TRANSPORTATION FUELS: BIODIESEL

TRANSPORTATION FUELS

Information and activities to teach students about biodiesel as a transportation fuel.

GRADE LEVEL
4–12

SUBJECT AREAS
Science
Social Studies
Math
Language Arts
Technology

NEED
2008-2009
Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

Teacher Advisory Board Vision Statement

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

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Correlations to National Science Standards

(Bolded standards are emphasized in the unit.)

PRIMARY (K–4) STANDARD D: EARTH AND SPACE SCIENCE

1. Properties of Earth Materials

a. Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways; for example, as building materials, as sources of fuel, or for growing the plants we use as food.

b. Earth materials provide many of the resources that humans use.

PRIMARY–F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

3. Types of Resources

a. Resources are things that we get from the living and nonliving environment to meet the needs and wants of a population.

b. Some resources are basic materials, such as air, water, and soil; some are produced from basic resources, such as food, fuel, and building materials; and some resources are nonmaterial, such as quiet places, beauty, security, and safety.

c. The supply of many resources is limited. If used, resources can be extended through recycling and decreased use.

4. Changes in Environments

a. Environments are the space, conditions, and factors that affect an individual's and a population's ability to survive and their quality of life.

b. Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad.

c. Pollution is a change in the environment that can influence the health, survival, or activities of organisms, including humans.

5. Science and Technology in Local Challenges

a. People keep inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people.

b. Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication. These benefits of science and technology are not available to all of the people in the world.

INTERMEDIATE (5–8) STANDARD E: SCIENCE AND TECHNOLOGY

2. Understandings about Science and Technology

c. Technological solutions are temporary and have side effects. Technologies cost, carry risks, and have benefits.

f. Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Risk is part of living in a highly technological world. Reducing risk often results in new technology.

INTERMEDIATE–F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

3. Natural Hazards

b. Human activities can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal.

c. Hazards can present personal and societal challenges because misidentifying the change or incorrectly estimating the rate and scale of change may result in either too little attention and significant human costs or too much cost for unneeded preventive measures.

INTERMEDIATE–F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

4. Risks and Benefits

b. Students should understand the risks associated with natural hazards, chemical hazards, biological hazards, social hazards, and personal hazards.

c. Students can use a systematic approach to thinking critically about risks and benefits.

d. Important personal and social decisions are made based on perceptions of benefits and risks.

5. Science and Technology in Society

c. Technology influences society through its products and processes. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.

d. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies.

e. Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

SECONDARY (9–12) STANDARD F: SCIENCE IN PERSONAL & SOCIAL PERSPECTIVES

3. Natural Resources

a. Human populations use resources in the environment to maintain and improve their existence.

b. The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and depletes those resources that cannot be renewed.

c. Humans use many natural systems as resources. Natural systems have the capacity to reuse waste but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

4. Environmental Quality

c. Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth.

5. Natural and Human-induced Hazards

b. Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change.

d. Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards—ranging from those with minor risk to a few people to major catastrophes with major risk to many people.

6. Science and Technology in Local, National, and Global Challenges

b. Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology related challenges. However, understanding science alone will not resolve local, national, and global challenges.

Teacher Guide

TO TEACH STUDENTS ABOUT BIODIESEL AND ENCOURAGE THEM TO EVALUATE ITS ECONOMIC AND ENVIRONMENTAL ADVANTAGES AND DISADVANTAGES.

BACKGROUND

This booklet provides background information on biodiesel as a transportation fuel at three reading levels—elementary, intermediate, and secondary—with activities to reinforce knowledge and develop critical thinking and research skills.

CONCEPTS

- All transportation fuels have economic and environmental advantages and disadvantages.
- Economic and environmental impacts are determining factors in the transportation fuels used by fleets and individual consumers.

TIME

- Two to five class periods.

SKILL REINFORCEMENT

- Critical thinking
- Math & graph analysis
- Cooperative learning
- Cost/benefit analysis
- Comparison and contrast
- Evaluation of multiple factors
- Research and writing
- Presentation

MATERIALS & PREPARATION

- Familiarize yourself with the booklet and decide which grade level factsheet and activities you will use.
- Make copies of the appropriate factsheet(s) and worksheets for the students.
- If possible, arrange for an expert (someone who produces or uses biodiesel) to make a presentation to the class.
- Procure any additional materials the students will need to conduct the activities.
- Call NEED at 1-800-875-5029 for additional transportation fuels activity booklets if you need them: *Transportion Fuels: The Future is Today* (Secondary), *What Car Will You Drive?* (Intermediate), *Transportation Fuels Debate Game* (5-12), *Transportation Fuels Expo* (4-12), and *Transportation Fuels Rock Performances* (4-12).

PROCEDURE

DAY ONE: Introduction and Learning

- Introduce biodiesel to the class using the concepts on page 4. Distribute the factsheets and have the students read them and make a list of the important facts and any new vocabulary words. Discuss the main facts and the new words.
- Have the students complete the crossword puzzles and math worksheets to reinforce the new vocabulary and the information presented. Review as a group.

DAYS TWO–FIVE: Synthesis and Reinforcement

Use activities from the list below to reinforce biodiesel information.

SUGGESTED ACTIVITIES

ELEMENTARY

1. Biodiesel Presentation Day

   Group 1: Soybean Song - write and perform a song about the energy in soybeans.

   Group 2: Biodiesel Song - write and perform a song about the benefits of biodiesel.

   Group 3: Biodiesel Newscast - write and conduct interviews of a farmer, a biodiesel manufacturer, and a person who uses biodiesel fuel in his/her vehicle.

   Group 4: Make a poster of soybean products or states that produce soybeans or biodiesel.

   Group 5: Write a commercial to convince people to use biodiesel.

2. Have the students write letters to local fast food restaurants to find out what they do with their used oil and grease. Find out what the school cafeteria does with its used grease.
3. Have the students design brochures to teach their peers and parents about biodiesel.
4. Have the students explore the Environmental Protection Agency's Clean School Bus website at www.epa.gov/cleanschoolbus to learn more about biodiesel and state-specific information.

INTERMEDIATE/SECONDARY

1. Have the students conduct research to answer the following questions and produce Power Point presentations on the results of their research:

   How many vehicles does your school district have, what kind of vehicles are they, what fuels do they use? Are there plans to switch to alternative fuels?

   How many vehicles does your community (town, city, county) have, what kind of vehicles are they, what fuels do they use? Are there plans to switch to alternative fuels?

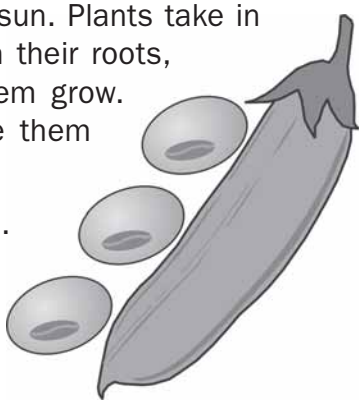
   What are the effects on the environment of diesel and biodiesel emissions?

   Where is biodiesel being used today? By how many fleets/vehicles?

   What states grow the most soybeans? How is soybean oil turned into biodiesel? What other feedstocks are used to make biodiesel?

2. Have the students produce Power Point presentations to convince a school district to use biodiesel.
3. Have the students design informational brochures on biodiesel to inform their peers, parents, and community about biodiesel.
4. Have the students conduct research and make their own biodiesel from vegetable oil.

ELEMENTARY: **What Can You Do With a Soybean?**



Soybeans, like all plants, are full of energy. They get their energy from the sun. Plants take in light energy from the sun and turn it into sugars. They store the sugars in their roots, leaves, stems, flowers, and seeds. The energy in the sugars makes them grow. When people or animals eat food made from soybeans, the sugars give them energy.

Soybeans belong to the **legume** family—plants that produce beans in pods. Legumes also take in **nitrogen** from the air and release it into the soil. Nitrogen is important for good soil and healthy crops. One soybean plant produces about 70 soybean pods with two-to-four beans in each pod. The seeds are about the size of peas and may be yellow, green, brown, black, or speckled.

Soybeans are native plants of Asia. Farmers in China have grown them for more than 5,000 years. They use soybeans for food, fertilizer, animal feed, medicines, and oils.

