ethanol, biodiesel) that are now being explored and used.
2. Discuss that all foods contain energy, but the amount they contain varies greatly with the food type used.

Food Energy

Procedure

In this investigation, we will compare the amount of energy in different food types — nuts, beans, snacks, etc. A calorie is the amount of energy needed to raise 1 g of water 1 degree Celsius. Remember: 1 g of water = 1 mL of water.

You will measure the change in temperature (T) of a known volume of water. The temperature change is caused by the absorption of heat from the burning food source. Based on the temperature change, you can calculate the amount of energy in the food sample. Using the chart below as a guide, create a chart that accommodates the various food samples provided in the classroom. Record your findings on this chart.

1. Untwist the coat hanger to get a heavy wire. Wrap the wire around the can in a spiral, making the lower spirals a little wider to make a base.
2. Embed the “head” of the pin into the clay. Place the food item on the point of the needle. Slide the needle under the can. Adjust the wire base so that there is about 2 cm separating the food and the can. Remove the needle/food assembly from under the can.
3. Cover the wire spiral with aluminum foil, leaving an opening for a door. The aluminum foil will hold more heat and the door is to place the match through.
4. Measure 50 mL of water and place it into the can. What is the mass of water in the can? Take the temperature of the water and record it on the chart.
5. Light the food particle with the match. Keep the bottom of the thermometer about three-fourths of the way into the water. When it starts to burn, slide the clay, pin and burning food particle under the can. If it sputters and goes out before totally burnt, get another piece, along with new water and start over.
6. When the particle is totally burnt, record the final temperature of the water onto your chart. Pour the water back into the graduated cylinder to see if any water loss occurred — some energy went with the steam if there was any.
7. Calculate the calories.
8. Repeat with other foods.
9. Clean up your lab area when done.

Sample Chart

	Initial		Final		
Food	water vol.	water temp	water vol.	water temp	calories
A.	50 mL				
B.					

Analysis

1. Which food had the most calories?
2. Discuss why calories are important to you.
3. Which food may be the best source of oil to use as a fuel source?
4. What was the original energy source of all foods tested?

Laboratory 2 Overview:
Useful Products from Rice Hulls

Purpose
Students will extract useful components to make functional products from the hull waste of rice.

Materials Needed
10 grams of rice hull ash
50 ml 1M NaOH
0.1M HCL
hot plate
glass stirrer
(2) 250 ml Erlenmeyer flasks
200 ml beaker
pH meter
10 ml pipette
watch glass
funnel
filter paper
safety fume hood
electronic scales
goggles
apron
gloves

Teaching Strategy
1. The lesson begins with a discussion of what we do with wastes, such as banana peels, the "ears" of corn, peanut shells, and uneaten or spoiled food. Ask the students if there are possible uses for these biomass materials. Encourage students to consider all feasible options and have them write their suggestions on the board.
2. Distribute and review the "Biomass Utilization" hand-out (13a). Ask selected students to read specific passages that highlight the importance of biomass utilization. Ask students to list the impact on our society and economy if we were to have a national policy of biomass utilization. Ask students to think of other biomasses that are not being utilized.
3. Advise students that they will be performing an experiment to produce silica, a usable material from the ash of rice hulls. Inform them that some of the chemicals they will be using are dangerous and then review Laboratory Safety (refer to "Resources" section, 2). Divide the class into groups of 4. When the experiment is complete, have each group report their responses to the following questions:
    1. Why did we use a fume hood?

2. What modifications would be necessary to run a large-scale extraction?
3. What was the final yield of silica gel?
4. What practical uses are there for silica?
5. What kind of a market exists for silica in the U.S. and the world?

4. Each student is to prepare a short report, incorporating the experiment results, that identifies the uses of silica. They should include the feasibility of mass production of silica, using a modified upscale version of our lab procedure. Access to library material and the Internet is recommended for this assignment.

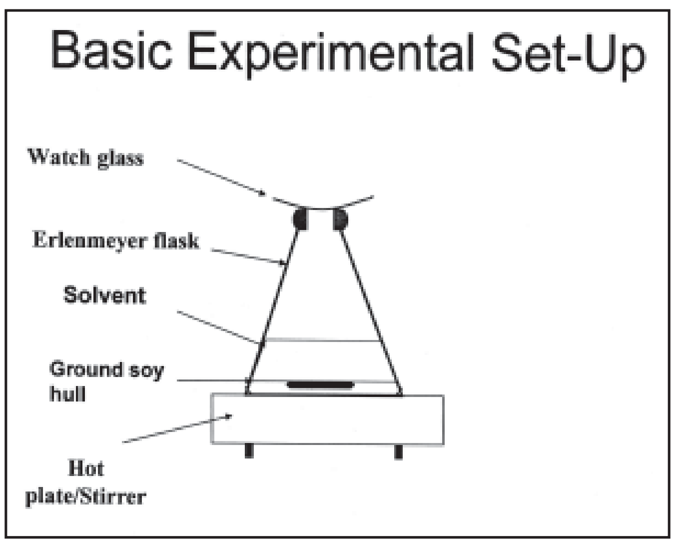
Useful Products from Rice Hulls

Directions

In this activity, you will be utilizing biomass from rice hull ash to produce silica. *Maintain a safe lab environment at all times.* Have one designated student collect the materials that your group needs. Before beginning, refer to the apparatus setup model at the teacher's lab table. Conduct the experiment, making observations and recording data.

Procedure

1. Refer to Basic Experimental Set-Up diagram below.
2. Add 10 grams of rice hull ash to one of the Erlenmeyer flasks. Carefully mix 50 ml of 1M NaOH with the ash in the flask.
3. Place the flask and hot plate under safety fume hood.
4. Place the flask on the hot plate, with watch glass on top.
5. Turn on hot plate to setting #8 and allow mixture to boil for one (1) hour, stirring occasionally with glass stirrer. Remember to use tongs, gloves, goggles, and apron.
6. Prepare 10 ml of boiling water to wash the residue (time this for end of experiment).
7. After 1 hour, remove flask and empty solution into a funnel/flask setup with filter paper.
8. Use the 10 ml of boiling water to wash the residue.
9. Collect and combine the filtrate and the washings (sodium silicate solution) in a beaker.
10. Slowly add and stir 1 ml of the 0.1M HCL at a time to the sodium silicate solution. Use the pH meter to monitor progress and stop when you get a pH of less than 10.
11. Allow the solution to gel.
12. Crush the gel and place in incubator at 80°C for 12–15 hours.
13. Remove after drying, and weigh and observe the silica gel.



Laboratory 3 Overview:
Production of Pectin from Soybean Hulls

Purpose

To demonstrate that biomass can be used to produce organic compounds for use in the everyday world. To demonstrate an organic decomposition reaction and the effects of reducing particle size and temperature on a reaction.

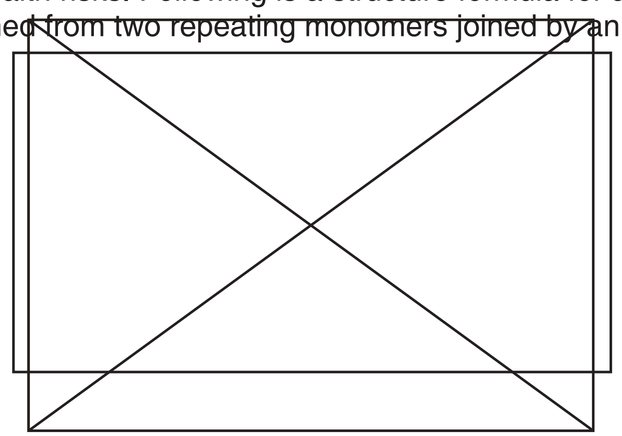
Materials Needed

soybean hulls
0.1 M HCl acid solution
90% Isopropanol solution
hot plate
250 ml Erlenmeyer flask
watch glass
funnel
filter paper
stirring rod
metric balance
Celsius thermometer (-20°C to 110 $^{\circ}$C)
graduated cylinder
mortar and pestle
aprons
goggles
exhaust hood or ventilation fan

Teaching Strategy

Introduce the concepts of polymers and monomers in addition to the benzene ring structure. Discuss the chemical digestion of organic molecules, along with the affects of grinding and heating on the removal of the pectin from the soybean hulls.

Explain to the students that pectin, along with cellulose and other compounds, is one of the major chemical compounds making up cell walls and fiber in plant materials. Pectin is a fiber. It is used in the production of jams and jellies, margarine, and artificial whipped cream. Pectin has a taste similar to fats, but without the calories or the health risks. Following is a structure formula for a pectin molecule. It is a polymer formed from two repeating monomers joined by an oxygen atom.



The soybean hulls will be ground, heated under the hood, and filtered from the flask on the first day. On the second day: the filtrate will be treated with isopropanol and set aside to settle. On the third day: precipitate will be filtered and washed and allowed to dry.