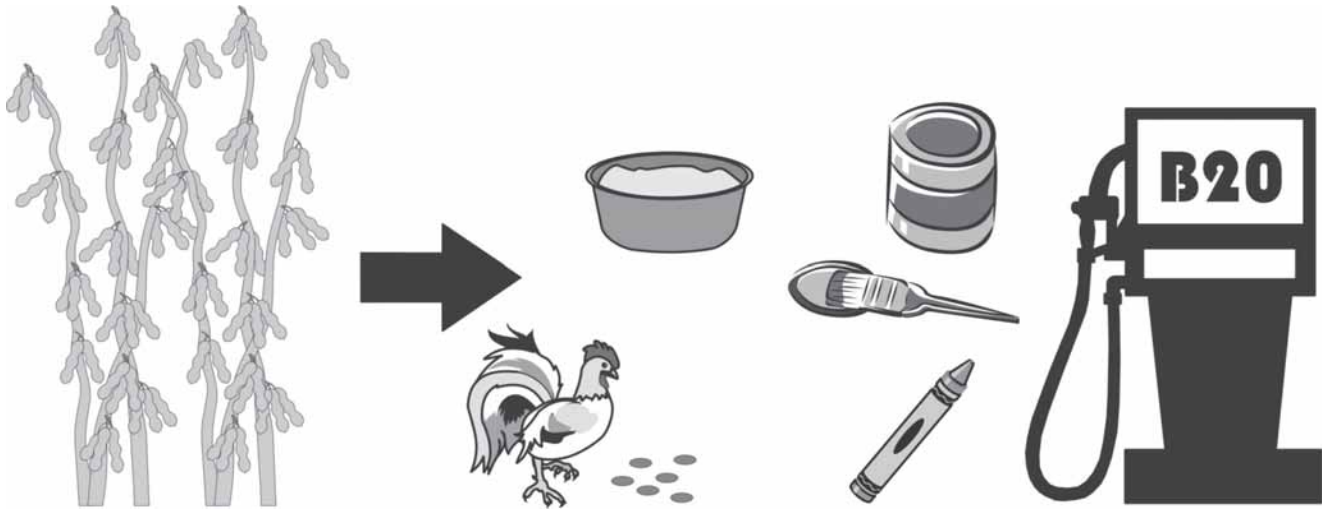
Soybeans were first grown in the United States in the early 1800s. They were used as a source of food for humans and farm animals. During the Civil War, coffee beans were hard to get. Soybeans were roasted and used to make a coffee substitute. They were called coffee berries.

In 1904, George Washington Carver began studying soybeans. He discovered that soybeans are a valuable source of oil, as well as protein. A 60-pound bushel of soybeans produces 48 pounds of soy protein, 11 pounds of soy oil, and one pound of **hulls** (the coatings of the beans). Henry Ford used soy oil to make plastic parts for his cars.

Farmers harvest the soybeans, which can be eaten fresh in their pods or dried and roasted. They can also be broken down into different forms. The beans are taken out of their pods by a machine called a combine. The beans are then sent to a processing plant where they are crushed, rolled into flakes, and mixed with a solvent to separate the oil and protein.

The oil and protein can be made into many kinds of animal and human foods, as well as products such as crayons, paint, glue, and plastics. The soybean oil can also be turned into a vehicle fuel called **biodiesel**.

Biodiesel can be blended (mixed) with regular diesel, which is a petroleum fuel. Many cities and school districts use a blend of 20 percent biodiesel and 80 percent diesel in their buses. This is called a **B20** blend. Using B20 reduces pollution from the buses, making the air cleaner.



ELEMENTARY: What is Biodiesel?

Most trucks, buses, boats, and tractors in the United States use **diesel** fuel. Diesel fuel is made from **petroleum**, a **nonrenewable** energy source. Petroleum is a fossil fuel; it takes millions of years to form under the ground, so we can't make more in a short time. We use so much petroleum in the U.S. that we have to buy two-thirds of it from other countries.

When petroleum fuels are burned in vehicle engines, they can pollute the air. If they spill onto the soil or into the water, they can damage the environment for a long time. Petroleum fuels are **toxic** and should be handled carefully.

Biodiesel is a fuel made from vegetable oils or animal fats. It is usually made from soybean oil, but it can also be made from corn oil or used restaurant grease and oil. If it is made from restaurant oil, it can smell like french fries. Since biodiesel is made from plant and animal oils, it is a **renewable** fuel. We can grow more plants in a short time to make more biodiesel.

Biodiesel works as well in engines as diesel fuel. In many ways, it is a better fuel, though it is more expensive. Burning biodiesel does not produce as much air pollution as burning petroleum fuels. This means the air is cleaner and healthier to breathe when biodiesel is used. Biodiesel is also **nontoxic**—it is not dangerous to people or the environment and is safe to handle. If biodiesel spills, it is **biodegradable**—it breaks down quickly into harmless substances.

Biodiesel can be used instead of diesel fuel or it can be mixed with diesel fuel. It is usually mixed with diesel fuel as two percent (B2), five percent (B5), or 20 percent (B20) biodiesel blends. Pure biodiesel is called B100. That means it is 100 percent biodiesel. The B stands for biodiesel and the number stands for the percent of biodiesel in the mixture or blend.

Most biodiesel used today is B20, which is 20 percent biodiesel and 80 percent diesel. Many school districts have begun using B20 in their school buses. In Arizona's Deer Valley Unified School District, school buses have driven more than four million miles using biodiesel. Everyone involved is pleased with the way the buses operate and believe using biodiesel improves the environment and the health of the students and drivers.

Many states, as well as the U.S. Army, Air Force and Department of Agriculture, are using biodiesel to run their buses, garbage trucks, snowplows, and other vehicles. These fleets have their own fueling stations. Biodiesel fuels are also becoming more available at public stations, as consumer demand grows.

The use of biodiesel fuels is growing every year. Farmers are growing more soybeans and other crops to meet the demand. Biodiesel is good for the country, the environment, and the economy.

Vehicles powered by biodiesel.

INTERMEDIATE: BIODIESEL—A Domestic, Renewable Fuel

What is Biodiesel?

Biodiesel is a fuel made from vegetable oils, animal fats, or greases, such as recycled restaurant grease. Most biodiesel today is made from soybean oil. Biodiesel is most often blended with petroleum diesel in ratios of two percent (B2), five percent (B5), or 20 percent (B20). It can also be used as pure biodiesel (B100). Biodiesel fuels can be used in regular diesel vehicles without making any changes to the engines. It can also be stored and transported using diesel tanks and equipment. It is the fastest growing alternative transportation fuel in the U.S.

Biodiesel contains no sulfur, so it can reduce sulfur levels in the nation's diesel fuel supply. If you remove the sulfur from petroleum-based diesel fuel, it loses its lubrication. Adding only one or two percent biodiesel can restore the lubricating properties of diesel fuel when the sulfur is removed. This is an important characteristic of biodiesel because the Environmental Protection Agency has issued a rule requiring that sulfur levels in diesel fuel be reduced 97 percent by 2006.

Biodiesel blends are slightly more sensitive to cold weather. The same cold weather precautions that are used for diesel should be used for biodiesel blends. In addition, biodiesel can act like a mild solvent. It can loosen and dissolve sediments in fuel storage tanks. For that reason, vehicles switching to biodiesel should have their fuel filters checked often in the first few months of biodiesel use and, in a small number of cases, replaced.

Biodiesel Consumers

Most trucks, buses, and tractors in the United States use diesel fuel. Diesel is made from petroleum, a nonrenewable energy source. Petroleum-based fuels can pollute the air. If they spill onto the soil or into the water, they can cause long-lasting damage to the environment. Petroleum-based fuels are also toxic—they are dangerous for people to handle.

Any vehicle that operates on diesel fuel can switch to biodiesel without changes to its engine. Many state fleets and school districts are switching to biodiesel blends to reduce emissions and improve air quality. In New Jersey, there are snowplows and public buses using B20. In San Jose, California, garbage trucks are running on B100. The U.S. Postal Service, the Department of Energy, and NASA are using biodiesel in some of their vehicles. Even the U.S. Army, Navy, Air Force, and Marines are using biodiesel in many of their vehicles.

All over the country, school districts are switching to biodiesel for their school buses to improve air quality and protect student and driver health. People with asthma are especially sensitive to exhaust fumes. School buses in St. Johns, Michigan, have recently begun using biodiesel and everyone involved is pleased with the results. The school district believes it is actually saving money, too.

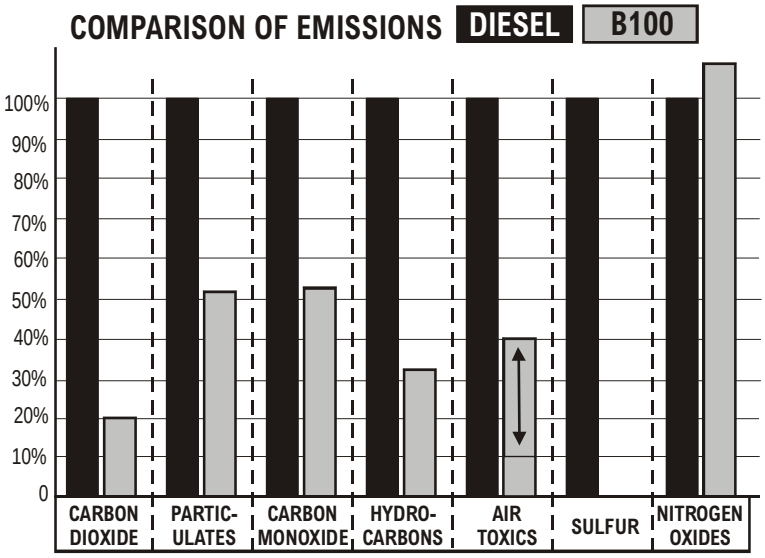
Characteristics of Biodiesel

Biodiesel blends provide vehicles with the same horsepower, acceleration, and fuel economy as diesel fuel. Biodiesel has a higher flashpoint, so it is safer—it won't catch fire as easily. The energy content of biodiesel is about 10 percent less than the same amount of diesel, so vehicles using B100 have a slightly lower range. Because biodiesel blends have very high lubricating qualities, many users report lower maintenance costs and increased mileage.