Answer Key for Production of Pectin from Soybean Data Sheet

1. Weight of Ground Soybean Hulls — 10.0 gm
2. Weight of Filter Paper + Pectin — (varies) gm
3. Weight of Filter Paper — (varies) gm
4. Weight of Pectin — (varies) gm (#2 minus #3)

Questions:

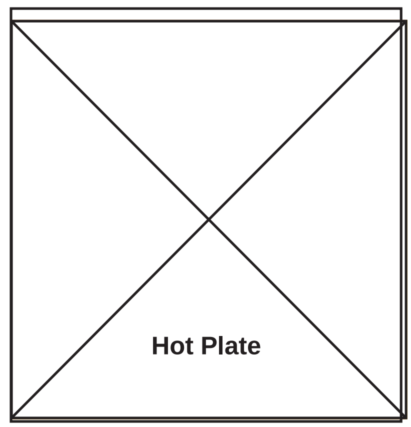
5. How does the amount of pectin produced compare to the amount of soybean hull used?
   Amount of pectin is less than the amount of soybean hulls used.
6. What was the purpose of the 0.1 M HCl in this lab?
   The acid broke down the plant fiber structure so the pectin could be removed.
7. Why did you grind up the soybean hulls, instead of using them whole?
   The soybean hulls were ground into smaller pieces to speed up the rate of the reaction, so that the acid could more easily come in contact with the molecules.
8. Why did you heat the crushed soybean hulls and the acid solution, instead of keeping it at room temperature?
   The heat raised the temperature of the molecules and the acid, causing more collisions between acid molecules and the molecules in the soybean hulls.
9. Based on what you did in this lab, do you believe that pectin is a monomer or a polymer?
   A polymer
   Explain your answer:
   Looking at the structural formula, the pectin molecule appears to be two repeating units.
10. What are some other uses for pectin, other than those listed above?
    (Various uses requiring fibers or the tastes of fats)

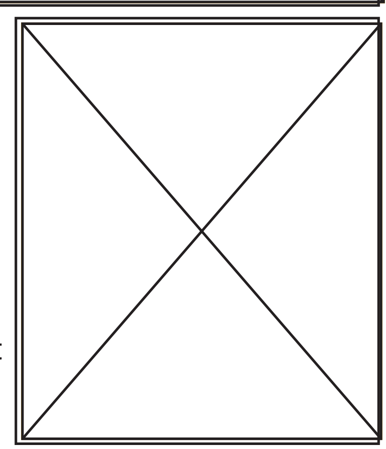
Production of Pectin from Soybean Hulls

Procedure

Day 1

1. Weigh out 10.0 grams of soybean hulls and grind to relatively small pieces. Record the weight of soybean hulls used.
2. Place ground soybean hulls in a 250 ml beaker and add 30 ml of 0.1 M hydrochloric acid solution (HCl).
3. Place the beaker on a hot plate set on low and place a watch glass over the opening of the beaker. (See Plate A.)
4. Heat the mixture in the beaker for 30 to 40 minutes, periodically checking the temperature with your thermometer, being sure to keep it around 90°C. Do not allow the contents of the beaker to reach boiling.
5. Filter the soybean hulls out of the contents of the beaker by pouring the solution through filter paper in a funnel and collecting the solution into a plastic cup with your and your lab partner's names written on the cup. (The solution should be clear.) (See Plate B.)
6. Place the cup where your teacher instructs you to, so it can be used the next day.





Day 2

7. Add 30 ml of 90% isopropanol to the liquid in your cup and set the cup aside where your teacher instructs you to. Allow the cup and its contents to sit overnight.

Day 3

8. Weigh a piece of filter paper and record its weight. Pour the contents of your cup through filter paper in a funnel and allow the liquid to collect in a beaker. (See Plate B.)
9. Pour a small amount of isopropanol (about 10 ml) into the filter paper in the funnel and allow it to drain into the beaker.
10. Pour the liquid collected in the beaker into the large beaker supplied by your teacher.
11. The solid trapped in your filter paper is pectin. Write your names on the filter paper and set it aside as instructed by your teacher.

Day 4

12. Weigh the filter paper with the pectin on it after it has dried overnight. Record its weight.

Production of Pectin from Soybean Data Sheet

Name ______________________________ Class ______________________________

1. Weight of Ground Soybean Hulls ____________ gm
2. Weight of Filter Paper + Pectin ____________ gm
3. Weight of Filter Paper ____________ gm
4. Weight of Pectin ____________ gm (#2 minus #3)

Questions:

5. How does the amount of pectin produced compare to the amount of soybean hull used?

   ____

   ____

6. What was the purpose of the 0.1 M HCl in this lab?

   ____

   ____

7. Why did you grind up the soybean hulls, instead of using them whole?

   ____

   ____

8. Why did you heat the crushed soybean hulls and the acid solution, instead of keeping it at room temperature?

   ____

   ____

9. Based on what you did in this lab, do you believe that pectin is a monomer or a polymer?

   ____

   Explain your answer:

   ____

   ____

10. What are some other uses for pectin, other than those listed above?

    ____

    ____

    ____

    ____

Biofuel and the Future

Purpose

Students will realize the need for alternative fuel and explore why it is important for South Carolinians to use alternative fuels.

Standards

Language Arts, Grade 7 through 12
C1, C2, C3, W1, W2, W3, W4, RS1, RS2

Sciences, Grade 7 through 12
Inquiry, 7–IB2b, 8–IC2b, 7–111A4c, 7–IIIA5b, 7–IIIA7e

Science, Grade 9 through 12
IIIB1b, IIIB1c

U.S. and South Carolina Studies, Grade 8
IV

Social Studies — Economics, Grade 9 through 12
ECON-1, ECON-2

Agricultural and Environmental Sciences, Grade 9 through 12
A1, E1

Vocabulary

alternative fuel	biofuel	EPA	global warming
alternative fuel vehicle (AFV)	biomass	ethanol	
biodiesel	E-85	flexible fuel vehicle (FFV)	

Materials Provided

“Inside-Outside Circles*” Activity (6b)
“My Dream Car” Activity Hand-out (14a)
“SUV” Poster (14b)
“Truck” Poster (14c)
“Compact Car” Poster (14d)
“Sports Car” Poster (14e)
“Research Fact Sheet” Hand-out (14f)
“Poster Rubric” Teacher Aid/Hand-out (14g)

Materials Needed

string
tennis ball
computer lab
poster board

*Kagan, Spencer. (1994). *Cooperative Learning*. San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
.

paper
pencil
markers

Teaching Strategy

1. Begin the lesson with the "My Dream Car" activity, having students write a paragraph (5 to 7 sentences) describing the dream car they plan to own when they are older. Have them explain why it's their favorite car. Give the students 15–20 minutes to write and then divide the class into four equal groups. Use the instructions for the "Inside-Outside Circle*" activity (in Lesson Plan 6b).
2. When finished, place small posters around the room in each of the four corners with types of different cars printed on each. Four originals have been provided for you: SUV (14b), Truck (14c), Compact Car (14d), and Sports Car (14e). Have students pick the type that is their favorite and go to that corner. Have them discuss with each other why they chose this type of car. Notice the amount of "cars" in each group. Discuss with the students which type of vehicle would use the most gas and which would use the least.
3. Next, follow these directions for making human graphs*:

   Human Graphing* — Bar Graph

   Have one person from each group hold the group's word and the others in that group form a line behind the person holding the poster. The last person in line will have his back against the wall; the other group members will line up one-by-one, facing away from the wall, with the person in the front of the line holding the poster. Have the other groups form lines in the same manner along the same wall. Explain that the class has created a bar graph that expresses students' preferences. Point out that a graph is a picture that represents facts.

   Human Graphing* — Line Graph

   Hand the first person in the first row the end of a ball of string. Walking in front of each row, have the first person take hold of the string, ending with the person at the front of the last row. Ask the class what graph they have now formed (a line graph).

   Make sure students understand that the bar graph and line graph both represent the same information.

   Human Graphing* — Pie/Circle Graph

   Have students in each line join hands. Form a circle beginning with the students in the first line. As the teacher marches in a circle, the students in each line take the hand of the last person in the line ahead of them. Once all four groups/lines are in the full circle, have students drop their hands. The person holding the word places it on the floor in the middle of his/her group such that everyone in the circle can see it. The teacher moves to the center of the circle holding four pieces of string attached to a tennis ball. The first person in each group goes to

*Kagan, Spencer. (1994). *Cooperative Learning.* San Clemente, CA: Kagan Publishing; www.KaganOnline.com/
.

the teacher and takes the end of one pieces of string and then returns to his/her place in the circle. Explain to the students they have just made a pie/circle graph.

Clarify with the class that each of the graphs created represents the same findings; these are merely three different methods to depict the data.

4. Bring the students together and discuss the following questions:
    1. What makes our cars run?
    2. What is gasoline and where does it come from?
    3. What would happen if we could no longer get petroleum from the Middle East?
    4. How would we fuel our cars?
    5. Name some other fuels for making our cars run or what we like to call "alternative fuels?"
    6. Where do these alternative fuels come from?
5. Explain to the students that they will be researching these "alternative fuels" in the computer lab. They will be searching for some very interesting facts – examples: what biomass, biofuel, biodiesel, ethanol, propane, and CNG (compressed natural gas) are and where they come from. Have students research and answer questions using the "Research Fact Sheet" hand-out (14f).
6. Put students in groups of 4–5 students and have them discuss their findings with their group. Have them put together an informational poster according to the "Poster Rubric" (14g), explaining where alternative fuel comes from and the benefits to using alternative fuel. Have each group display their poster and share their findings, explaining why they feel alternative fuel is a good thing and why they see this as a must for the future.
7. Last, have each student write a one-page essay about alternative fuel and our future. Explain why it is important we start getting serious about alternative fuel.

Background Information

"Alternative fuel" describes fuels other than gasoline that can be used to power our cars. In 1992, the U.S. Congress passed the Energy Policy Act (EPA) that made it a law for governments and utilities to use alternative fuels made in the U.S. to power some of the vehicles in their fleets. The fuels that must be used are natural gas, propane, electricity, ethanol, and biodiesel. The U.S. uses more oil than any other country in the world — less than 50 percent of that oil comes from the U.S. The rest of it is imported mostly from Middle Eastern countries. U.S. dependence on oil from other countries makes us very vulnerable and jeopardizes national security.

The EPA was intended to drastically reduce our dependence on foreign oil by increasing the use of domestically produced fuels in government and utility-provider fleets. Beginning in 1996, fleets were required to begin purchasing alternative fuel vehicles (AFVs). The percentage of AFVs was increased each year and by 2001, 75 percent of new vehicles purchased had to be capable of using alternative fuels. In spite of this law, demand for oil continues to rise, with Americans now using roughly 19.5 million barrels of oil a day, with 54 percent of it coming from foreign countries.

Overuse of fossil fuels has also caused significant air pollution throughout the U.S. Most people think of air pollution as afflicting large cities such as Los Angeles and Houston, but Charlotte and Atlanta have some of the highest pollution rates in the country. Even in South Carolina, air quality is threatened by emissions from gasoline-powered cars and trucks. Alternative fuels can help ease these problems, as they burn cleaner than gasoline and diesel fuel.

("Background Information" provided by the South Carolina Energy Office and the SC Department of Health and Environmental Control)

My Dream Car

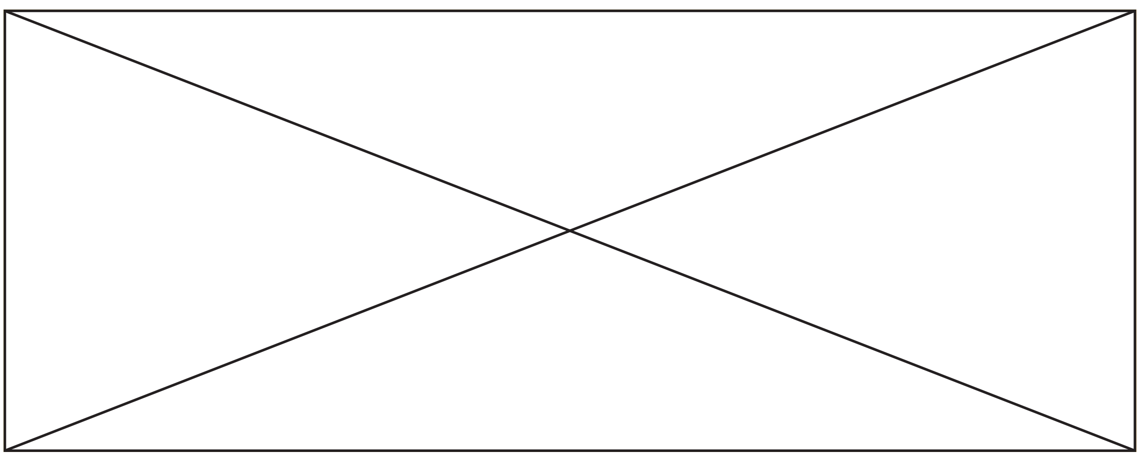
Name____

Date____

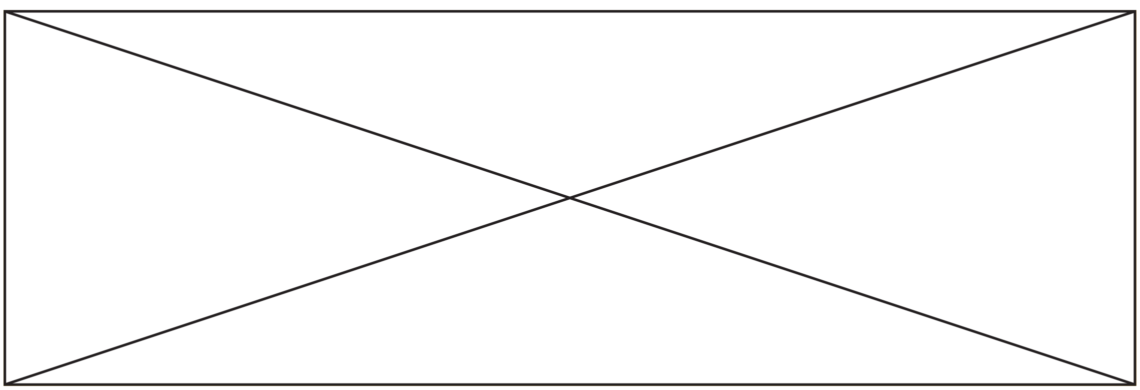
Directions:
Write a paragraph about the "Dream Car" you plan to own some day. Explain why this would be your "Dream Car" (5 to 7 sentences).

SUV

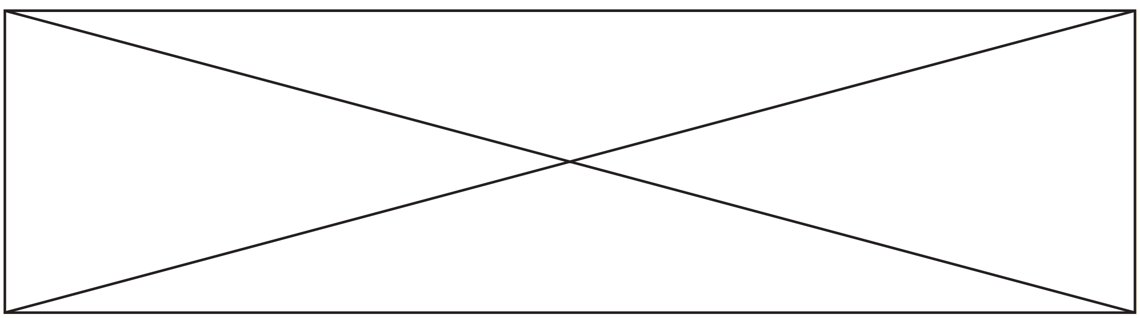
(Sports Utility Vehicle)



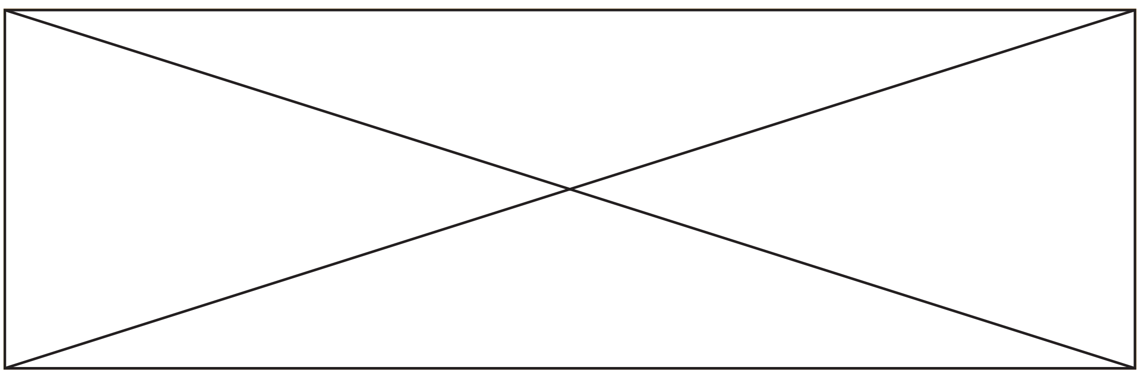
Truck



Compact Car



Sports Car



Research Fact Sheet: Alternative Fuels

1. What are alternative fuels? ______________________________

2. List some major alternative fuels: ______________________________

3. In 1992, U.S. Congress passed a law called: ______________________________ . This Act made it a law for governments and utilities to use alternative fuels made in the United States to power some of the vehicles in their fleets.