Environmental Impacts

Biodiesel is renewable, nontoxic, and biodegradable. Compared to diesel, biodiesel is significantly cleaner burning. It produces fewer air pollutants, less black smoke, and smells better, too.

Biodiesel is made from organic compounds and alcohol. It is no more toxic than table salt. It quickly degrades (breaks down) into natural organic residues if it is spilled. It is often used in boats to protect wildlife and fish hatcheries. In addition, people who use biodiesel find that their hands don't dry out and crack the way they do with diesel.



Distribution of Biodiesel

Today, distributors are making biodiesel fuels available across the entire United States and there are a growing number of public biodiesel stations. Since it is mainly available through bulk suppliers, biodiesel is at present more practical for fleets with their own fueling facilities. As consumers learn about biodiesel fuels and their benefits, the demand will grow.

Economics of Biodiesel

Today, B100 costs more than diesel; B20 costs 13–22 cents more per gallon. Because it is so clean burning and easy to use, biodiesel is the fastest growing and most cost efficient alternative fuel for fleet vehicles. Many states are planning to offer incentives to encourage the use of biodiesel blends to improve air quality.

Another benefit of biodiesel is its effect on agriculture. Expanding the use of biodiesel fuels will require more soybeans and other oilseed crops. Farmers will have a better market for their crops, and that will help keep the farm economy growing.

Today, the United States imports nearly two-thirds of the petroleum it uses. Biodiesel is a domestic fuel; using biodiesel can reduce the need to import foreign oil and promote national security.

Biodiesel ferry at Mammoth Cave, KY

Biodiesel bus used by National Park Service

SECONDARY: BIODIESEL—A Domestic, Renewable Fuel

What is Biodiesel?

Biodiesel is a fuel made by chemically reacting alcohol with vegetable oils, animal fats, or greases, such as recycled restaurant grease. Most biodiesel today is made from soybean oil. Biodiesel is most often blended with petroleum diesel in ratios of two percent (B2), five percent (B5), or 20 percent (B20). It can also be used as neat (pure) biodiesel (B100). Biodiesel fuels are compatible with and can be used in unmodified diesel engines with the existing fueling infrastructure. It is the fastest growing alternative transportation fuel in the U.S.

Biodiesel contains virtually no sulfur, so it can reduce sulfur levels in the nation's diesel fuel supply. Removing sulfur from petroleum-based diesel results in poor lubrication. Biodiesel is a superior lubricant and can restore the lubricity of diesel fuel in blends of only one or two percent. This is an important characteristic because the Environmental Protection Agency has issued a rule requiring that sulfur levels in diesel fuel be reduced 97 percent by 2006.

Biodiesel blends are slightly more sensitive to cold weather. The same precautions that are used for diesel should be used for biodiesel blends in cold weather operations. In addition, biodiesel can act like a mild solvent, loosening and dissolving sediments in fuel storage tanks. For that reason, vehicles switching to biodiesel blends should have their fuel filters checked often in the first few months of biodiesel use, and in a small number of cases, replaced. Switching to biodiesel blends produces no major compatibility issues.

Biodiesel Consumers

Most trucks, buses, and tractors in the United States use diesel fuel. Diesel is made from petroleum, a nonrenewable energy source. When petroleum-based fuels are burned in vehicle engines, they produce particulates, as well as toxic and ozone-forming emissions. If petroleum-based fuels spill onto the soil or into the water, they can cause long-lasting damage to the environment. Petroleum-based fuels are toxic and should be handled carefully.

Any vehicle that operates on diesel fuel can switch to B100 or a biodiesel blend without changes to its engine. Many state fleets and school districts are switching from diesel to biodiesel blends to reduce emissions and improve air quality. In New Jersey, there are snowplows and transit buses using B20. In San Jose, California, garbage trucks are running on B100. The U.S. Postal Service, the Department of Energy, and NASA are using biodiesel in some of their vehicles. Even the U.S. Army, Navy, Marines, and Air Force are using biodiesel in many of their non-combat vehicles.

All over the country, school districts are switching to biodiesel blends for their school buses to improve air quality and protect student and driver health. Ten support vehicles and 31 school buses in St. Johns, Michigan, recently began operating on B20. The school district has experienced very positive results and believes it actually reaps cost savings when lower maintenance costs are factored in.

Environmental Impacts

Biodiesel is renewable, nontoxic, and biodegradable. Compared to diesel, biodiesel (B100) reduces carbon dioxide emissions by 80 percent, sulfur oxide by 100 percent, particulates by 48 percent, carbon monoxide by 47 percent, unburned hydrocarbons by 67 percent, and air toxics by 60–90 percent. Emissions of nitrogen oxides, however, increase slightly (10 percent). Biodiesel blends generally reduce emissions in proportion to the percentage of biodiesel in the blend.

Biodiesel is made from organic compounds and alcohol; it is no more toxic than table salt. It quickly degrades into natural organic residues if it is spilled. It is often used in marine environments to reduce the impact on wildlife and fish hatcheries. In addition, people who use biodiesel find that their hands don't dry out and crack the way they do with diesel.

Characteristics of Biodiesel

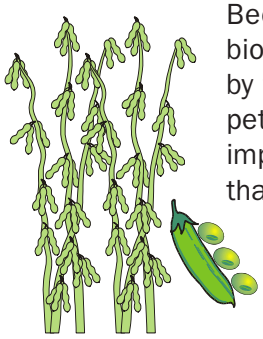
Biodiesel exceeds diesel in cetane number (performance rating of diesel fuel), resulting in superior ignition. Biodiesel has a higher flashpoint, making it more versatile where safety is concerned. Horsepower, acceleration, and torque are comparable to diesel. Lubricity is superior. Biodiesel has the highest Btu content of any alternative fuel, though it is slightly less than that of diesel. This might have a small impact on vehicle range.

Distribution of Biodiesel

Biodiesel is available throughout the United States, mainly through commercial fuel distributors. Currently there are relatively few public pumps that offer biodiesel; it is a more practical fuel for fleets with their own fueling facilities. Availability for consumers is steadily expanding as demand grows.

Economics of Biodiesel

Today, B100 costs between $1.00 and $3.00 a gallon, depending on purchase volume and delivery costs. Historically, biodiesel has cost about one cent per gallon more than diesel for every percent in the blend. B20, for example, a blend of 20 percent biodiesel and 80 percent diesel, has typically cost about 20 cents more per gallon. Federal and state policies have recently been enacted that reduce the cost of biodiesel to the consumer. On January 1, 2005, the Biodiesel Excise Tax Credit went into effect. Blenders of biodiesel receive tax credits for the biodiesel they blend with diesel, allowing them to make biodiesel fuel available at lower cost. Blenders can claim the tax credit on biodiesel in both taxable and non-taxable fuel.



Because it is stored in existing infrastructure and can fuel vehicles without modification, biodiesel has emerged as the fastest growing and lowest cost alternative fuel for fleets regulated by the Energy Policy Act (EPACT). The cost difference will continue to decrease due to projected petroleum price increases, new EPA rules requiring reduced sulfur in diesel, and production improvements in the biodiesel industry. In addition, many states are considering legislation that will encourage greater use of biodiesel fuels to improve air quality.

Another economic consideration is the agriculture industry. The expanded use of biodiesel in the nation's fleets will require the agriculture industry to substantially increase production of soybeans and other oilseed crops that can be used as feedstocks for biodiesel. Farmers will have new crops and markets to support economic stability.

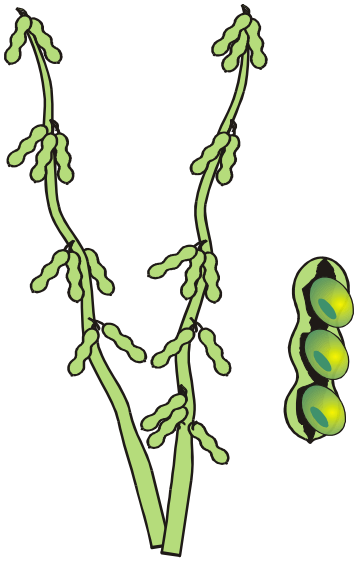
Today, the United States imports nearly two-thirds of the petroleum it consumes, contributing to a trade deficit. Biodiesel is an environmentally friendly, renewable, domestically produced fuel. The expanded use of biodiesel by fleets, as well as individual consumers, has the potential to reduce the importation of foreign oil and promote national security.

Biodiesel ferry at Mammoth Cave, KY

Biodiesel bus used by National Park Service

ELEMENTARY Biodiesel **MATH: Count the Soybeans**

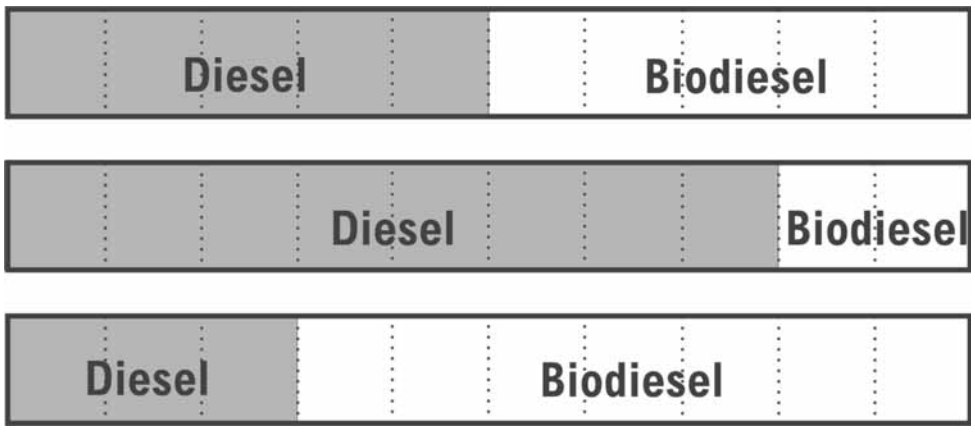
1. **A bushel of soybeans can be separated into the products shown below. How much does the bushel of soybeans weigh? Write your answer in the triangle.**



2. **If each pod on the soybean plant in the picture contains three soybeans, how many soybeans are on the plant?**

3. **If each pod on the left branch contains four soybeans and each pod on the right branch contains two soybeans, how many soybeans are on the plant?**

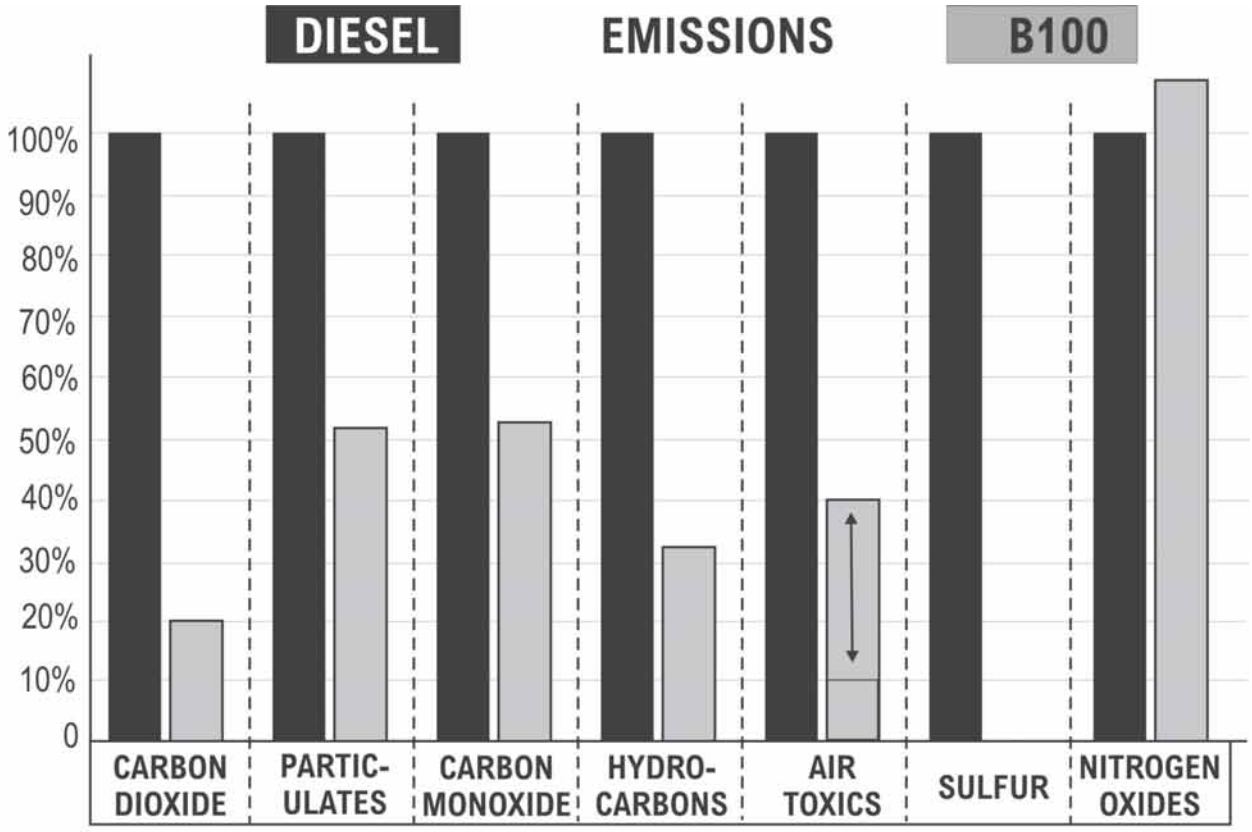
4. **B20 is a blend of 20 percent biodiesel and 80 percent diesel fuel. Circle the bar below that represents the B20 blend.**



INTERMEDIATE Biodiesel **MATH: Graphing Emissions**

DIRECTIONS: Graph 1 shows a comparison of emissions using diesel and B100. In Graph 2, fill in the biodiesel emissions for B20, assuming they are proportional to the percentage of biodiesel in the blend.