4. What is ethanol? ______________________________

5. Name some commodities used to make ethanol: ______________________________

6. What is biodiesel? ______________________________

7. Name some commodities used to make biodiesel: ______________________________

8. FFVs (flexible fuel vehicles) are specially designed to run on: ______________________________

9. E-85 means: ______________________________

10. B-10 means: ______________________________

11. What is biomass? ______________________________

12. How would ethanol and biodiesel strengthen our nation's economy and security? ______________________________

13. In your own words, explain why alternative fuels are important to South Carolina and its future.

Poster Rubric

Work together as a group to design and create a poster that will inform the public about the need for alternative fuel in South Carolina. Make sure your poster is colorful, neat, eye-catching, and interesting with facts you have collected from your research.

Create a poster with your group that displays the following:

1. A catchy title for your poster promoting alternative fuel. — 20 points
2. Pictures of the commodity(s) used to make ethanol. — 20 points
3. Pictures of the commodity(s) used to make biodiesel. — 20 points
4. A slogan to convince the public to change to an alternative fuel. — 20 points
5. Use of color, graphics and layout skills to make your group's poster stand out. — 20 points

100 points

SC Farm Bureau AG in the classroom

SOUTH CAROLINA Energy Office

Resources

The average person in the U.S. produces about 4.3 pounds of solid waste in a day.
(Annenberg Foundation/CPB, **learner.org/exhibits/garbage/intro.html**)

Biomass is any organic matter that can be used as an energy source.

Biomass contains little sulfur and nitrogen, so it does not produce the pollutants that can cause acid rain.

Acre facts:
43,560 sq feet = acre
4,047 sq meters = acre
An acre is about the size of a football field.

Using biomass for energy reduces the amount sent to landfills.

Garbage is one source of biomass.

A ton (2,000 lb) of garbage can contain as much heat energy as 500 lb of coal.

Landfills can collect methane gas, purify it and use it as an energy source.

Garbage can be burned to generate steam and electricity.

In 2000, about 44% of all renewable energy consumed in the U.S. came from biomass.

In some landfills, wells are drilled into piles of garbage to capture methane gas produced from the decaying waste.

Methane gas can be purified and used as an energy source, just like natural gas, that we burn in our stoves and furnaces.

Bacteria feed on dead plants and animals. As plants and animals decay, they produce a colorless, odorless gas called methane.

A landfill in Florence, Alabama recovers 32 million cubic feet of methane gas per day. The City purifies the gas and pumps it into natural gas pipelines.

Methane gas can cause fires or explosions if it seeps into nearby homes and is ignited.

Methane gas, the main ingredient in natural gas, is rich in energy.

New regulations require landfills to collect methane gas for safety and environmental reasons.

In China, many farmers use all of their garbage, even animal and human waste, to make methane. They put the waste into a big tank without air. It makes methane as it rots. Farmers use the gas to cook food and light their homes. The waste that is left can be used as fertilizer to grow more crops.

Power plants that burn garbage and other waste for energy are called waste-to-energy plants.	Biomass can be converted into usable energy in four ways: burning; fermentation; bacterial decay; and conversion.	Less than 2% of Americans farm for a living.
77% of biomass energy is used by industry.	Biodiesel can be made from vegetable oil, animal fat or recycled cooking oil.	Farm forest products include paper, pulp and wood used to make products such as furniture and houses.
The energy in biomass is stored as chemical energy and can be burned, or converted to methane gas or ethanol.	Americans only spend about 11% of their income for food.	Wood (logs, chips, bark and sawdust) accounts for about 79% of biomass energy.

The exhaust from biodiesel-fueled vehicles smells like fried potatoes!

Clemson University and South Carolina State University are the state's two land grant institutions.

Farmers who use crop protection chemicals are required to be trained in application methods and to keep accurate records of usage.

Biomass gets its energy from the sun. Plants absorb sunlight in a process called photosynthesis.

Agricultural biotechnology helps farmers produce healthier, pest-resistant crops that require fewer crop protection chemicals.

Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.

Biodiesel has significantly improved lubricity, which can decrease maintenance costs and reduce engine wear. Even blends as low as 1% can improve lubricity by as much as 65%!

A large tractor with attachments can cost more than a house.

Using biomass does not increase the amount of carbon dioxide in the atmosphere.

Biomass produces 2% of the electricity we use (produced by electric utilities).

Biomass is called a renewable energy source because we can grow more in a short amount of time.

Biofuel blends are referred to with the initial of the biofuel, then a number indicating the biofuel percentage of the blend. For example, E-10 is a 10% ethanol blend; B-20 is a 20% biodiesel blend.

Ethanol is an alcohol fuel made by fermenting the sugars found in grains, such as corn and wheat.

Ethanol usage can reduce total carbon dioxide emissions.

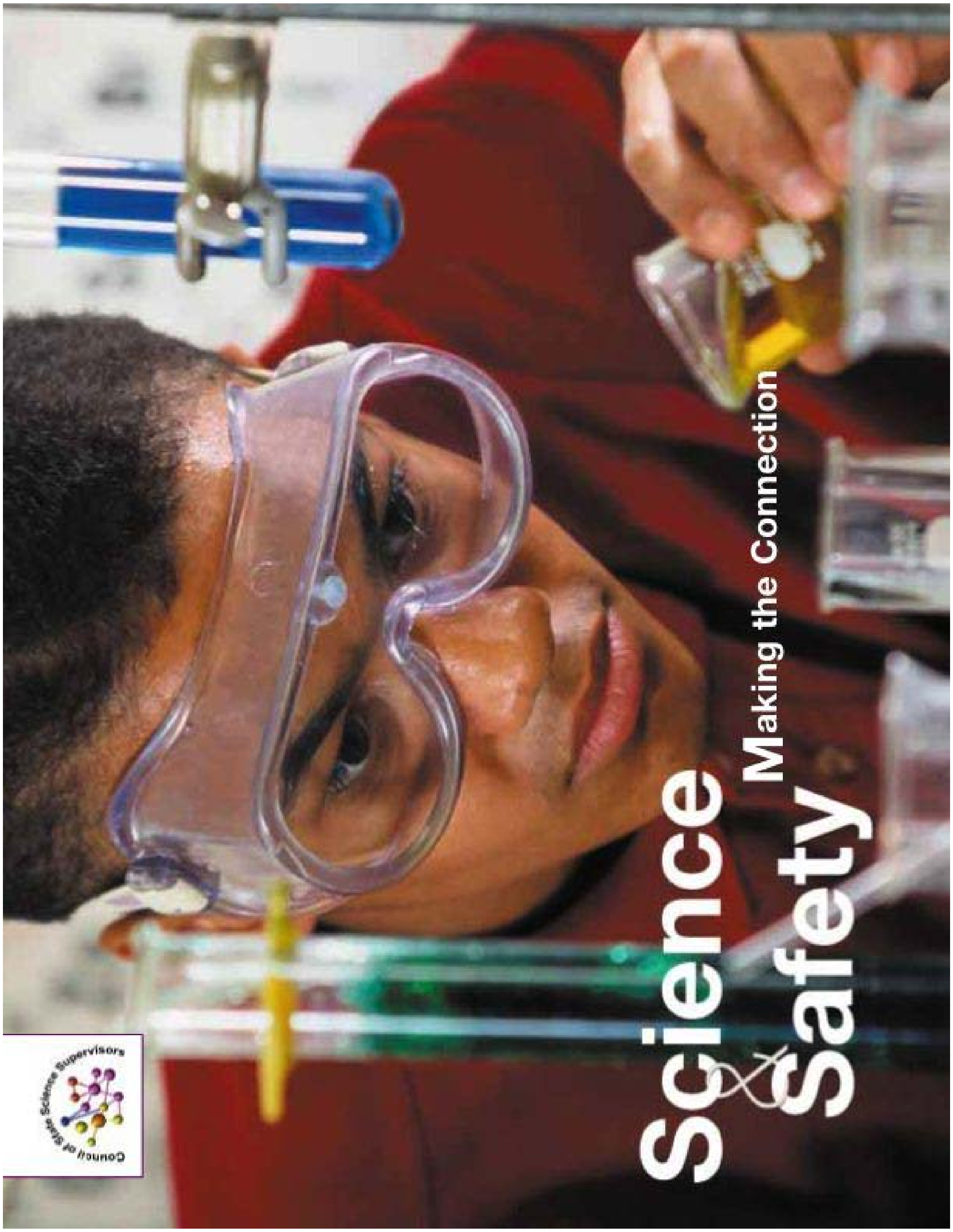
Growth in biobased products will stimulate rural development efforts in farming, forestry and associated service industries.

Gasohol refers to gasoline blends containing up to 10% ethanol.

Agriculture is the number 2 industry in South Carolina, and the number 1 industry in the U.S.

Domestic bioenergy sources could help our nation to substantially reduce dependency on petroleum.

Biomass can make ethanol, a fuel a lot like gasoline. Ethanol costs more than gas to use, but it is cleaner and renewable.	Ethanol is a water-free additive that absorbs moisture and helps prevent gas line freeze up in cold weather.	
Biomass can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels.		
Land not needed for food production can be used to grow energy crops.		



This science safety guide, geared to higher school grades, is available online at csss.enc.org/safetym, published by the Council of State Science Supervisors (CSSS) with support from the American Chemical Society, the Eisenhower National Clearinghouse for Mathematics and Science Education, National Aeronautics and Space Administration, Dupont Corporation, Intel Corporation, and the National Institutes of Health.

Science & Safety
Making the Connection

A Note to the User

With the increasing emphasis on hands-on, minds-on inquiry instruction at all levels in the National Science Education Standards (NSES) and most state frameworks or courses of study, it becomes more incumbent upon science teachers to be as knowledgeable as possible about laboratory safety issues and their own responsibilities. As science supervisors/specialists, the members of the Council of State Science Supervisors (CSSS) are constantly receiving questions from teachers and administrators about safety issues, responsibilities, and liability. This document, which addresses ten of the most commonly asked questions, is one response to those inquiries.

The goal of this document is to provide a handy, concise reference for science teachers, primarily at the secondary (9–12) level. They can refer to it for information and resources on some of the most commonly asked questions that concern science teachers. Resources cited are in paper, electronic, and Internet accessible forms. It should be clear that this document cannot be comprehensive because of limitations of the format and purpose. It is hoped that the most important information needed about the topics is incorporated. No implication of endorsement or lack of endorsement should be read into inclusion or omission of any referenced material within this document. For more information about specific questions in the document as they pertain to a particular locale or state, contact your local or state fire marshal, building commission, health department/poison control center, environmental regulatory and state Occupational Safety and Health Administration (OSHA) agency, or science specialist at the local or state board of education/education agency.

The Council of State Science Supervisors, an organization of state science supervisors/specialists throughout the United States, has a long history of working with other science education organizations and professional groups to improve science education. For more information about CSSS and its membership, direct your browser to http://csss.enc.org.

Members of the CSSS Safety Committee who developed this document are:

Christina Castillo-Comer, Texas Education Agency

Bob Davis, Secondary Science Specialist, Alabama Department of Education (Chair)

Bill Fulton, Science Specialist, Arkansas Department of Education

Linda Sinclair, Science Consultant, South Carolina Department of Education

Brenda West, West Virginia Department of Education

Marsha Winegarner, Science Program Specialist, Florida Department of Education

The Chair of the CSSS Safety Committee wishes to thank Dr. Jack Gerlovich, Drake University, Des Moines, Iowa; Dr. Lee Summerlin, University of Alabama at Birmingham; Steve Weinberg, president of CSSS; and the staff of the American Chemical Society (ACS), Washington, D.C., for their review of the draft of the document and valuable comments and suggestions. Thanks are also due to the American Chemical Society, the Eisenhower National Clearinghouse (ENC), the National Aeronautics and Space Administration (NASA), the National Institutes of Health (NIH), and others who made the printing and distribution of this document to teachers across the country possible at no charge.

What are my legal responsibilities as a science teacher relating to negligence?

The LEGAL DEFINITION of "negligence" is important for every teacher to know. Negligence, as defined by the courts today, is conduct that falls below a standard of care established by law or profession to protect others from an unreasonable risk of harm, or the failure to exercise due care. It should be noted that in the absence of specific laws or local policies, the standard of care expected is set by the profession, e.g., position statements adopted by the National Science Teachers Association (NSTA), the National Association of Biology Teachers (NABT), the American Chemical Society (ACS), or the Council of State Science Supervisors (CSSS).

The science teacher has three basic duties relating to the modern concept of negligence:

- Duty of instruction.
- Duty of supervision.
- Duty to properly maintain facilities and equipment.

Failure to perform any duty may result in a finding that a teacher and/or administrator within a school system is/are liable for damages and a judgment and award against him/them.

DUTY OF INSTRUCTION includes adequate instruction before a laboratory activity (preferably in writing) that:

- Is accurate; is appropriate to the situation, setting, and maturity of the audience; and addresses reasonably foreseeable dangers.
- Identifies and clarifies any specific risk involved, explains proper procedures/techniques to be used, and presents comments concerning appropriate/inappropriate conduct in the lab.

Instruction must follow professional and district guidelines.

Teachers who set bad examples by not following proper laboratory procedures may be sued if injury results from students following the teacher's bad examples.

DUTY OF SUPERVISION includes adequate supervision as defined by professional, legal, and district guidelines to ensure students behave properly in light of any foreseeable dangers. Points to remember:

- Misbehavior of any type must not be tolerated.
- Failure to act or improper action is grounds for liability.
- The greater the degree of danger, the higher the level of supervision should be.
- The younger the age of students or the greater the degree of inclusion of special population students, the greater the level of supervision should be.
- Students must never be left unattended, except in an emergency where the potential harm is greater than the perceived risk to students. Even then, risk should be minimized or responsibility transferred to another authorized person if the situation allows.

DUTY OF MAINTENANCE includes ensuring a safe environment for students and teachers. This requires that the teacher:

- Never use defective equipment for any reason.
- File written reports for maintenance/correction of hazardous conditions or defective equipment with responsible administrators.
- Establish regular inspection schedules and procedures for checking safety and first-aid equipment.
- Follow all safety guidelines concerning proper labeling, storage, and disposal of chemicals.

By keeping files of all hazard notifications and maintenance inspections, teacher liability in the event of an accident is minimized in cases where no corrective actions were subsequently made.

Where can I find a general science-safety checklist?

The following Internet sites and software are excellent sources for information concerning science safety:

- Flinn Scientific
  http://www.flinnsci.com/
- Sargent-Welch
  http://www.sargentwelch.com/html/safety-ck.html
- Wellesley College
  http://www.wellesley.edu/ScienceCenter/lab-safe-home.html
- Gerlovich, Jack A., et al. Total Science Safety System Software. JaKel, Inc., 1998. JaKel, Inc. Online Information Site: http://www.netins.net/showcase/jakel
- Kaufman, Jim. The Laboratory Safety Institute. Online Information Site: http://www.labsafety.org

Here is a general science-safety checklist to copy and use.

- Have appropriate protective equipment, e.g., American National Standards Institute (ANSI) Z87 or Z87.1 coded goggles, chemical aprons, non-allergenic gloves, dust masks, eyewash, shower(s), ABC fire extinguisher(s), sand bucket(s), fire blanket(s), in easily accessible locations. (General rule is accessibility within 15 seconds or 30 steps from any location in the room.) Make certain that instructor and students wear adequate protective equipment, including especially safety goggles and aprons, when experiments involving hazardous chemicals or procedures are conducted.
- Notify supervisors immediately of hazardous or potentially hazardous conditions, such as lack of Ground-Fault Interrupters (GFIs) near sinks, inadequate ventilation, or potential hazards, e.g., study halls scheduled in laboratories or tile floors not waxed with non-skid wax.
- Check the fume hood regularly for efficiency and never use the hood as a storage area. Ensure that the hood is vented properly through the roof.
- Use only equipment in good condition (not broken) and efficient working order.
- Have a goggle sanitation plan for goggles used by multiple classes per day.
- Have separate disposal containers for broken glassware or flammables.
- Discuss and post emergency/escape and notification plans/numbers in each room/laboratory. Clearly mark fire exits, and keep exits (preferably two from laboratories) unobstructed.
- Have and enforce a safety contract with students and parents.
- Identify medical and allergy problems for each student to foresee potential hazards.
- Model, post, and enforce all safety procedures. Display safety posters.
- Keep laboratory uncluttered and locked when not in use or when a teacher is not present.
- Know district and state policies concerning administering first aid and have an adequately stocked first-aid kit accessible at all times.
- Know and follow district and state policies/guidelines for use of hazardous chemicals, live animals, and animal and plant specimens in the classroom/laboratory.
- Report all injuries, including animal scratches, bites, and allergic reactions, immediately to appropriate supervisors.
- Keep records on safety training and laboratory incidents.
- Provide the number of accessible lab stations having sufficient workspace (60 square feet or 5.6 square meters) workspace per student; 5 foot or 1.5 meters wide aisles and low lab table sections for wheelchair accessibility that can be supervised by the number of qualified teachers/aides present (maximum 24:1).
- Have master cut-off switches/valves within each laboratory (preferably in one secure location); know how to use them; and keep water, gas, and electricity turned off when not in use.