1



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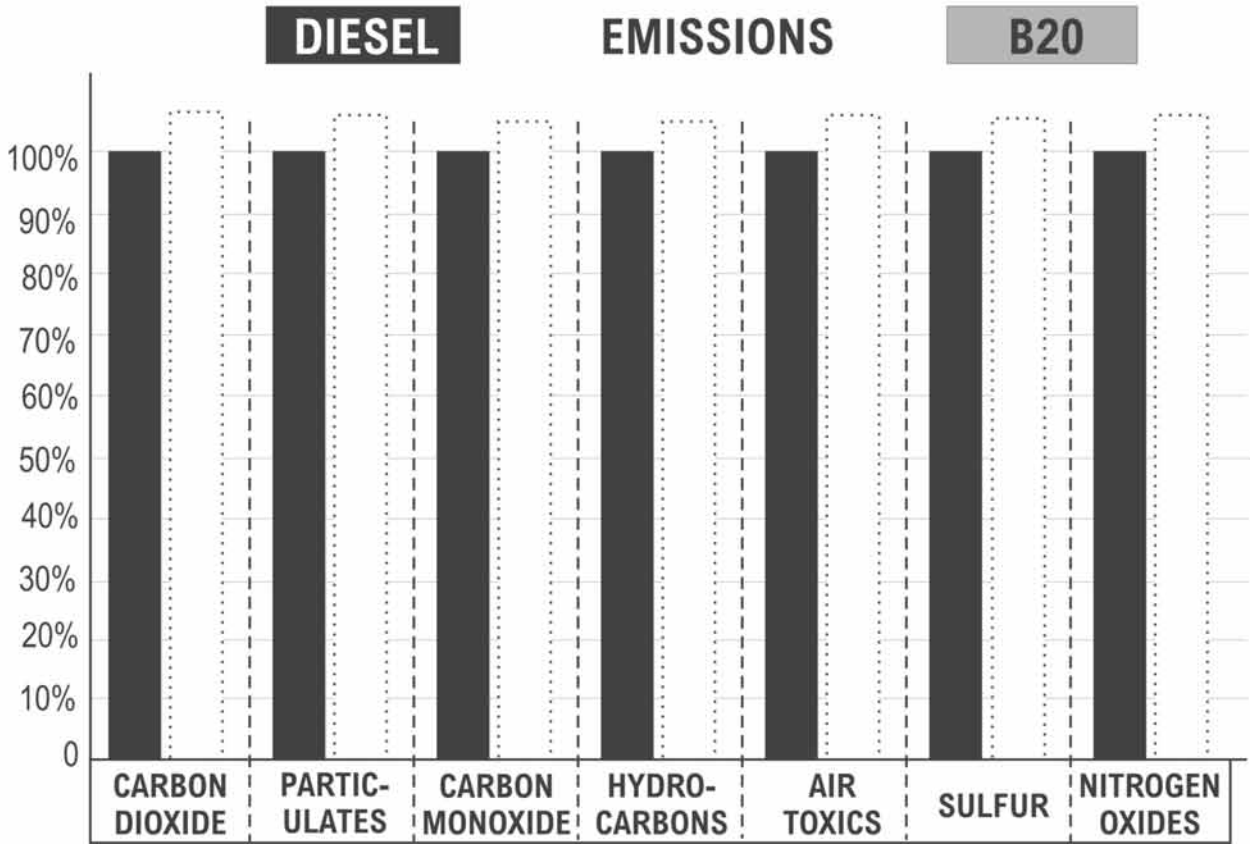
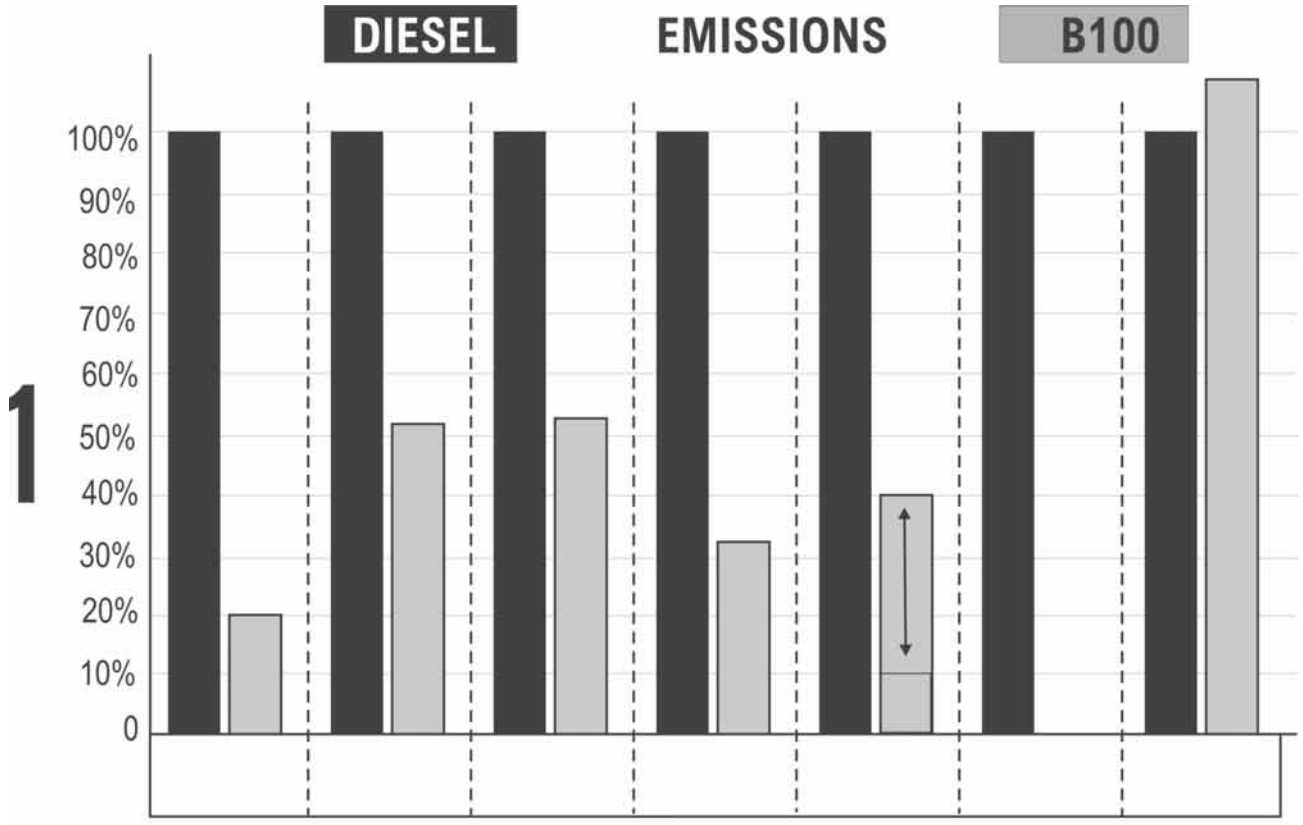
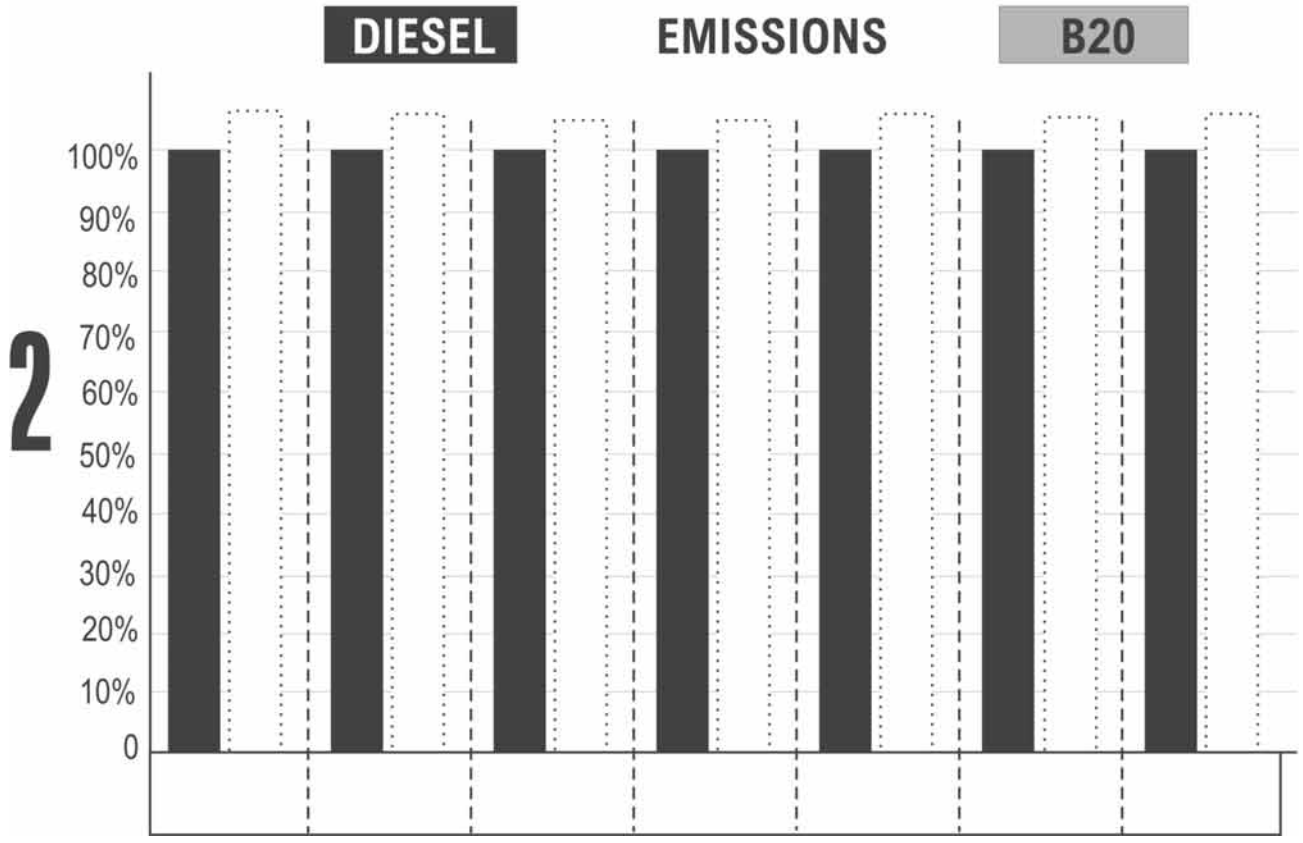


SECONDARY Biodiesel **MATH: Graphing Emissions**

DIRECTIONS: Using the information in the Secondary Biodiesel Factsheet, determine which emission each set of graphs represents in Graph 1 and write the name of the emission in the blank space at the botom of the set. In Graph 2, fill in the biodiesel emissions for B20, assuming they are proportional to the percentage of biodiesel in the blend.



1



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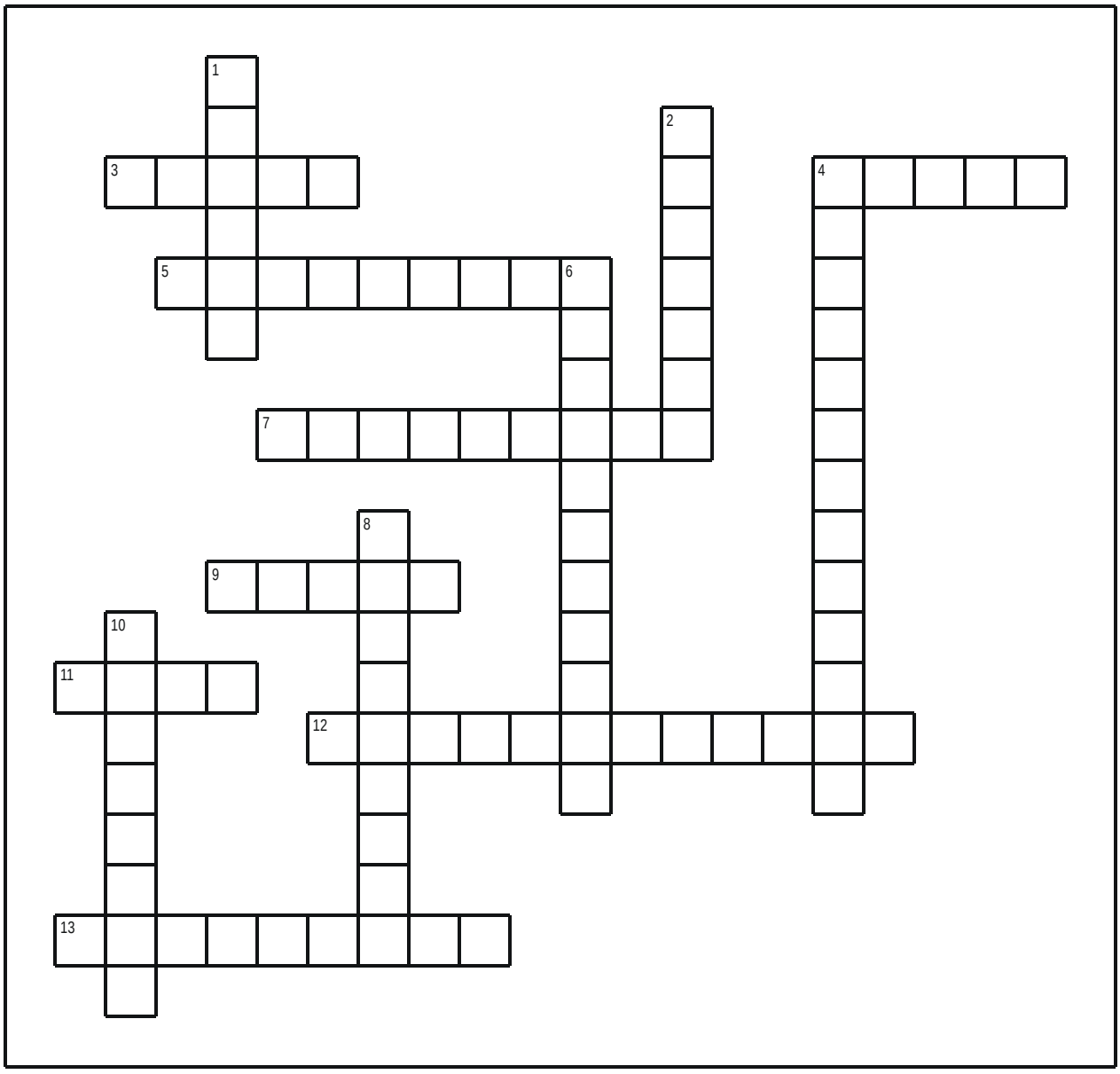
Elementary Crossword