- Maintain up-to-date chemical and equipment inventories, including Material Safety Data Sheet (MSDS) files.
- Label equipment and chemicals adequately with respect to hazards and other needed information.
- Post the National Fire Protection Association (NFPA) "diamond" at all chemical storeroom entrances denoting the most hazardous chemical in each category within. Regularly send an updated copy of the inventory to the local fire department.
- Organize chemical storerooms properly. Arrange chemicals by National Institute for Occupational Safety and Health (NIOSH)/ Occupational Safety and Health Administration (OSHA) compatibility classes, with special storage available for oxidizers, non-flammable compressed gases, acids, and flammables.
- Store chemicals in appropriate places—e.g., below eye level, large containers no higher than 2 feet (.6 meters) above floor, acids in corrosives cabinets, and solvents in OSHA/NFPA approved flammables cabinets—with acids physically separated from bases and oxidizers physically separated from organics within secure, limited access, adequately ventilated storerooms. Chemical shelving should be wooden, with a front lip and without metal supports.
- Provide in a readily accessible location appropriate materials and procedures for clean-up of hazardous spills and accidents, e.g., aspirator or kit for mercury spills, vermiculite and baking soda for acids, and 10% Clorox bleach solution or 5% Lysol solution for body fluids, and appropriate procedures for disposal of chemo- and bio-hazardous materials.
- Prohibit the use of pathogens or any procedures or materials in any school laboratory above Biosafety Level 1 as outlined by Centers for Disease Control/National Institutes of Health protocols.
- Keep live animals and students adequately protected from one another.

How should I label and store chemicals?

A Material Safety Data Sheet (MSDS) should be kept on file and be easily accessible for ALL chemicals. MSDS sheets should be referenced for proper storage and for appropriate personal protective equipment (PPE). Refer to your school district and state policies for local storage requirements and mandates.

Labeling Chemicals

Include the following minimum essential information on chemical labels:

- Chemical manufacturer or supplier (including address and telephone number).
- Chemical name and/or trade name of the product (same as MSDS when applicable).
- Date received or date placed in the container.
- Strength of the chemical.
- Precautions to be observed in handling or mixing the chemical.
- Appropriate hazard symbol National Fire Protection Association (NFPA) rating.

Chemical Storage

Store chemicals according to the following minimum storage requirements:

- Separate storage area from the classroom area. Use appropriate warning symbols to mark storage areas.
- Make certain that storage area is properly ventilated.
- Make certain that fire door or adequate exits are provided.
- Provide appropriate fire extinguisher(s) or extinguishing systems.
- Make certain that storage shelves are securely attached to wall (each shelf with a front one-inch or 2.5 centimeters lip to prevent bottles from sliding off shelves).
- Separate inorganic chemicals from organic chemicals.
- Use a reputable guide, e.g., National Institute for Occupational Safety and Health/ Occupational Safety and Health Administration (NIOSH/OSHA), to help you properly separate incompatible chemical families.
- Do not store chemicals past the manufacturer's suggested shelf life.
- Make certain that chemicals are labeled and stored in appropriate containers.
- Store flammables and corrosives separately in appropriate cabinets.

How should I purchase new chemicals and dispose of old chemicals?

A purchasing policy should be developed by the school/district. Before purchasing a new chemical, review the Materials Safety Data Sheet (MSDS) that will provide important information on physical properties, toxicology, storage, and handling for the chemical.

Consider these factors BEFORE purchasing:

- Will amounts be used within 1–2 years?
- Can the chemical be stored properly?
- Is the facility properly designed to use the material safely?
- Can the chemical be easily disposed of and will it be disposed of as a hazardous waste?
- Does the facility have proper personal protective equipment (PPE)?
- Are facility personnel aware of any hazards associated with this product?
- Are facility personnel properly trained in the use and handling of the material?
- Does the budget allow for disposal of the chemical or by-products?

Disposal

The Environmental Protection Agency (EPA) and the American Chemical Society (ACS) list the following possible disposal methods:

- Sanitary landfills.
- Hazardous waste landfills.
- Sewer system (regulations differ for different locations).
- Thermal treatment (incineration).
- Recycling or reuse.
- Chemical, physical, or biological treatments, including neutralization, oxidation, precipitation, and solidification.

For safe disposal of materials, consult the appropriate MSDS sheet. If an MSDS is not available, request one from the manufacturer or obtain one online at http://www.msdsonline.com. Disposing of wastes in landfills is not environmentally recommended; reducing wastes, recycling, and destruction are preferable.

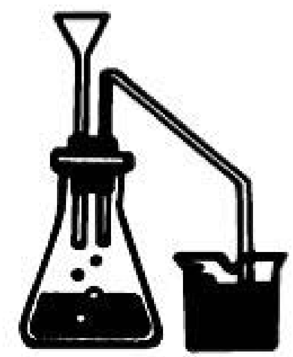
If you are not sure if a waste is hazardous, contact a local/state hazardous waste management agency or your state or regional EPA office, fire marshal's office, or state department of education.

What should a chemical hygiene checklist for school science labs include?

Most states and the Occupational Safety and Hazard Administration (OSHA) require work environments, including schools, to have a safety plan that reduces risks and ensures a safe workplace for employees (OSHA Laboratory Standard—29 CFR 1910.1450). This is referred to as the Chemical Hygiene Plan (CHP) and includes policies, procedures, and responsibilities designed to develop an awareness of potentially harmful chemicals in the workplace. It is important that laboratory chemicals be used only with knowledge of possible risks involved and within acceptable limits of exposure. The CHP must stress that everyone in the school has the right to know what hazards he or she will be exposed to and is responsible for implementing safety procedures and policies. Immediate supervisors have the responsibility to provide continuing education on safety guidelines and procedures to those under their direction. The CHP should be reviewed at least annually and revised as needed.

The science department chairperson or the chemistry teacher is usually responsible for developing the CHP for the school and may share this task with the facility supervisor. Since care and supervision of the science room are primarily the responsibilities of the classroom teacher, the CHP should serve as a guide to safe science instruction. Teacher responsibilities include:

- Development of a statement that includes clearly defined responsibilities of the superintendent, principals, department chairs, classroom teachers, students, and parents.
- Inclusion of a laboratory safety program as part of the curriculum and instruction.
- Regular training for all staff on safety policies, record keeping, and other procedures.
- Evaluation of laboratory facilities and procurement of equipment needed.
- Development and enforcement of a plan for monitoring safety equipment and storage areas.
- Preparation and storage of safety records, i.e., inventories, Materials Safety Data Sheets (MSDS), accident/incident reports, hazard notification reports.
- Identification of hazardous chemicals and minimizing exposure to students and teachers, e.g., computerized/written inventory.
- Development of safety policies and procedures for procurement, distribution, storage, and disposal of chemicals, e.g., using MSDS file.
- Development of a written emergency plan and practiced procedures for spills or accidents involving chemicals.
- Implementation of a plan for posting signs and labels.



What general guidelines should I follow in case of student accidents?

In the event of accident, teachers should act promptly and decisively, following a pre-existing, approved local emergency plan that has been previously practiced! This plan might include the following general steps:

- Check the scene, assess the general situation, and take whatever immediate action is necessary to remove the hazard and prevent students from being further exposed to injury.
- Check the injured party with a quick scan to assess the severity of the injury and decide on a course of action.
- Notify school authorities (school principal and school nurse) and call 911 or other predetermined emergency or medical personnel, if injury appears to make that necessary.
- Have a properly trained person appropriately care for the injured party.
- Ensure that a parent, guardian, or designated alternate person and/or the family physician have been contacted.
- After the emergency has passed, record the facts and obtain witness reports. Provide copies of records (accident reporting forms) to an administrator and keep records on file in a safe place.

The following actions are recommended for specific emergencies. Remember, you must assess the situation and determine what is appropriate to the immediate situation. Always refer to the appropriate Material Safety Data Sheet (MSDS) for information regarding health hazards, reactivity, disposal, and personal protective equipment before using a chemical for personal or class use.

Chemical in the Eye:

Call 911 and send someone to notify the school nurse and an administrator. Flush the eye immediately with potable, aerated 60°F–90°F (15.5°–32.2°C) water at a rate of 3–5 gallons/minute (11.4–18.9 liters/minute). Hold eyelids apart as wide as possible and flush for at least 15 minutes or until emergency personnel arrive. Do NOT try to neutralize acids or bases, but wash the offending chemical out of the eye as quickly as possible to prevent further damage. If contact lenses are being worn, the water should wash them away. If the lens chemically adheres to the eye, do NOT try to remove it. Let a professional do that.