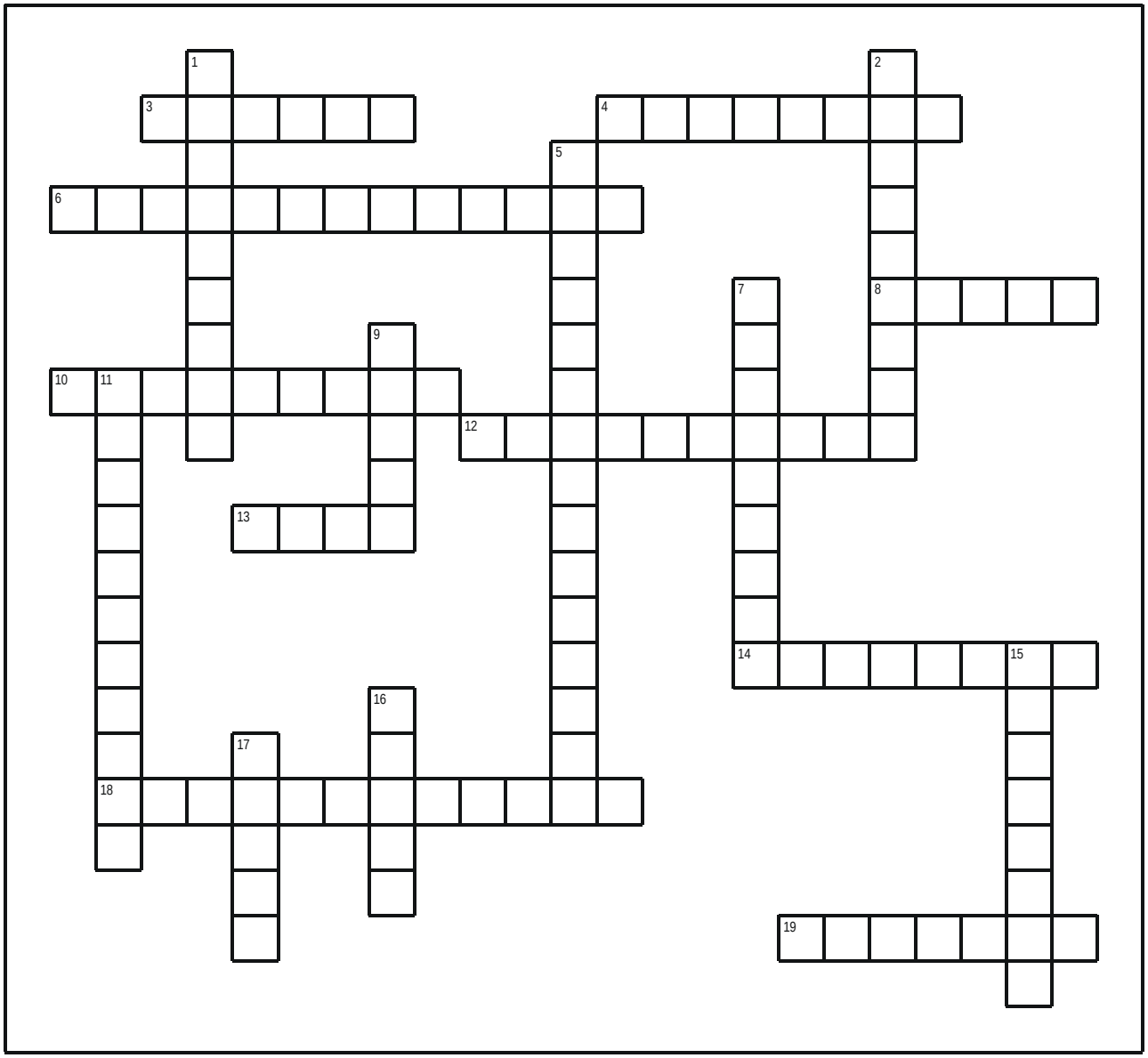
Across

3. group of vehicles
4. mixture
5. can be made again in a short time
7. something that damages the environment
9. vehicle that moves goods
11. water vehicle
12. cannot be remade again
13. fuel from vegetable oil and animal fat

Down

1. fuel made from petroleum
2. biodiesel is made from its oil
4. can break down quickly
6. the world around us
8. student transportation
10. safe to handle

Intermediate Crossword



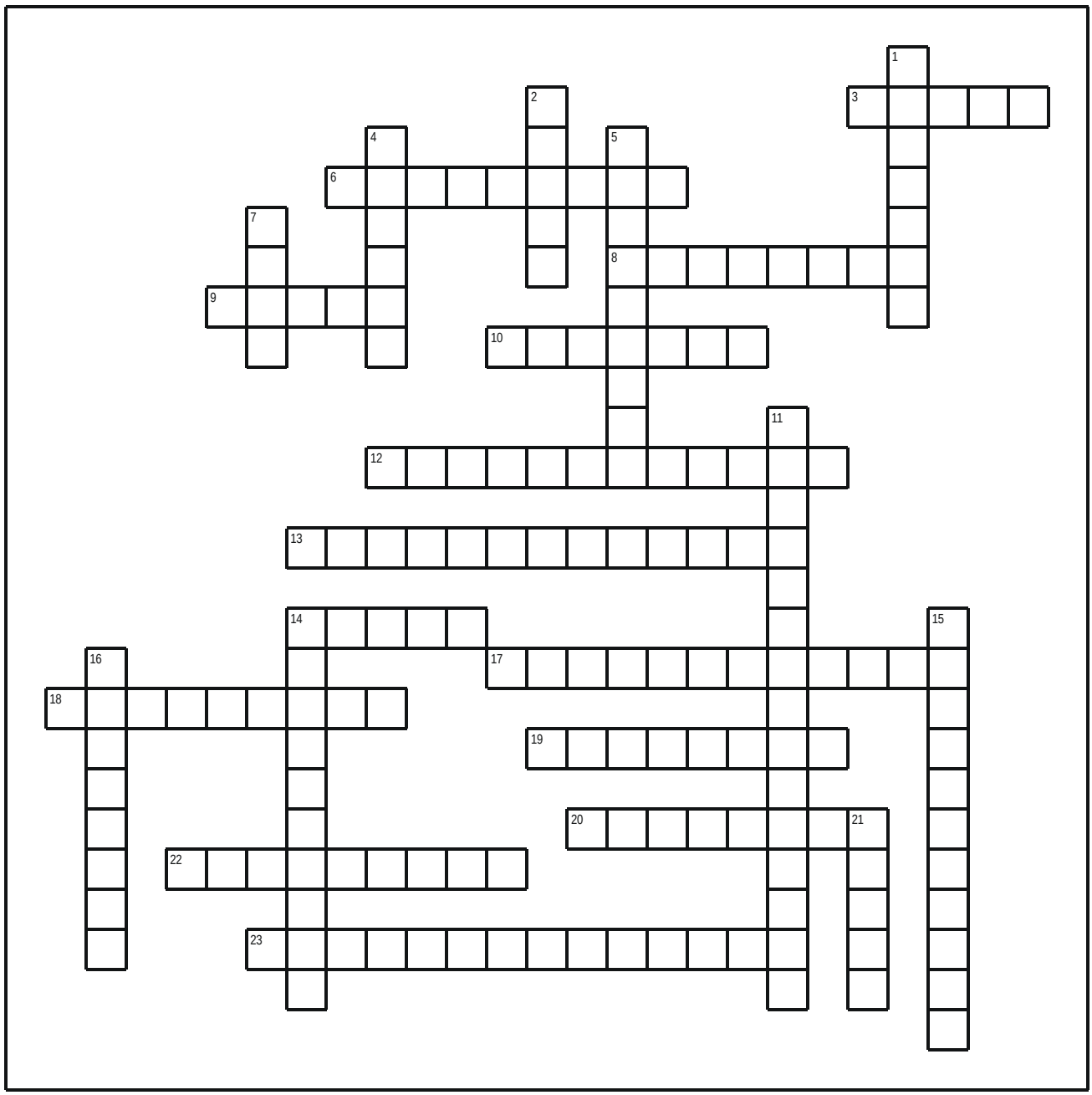
Across

3. petroleum-based fuel
4. by-product of burning fuel
6. capable of breaking down
8. dangerous to handle
10. replenished quickly
12. ignition temperature
13. marine transportation vehicle
14. biodiesel feedstock
18. cannot be remade again
19. from animal or plant matter