Student or Chemical/Material on Fire:

Remember a panicky student on fire will probably not be cooperative! You may need assistance from other students or faculty. If you are near an emergency shower, obtain assistance in getting the student under the drench shower and douse flames with water. If not near an emergency shower, drop and roll the student and smother the flames with a retardant-treated wool fire blanket. (Never wrap a standing student in the blanket, because this creates a "chimney" effect.)

For materials on fire, obtain the nearest ABC fire extinguisher, remove safety pin, and approach the fire. Only when 5–6 feet (1.5–1.8 meters) from the fire should you begin to discharge the extinguisher. Remember, the average fire extinguisher only operates 8–10 seconds at maximum efficiency. Take care to smother, not scatter, the burning chemical material.

Smother burning alkali metals with clean, dry sand. Keep a covered sand bucket for that purpose.

Acid/Base Spills:

Neutralize spilled acids with powdered sodium hydrogen carbonate (sodium bicarbonate/baking soda) and bases with vinegar (5% acetic acid solution). Avoid breathing vapors. Spread diatomaceous earth to absorb neutralized chemicals, sweep up, and dispose of properly.

If the spill is directly on skin, flush the area as soon as possible with copious amounts of cold water from faucet or drench shower for at least 5 minutes. If the spill is on clothing, drench with water and cut/remove the clothing to remove the chemical from contact with the skin as soon as possible. If the skin appears acid-burned, daub a paste of sodium hydrogen carbonate on the affected area and obtain medical attention as soon as possible. If the skin appears burned by a strong base, daub vinegar on the affected area and obtain medical attention as soon as possible. Do NOT cover with bandages.

Release of Body Fluids, Pathogenic Bacteria, or DNA Samples:

For cleanup of body fluids, pathogenic bacteria, or spilled DNA samples, it is imperative that gloves be worn during the cleanup. A diluted disinfectant, such as 5% Lysol, Zephiran, Wescodyne, or similar disinfectant or 10% Clorox bleach solution should be poured on the spill and worked toward the center with paper towels. The paper towels should be disposed of in biohazard bags. Contaminated glassware should be sterilized in an autoclave for at least 30 minutes at 15 p.s.i. and temperatures above 248°F (120°C).

Mercury Spills:

Retrieve mercury with an aspirator bulb or mercury vacuum device. Cover droplets with sulfur to reduce volatility.

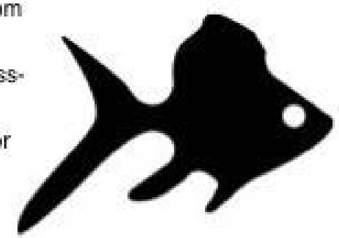
What precautions should I take when using animals or plants in the laboratory?

Animals:

Before using animals, teachers should establish guidelines to avoid any intentional or unintentional abuse, mistreatment, or neglect of animals and to promote humane care and proper animal husbandry practices. Whenever animals are to be used in science activities with students, it is imperative that care be exercised to protect both the animals and the students. If animals are to be kept for any time in the room in cages, be certain that adequately sized and clean cages are provided to all animals. Keep cages locked and in safe, comfortable settings.

Animals can stimulate and enhance learning and should be used safely in the laboratory/classroom. Because increased activity and sudden movements can make animals feel threatened, ALL student contact with animals should be highly organized and supervised. Teachers should keep the following precautions in mind to ensure an enjoyable and comfortable experience for their students.

- Inquire beforehand about student allergies associated with animals.
- Allow students to handle/touch animals only after proper directions and demonstrations have been given.
- Have students use gloves while handling vertebrates and appropriate invertebrates and wash hands afterward.
- Report to the principal and school nurse immediately any animal bites or scratches.
- Have a veterinarian evaluate all animals that die unexpectedly.
- Never dispose of fecal matter in sinks or with commonly used equipment.
- Never use wild animals. Obtain classroom animals from reputable pet suppliers.
- Never use poisonous animals in the classroom.
- Never allow students to tease animals or touch animals to their mouths.



Plants:

While plants produce the oxygen necessary for animal life, provide us with food, and beautify our surroundings, some produce very toxic substances. Teachers should familiarize themselves thoroughly with any plants they plan to use in the classroom.

- Inquire beforehand about student allergies associated with plants.
- Never use poisonous or allergy-causing plants in the classroom.
- Never burn plants that might contain allergy-causing oils, e.g., poison ivy.
- Make a clear distinction between edible and non-edible plants.
- Never allow plants to be tasted without clear direction from the teacher.
- Have students use gloves while handling plants and wash hands afterward.

What protective equipment should be kept/provided in a laboratory for teacher and student use?

The following list is excerpted from Total Science Safety System software (JaKel, Inc., 1998), with the approval of the authors.

- Master shut-off valves/switches should be located within each laboratory, preferably in one secure location accessible only to the instructor. Water, gas, and electricity should be turned off when not in use.
- Adequate numbers of tri-class ABC fire extinguishers should be strategically placed within 30 steps or 15 seconds of any location in the room. These should be checked and certified as fully charged and in working order at least every six months.
- Multiple faucet-type portable eyewash stations should be strategically placed within 30 steps or 15 seconds of any location in the room. Eyewash stations should be forearm or foot-operated for hand-free operation. Flow rate of potable water at 1.5 gallons/minute (5.7 liters/minute) at pressure below 25 p.s.i. is recommended if a standard eyewash unit is installed.
- Forearm or foot-operated face/body sprayers, with adequate flexible hoses and water pressure, should be strategically placed within 30 steps or 15 seconds of any location in the room. If a standard plumbed safety shower unit is used, it should provide potable water at a flow rate of 30–60 gallons/minute (113.6–227.2 liters/minute) at a pressure of 20–50 p.s.i.
- An appropriate fume hood, vented through the roof to at least 8 feet (2.4 meters) above the roof line, should have a face velocity of 60–100 feet/minute (18.3–30.5 meters/minute) of air through the hood. The hood should not be within 10 feet (3.1 meters) of an exit or on a main aisle.
- All electrical outlets within 5 feet (1.5 meters) of sinks and serving delicate electrical equipment should be fitted with Ground-Fault Interrupters (GFI). Where thunderstorm activity is a regular meteorological phenomenon, it is essential that outlets be equipped with GFIs. Outlets should be capped when not in use and placed along walls or counters at intervals of 6–8 feet (1.8–2.4 meters).
- Retardant-treated wool fire blankets, free of friable asbestos, should be prominently labeled and strategically placed within 30 steps or 15 seconds of any location in the room.
- A bucket of dry, organics-free sand should be available for alkali metals fires.
- American National Standards Institute (ANSI) coded Z87 or Z87.1 approved safety goggles should be provided for each student when there is danger of chemical or projectile hazard. Specially marked, non-vented goggles should be available for contact lens wearers.
- Sanitizing and/or sterilizing equipment or materials, e.g., ultraviolet cabinets or alcohol swabs, should be available and used between classes to clean safety cover goggles.
- Non-absorbent, chemical-resistant aprons should be provided for each student during laboratory activities where there is a danger of spillage or spattering of chemicals or hot liquids.
- Heavy-gauge metal storage cans with an internal flame arrester (heat sump) should be used for storage and dispensing of flammable chemicals by the teacher only.
- Separate corrosives (primarily for acids) and Occupational Safety and Health Administration/National Fire Protection Association (OSHA/NFPA) approved flammables cabinets (primarily for alcohols and solvents) should be secured in the storeroom.
- A container should be provided and clearly marked for the disposal of broken glass only.
- Containers of diatomaceous earth should be kept available for general chemical spills. Vinegar and sodium hydrogen carbonate (sodium bicarbonate/baking soda) are needed for neutralization of bases and acids respectively. An aspirator and a mercury spill kit should be available for mercury spills. Disinfectants and 10% Clorox bleach solutions should be used to sterilize equipment and wash down counter tops.
- An adequately stocked first-aid kit for teacher use should be easily accessible in an emergency.
- Safety posters should be prominently displayed in the room.
- Emergency procedures and telephone numbers should be prominently posted in the room.

Where should I look for general information on federal safety mandates with which my school system is expected to comply?

The following is a list of federal agencies and their most applicable regulations concerning safety in schools. This list is not to be considered comprehensive. Many of the regulations cited and any recent updates/changes can be found on the Internet at the agency's web address, e.g., www.osha.gov or www.epa.gov.

- Asbestos Hazard Emergency Response Act (AHERA) – Environmental Protection Agency (EPA)
- Code of Federal Regulations (CFR), Appendix C, Part 20, Title 10, United States Nuclear Regulatory Commission (NRC) exempt quantities
- CFR, Part 29 (pertinent sections), Occupational Safety and Health Administration (OSHA) Standards:
  - 1910. General Workplace Standards
  - 1910.Subpart Z Exposure Standards
  - 1910.133 Eyewear Standards
  - 1910.134 Respirator Standard
  - 1910.1028 Benzene Standard
  - 1910.1030 Bloodborne Pathogens Standards
  - 1910.1048 Formaldehyde Standard
  - 1910.1200 Hazardous Communication Standard
  - 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories
  - 1910.20 Access to Employee Exposure and Medical Records
- Resource Conservation and Recovery Act (RCRA) – EPA
- Title III Emergency Planning and Right-to-Know Sections 301-304, 311-313 – EPA
- Title IV – Superfund Amendments and Reauthorization Act (SERA) (indoor air quality) – EPA
- Toxic Substances Control Act (indoor air quality) – EPA

Are there recommended checklists covering the physical layout/specifications of science labs?

Several publications cited in the References contain checklists or information that could easily be used by those wanting to renovate or build new science labs. Much of what is cited below is excerpted from Total Science Safety System software (JaKel, Inc., 1998) with approval of the authors. This is NOT an exhaustive checklist and is only intended to address the secondary (9–12) science laboratory.

- The room should not be overcrowded, with 45–60 square feet (4.2–5.6 square meters) of working space/student, depending upon the type of activities to be performed. It should be designed for no more than 24 students/teacher.
- There should be no less than 6 linear feet (1.8 meters) of workspace per student in the classroom/laboratory.
- In order to meet Americans with Disabilities Act (ADA) requirements for handicapped and disabled students, there should be at least an additional 20 square feet (1.9 square meters) of working space per student.
- Approximately 15 square feet (1.4 square meters) per computer station, 10 square feet (.9 square meters) for a TV with VCR or laser disc player, and 12 square feet (1.1 square meters) for a projector should be added to total lab area to accommodate minimum technological equipment.
- The room should have no blind spots where students cannot be observed and supervised.
- General light level should be between 538.2–1076.4 lumens per square meter with diffuse lighting preferred.
- Aisle width should be adequate (4–5 feet or 1.2–1.5 meters) to accommodate handicapped students and equipment needs.
- The room should have two exits, both opening outward and at least 5 feet wide (1.5 meters) to accommodate handicapped students and facilitate equipment carts and emergency exit. Doors should have reinforced glass viewing windows or peepholes.
- During labs, air in the room should be regularly recycled and mixed with outside air at a rate of 4–12 complete laboratory air changes per hour, depending on the chemicals used.
- The exhaust ventilation system should be separate from that of the chemical fume hood and should meet the American National Standards Institute (ANSI) Z9.5 Standard.
- For high school labs where chemicals of low to moderate toxicity are used, at least one functioning exhaust hood (portable or permanent) that meets American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 110 testing standard, with a face velocity of approximately 80–120 linear feet/minute (24.4–36.6 meters/minute), should be provided. Exhaust should be vented to the outside through the roof or outside wall. A common through-the-wall hood may serve the laboratory and preparation room. Exhaust hood(s) should be located away (10 feet or 3.1 meters) from entrances/exits, windows, intake ducts, and high traffic areas.
- There should be a telephone or an intercom available for notifying the office and others of emergencies.
- Tile floors should be covered with a nonskid wax.
- There should be lockable storage for certain items. Emergency/master shut-off controls for water, gas, and electricity should be in a securable location near the teacher's station.
- There should be sufficient electrical outlets located at intervals of 6–8 feet (1.8–2.4 meters) that make extension cords unnecessary. They should be capped when not in use. Those outlets within 5 feet (1.5 meters) of water should be equipped with Ground-Fault Interrupters (GFIs).
- Goose-necked faucets should be used on sinks to allow attachment of portable eyewashes and shower hoses.
- Lab surfaces should be made of material unaffected by acids, alkalis, solvents, and temperate heat.

REFERENCES

The following is a list of general references. It should be obvious that it is not exhaustive. The references provided are for those interested in obtaining additional information from primary sources. A much more exhaustive listing of references and resources can be found in two excellent state documents: Guidebook for Science Safety in Illinois, available from the Illinois State Center for Educational Innovation and Reform (contact Illinois State Board of Education) and Maryland Science Safety Manual, K-12, available from the Maryland Science Supervisors Association (contact the Maryland State Department of Education). No implication of endorsement or lack of endorsement should be read into inclusion or omission of any referenced material within this document.

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American Association of Law Librarians: http://www.aallnet.org/aallnetweb.html

American Chemical Society: http://www.acs.org

Centers for Disease Control: http://www.cdc.gov

Council of State Science Supervisors: http://csss.enc.org

Eisenhower National Clearinghouse: http://www.enc.org

Environmental Protection Agency: http://www.epa.gov

Flinn Scientific: http://www.flinnsci.com/

Howard Hughes Medical Institute. Online Information Site: http://www.practicingsafescience.org and http://www.hhmi.org/science/labsafe/lcss/

Humane Society of the United States: http://www.hsus.org/programs/research/animals_education.html

JaKel, Inc. Online Information Site: http://www.netins.net/showcase/jakel

Kansas City Hazardous Waste Program: http://www.metrokc.gov/hazwaste/rehab/

Laboratory Safety Institute. Online Information Site: http://www.labsafety.org

MSDS Online: http://www.msdsonline.com

National Association of Biology Teachers: http://www.nabt.org

National Fire Protection Association: http://www.nfpa.org

National Institutes of Health: http://www.nih.gov/od/ors/

OSHA Laboratory Standard - 29 CFR 1910.1450: http://www.osha.gov

Sargent-Welch: http://www.sargentwelch.com/html/safetyck.html

University of Virginia: http://keats.admin.virginia.edu/

VWR Scientific: http://www.vwrsp.com/search/index.cgi?tmpl=msds

Wellesley College: http://www.wellesley.edu/ScienceCenter/lab-safe-home.html

Please note: Some of the above-noted Web sites have moved or are no longer available.
Please refer to the source, **csss.enc.org/safetym**, for updates as they are issued.

Council of State Science Supervisors
http://csss.enc.org

American Chemical Society
http://www.acs.org

Eisenhower National Clearinghouse
http://www.enc.org

National Aeronautics and Space Administration
http://education.nasa.gov

National Institutes of Health
http://science-education.nih.gov

For additional copies of this publication, contact your state science consultant/supervisor.

Web Sites

All Web sites are current to June 2005, but are subject to change by their host. As a courtesy, please refer to the source if you use information from any of the links provided in this resource.

Biodiesel Information

The following links will provide you with biodiesel information that is downloadable onto a computer and easily printed out for distribution. These files open in Adobe™ Reader, which is available free online at adobe.com.

biodiesel.org/pdf_files/kids_sheet.pdf
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biodiesel.org/pdf_files/CommonlyAsked.pdf
biodiesel.org/pdf_files/bdreport.pdf
biodiesel.org/pdf_files/Energy_Security0604.pdf

Enviro-logs

This URL provides the background for a genuinely environment-friendly firelog product.

enviro-log.net/features.htm

Ethanol Resources

ilcorn.org/Education/Ethanol_Fastback/ethanol_fastback.html
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ncga.com/03world/main/
usda.gov/nass/nasskids/nasskids.htm
ca.uky.edu/agripedia/

Forest Biomass

psnh.com/Energy/EnergyProject/pdfs/NWPPBrochure.pdf *Web page of a New Hampshire utility that recently made the decision to convert a coal plant to biomass with the ratification behind their decision.*

natural-resources.ncsu.edu/wps/wp/fps/BENNETT.pdf *PowerPoint presentation by Wade Bennett with the Craven Wood Energy project in New Bern, NC.*

nrel.gov/biomass/ *National Renewable Energy Laboratory's site on biomass with information about the latest research.*

fpl.fs.fed.us/documnts/techline/wood_biomass_for_energy.pdf *Overview document on the use of wood biomass for energy, published by the Forest Products Laboratory.*

fpl.fs.fed.us/ *Home page for the Forest Products Laboratory with documents for biomass-related information and publications.*

Web Sites, Cont'd...

serbep.org/ *Regional information about biomass efforts in the Southeast.*
eere.energy.gov/biopower/main.html *US Department of Energy site provides basic information on the benefits of biomass for energy.*
bioproducts-bioenergy.gov/default.asp *Information about the political side of implementing biomass projects.*
ars.usda.gov/bbcc/index.htm *US Department of Agriculture site describes basic information on biomass projects.*
srsfia2.fs.fed.us/ *USDA Forest Service site with up-to-date information on South Carolina's forest resources. Part of the site is interactive — query the database for specific information.*
state.sc.us/forest/fia2000.pdf *The latest report on the status of South Carolina's forest resources.*
state.sc.us/forest/ *Home page for the SC Forestry Commission provides information on various programs.*

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