Down

1. renewable transportation fuel
2. substance that damages the environment
5. cleaner fuel to replace a traditional fuel
7. student transportation
9. group of vehicles
11. surroundings
15. safe to handle
16. mixture
17. mover of goods

Secondary Crossword



Across

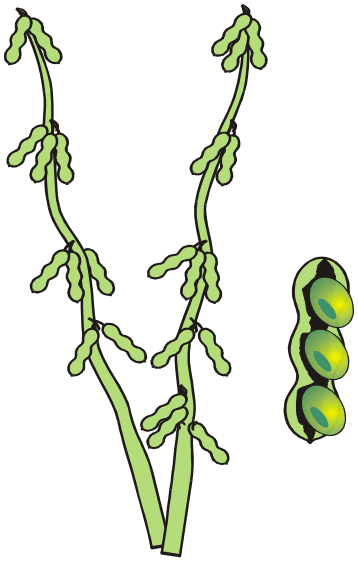
3. dangerous to handle
6. renewable transportation fuel
8. by-product of burning fuel
9. distance a vehicle can travel
10. from animal or plant matter
12. cannot be remade again
13. capable of breaking down
14. group of vehicles
17. change
18. substance that damages the environment
19. safe to handle
20. solid that settles out of a liquid
22. student transportation
23. supporting equipment

Down

1. substance that can dissolve some materials
2. mixture
4. petroleum-based fuel
5. replenished quickly
7. marine transportation vehicle
11. cleaner fuel to replace a traditional fuel
14. ignition temperature
15. surroundings
16. biodiesel feedstock
21. mover of goods

BIODIESEL**MATH**––*Answer Key*

1. **A bushel of soybeans produces the products shown below. How much does the bushel of soybeans weigh? Write your answer in the triangle.**



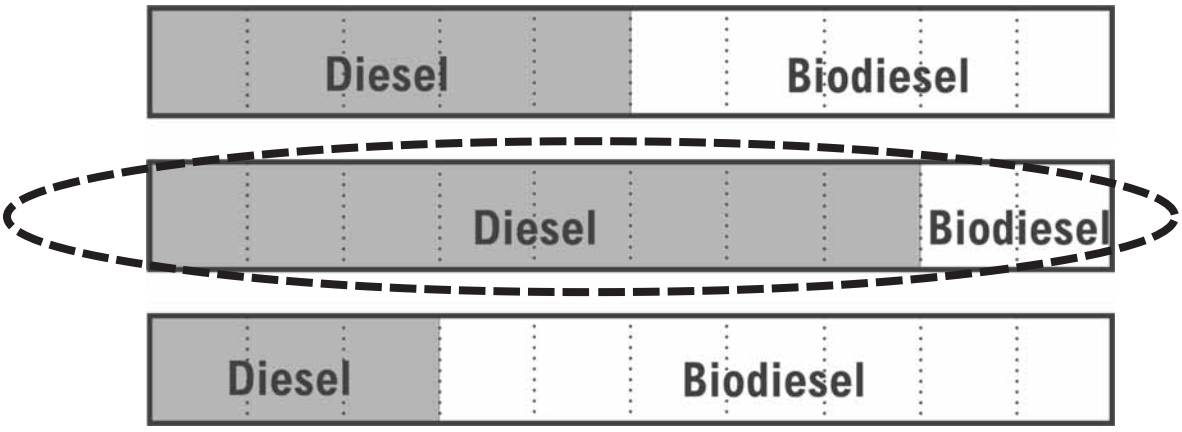
2. **If each pod on the soybean plant in the picture contains three soybeans, how many soybeans are on the plant?**

23 x 3 = 69

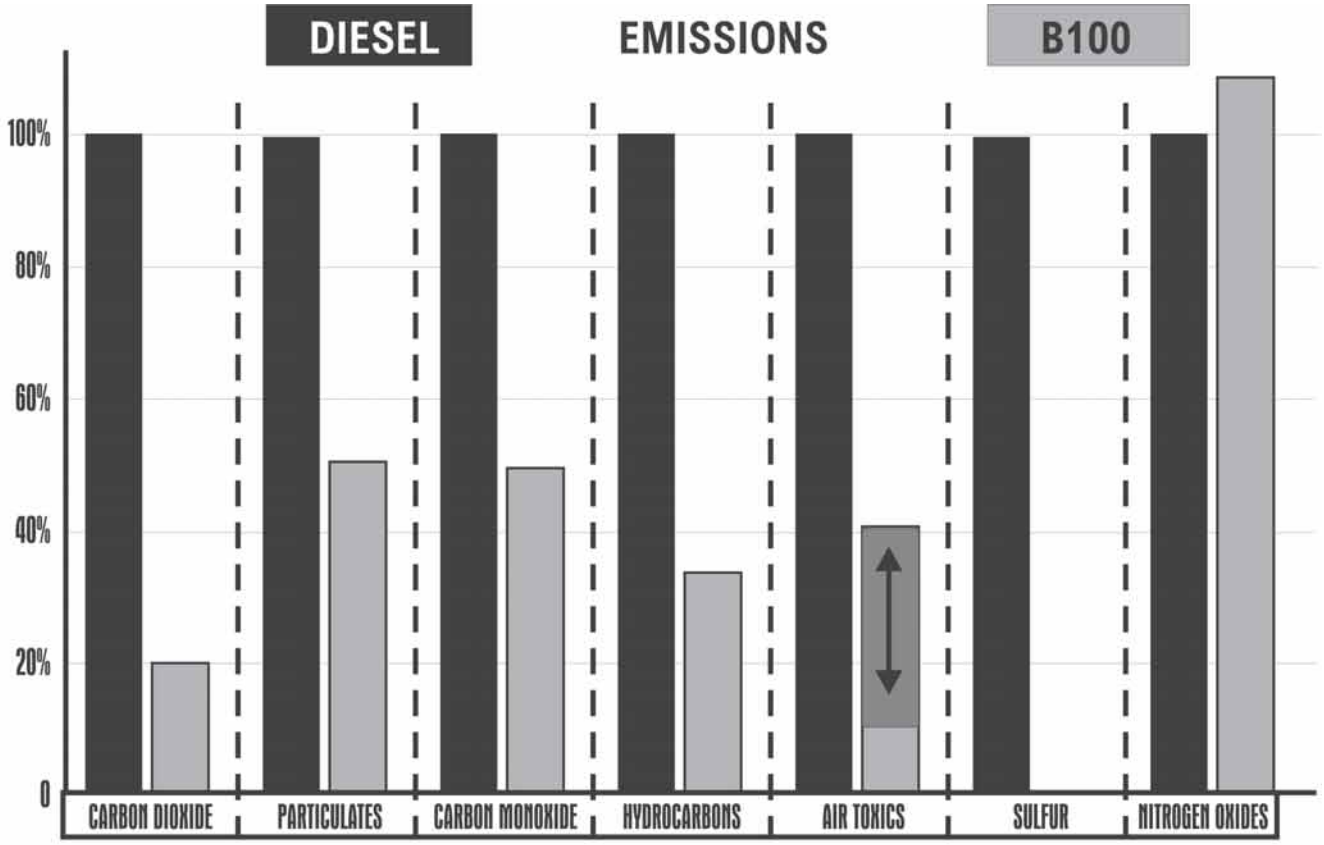
3. **If each pod on the left branch contains four soybeans and each pod on the right branch contains two soybeans, how many soybeans are on the plant?**

(10 x 4) + (13 x 2) = 40 + 26 = 66

4. **B20 is a mixture of 20 percent biodiesel and 80 percent diesel fuel. Circle the bar below that represents the B20 mixture.**



1



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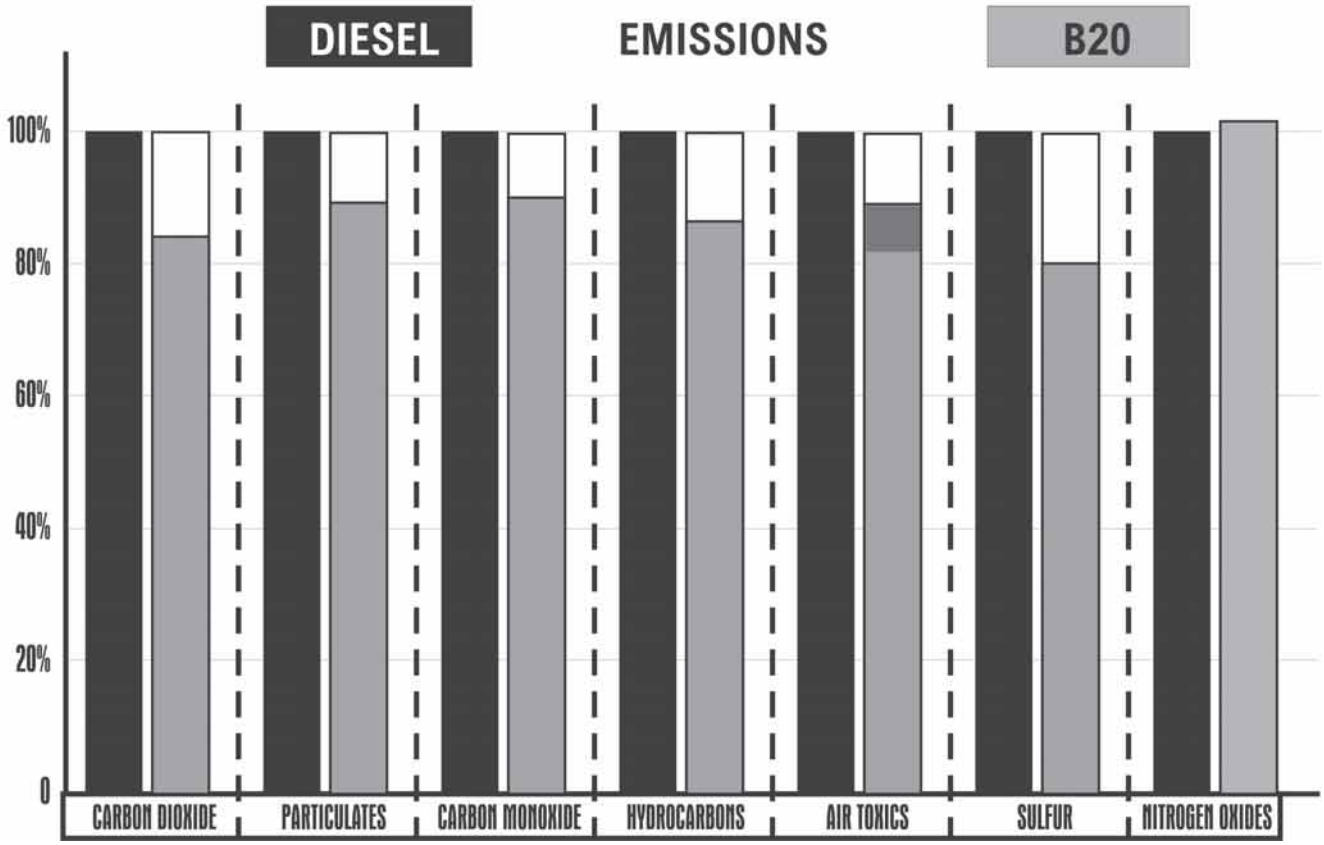
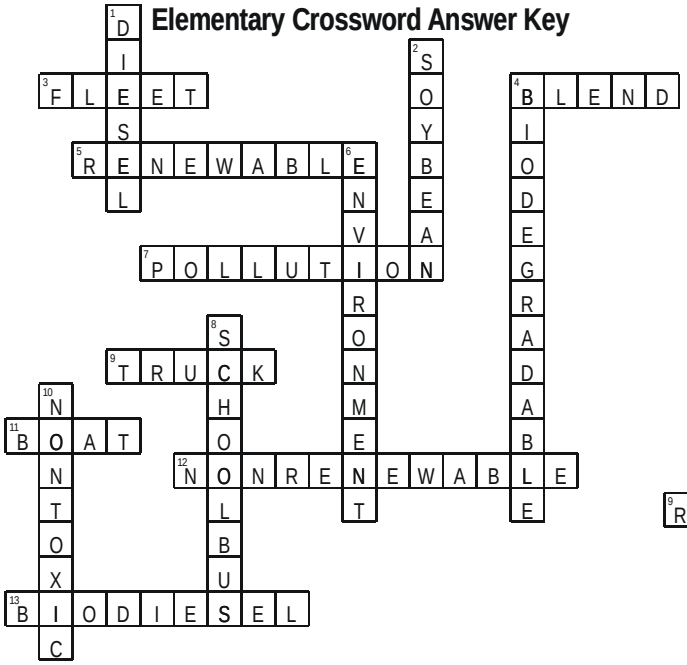
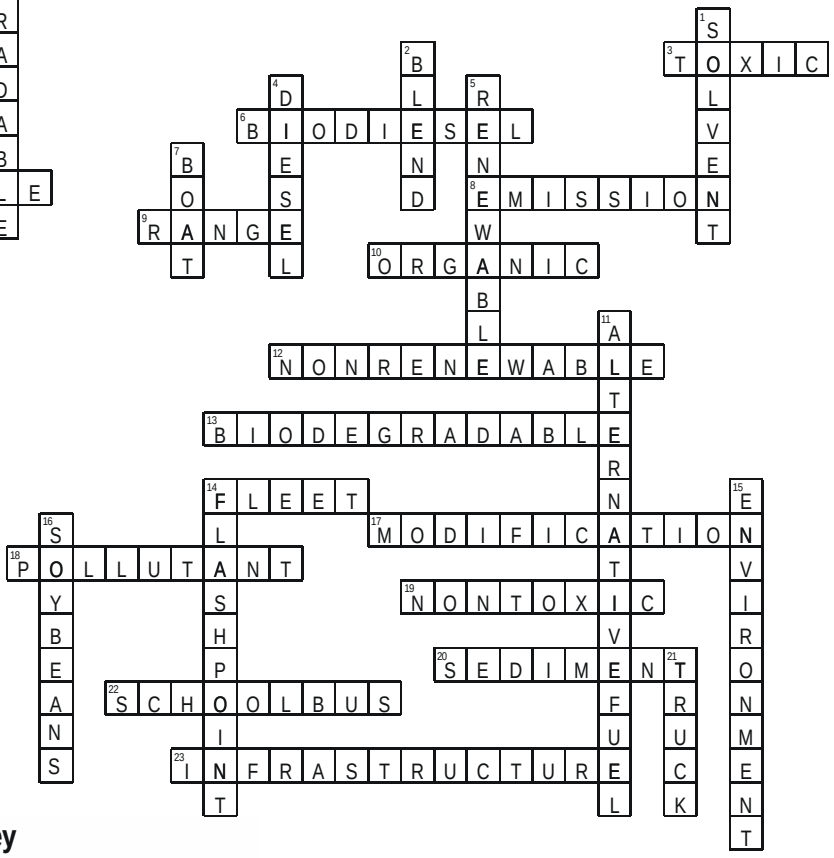


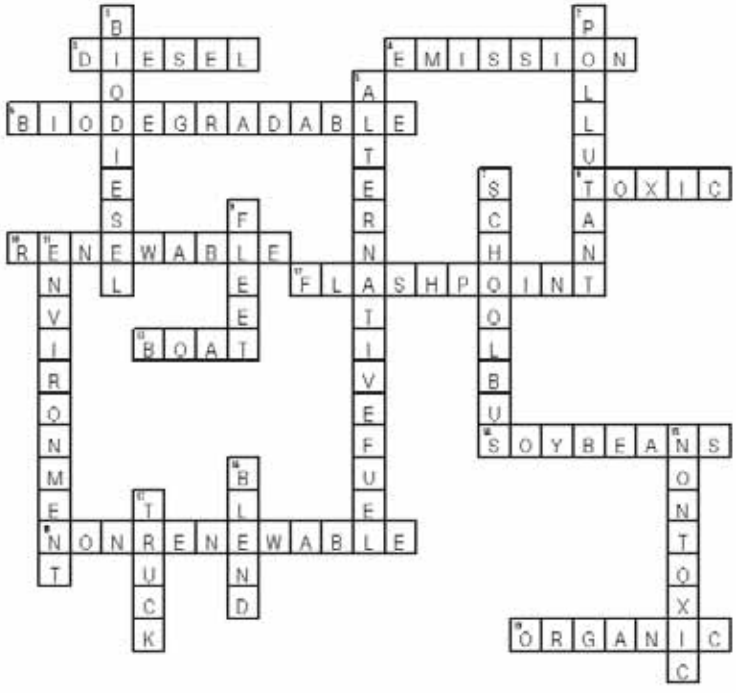
Elementary Crossword Answer Key



Secondary Crossword Answer Key



Intermediate Crossword Answer Key



BIODIESEL
Evaluation Form

State: _____ Grade Level: _____ Number of Students: _____

1. Did you conduct the entire activity?	Yes	No
2. Were the instructions clear and easy to follow?	Yes	No
3. Did the activity meet your academic objectives?	Yes	No
4. Was the activity age appropriate?	Yes	No
5. Were the allotted times sufficient to conduct the activity?	Yes	No
6. Was the activity easy to use?	Yes	No
7. Was the preparation required acceptable for the activity?	Yes	No
8. Were the students interested and motivated?	Yes	No
9. Was the energy knowledge content age appropriate?	Yes	No
10. Would you use the activity again?	Yes	No

How would you rate the activity overall (excellent, good, fair, poor)?

How would your students rate the activity overall (excellent, good, fair, poor)?

What would make the activity more useful to you?

Other Comments:

Please fax or mail to:
NEED Project
PO Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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Maine Public Service Company
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Maryland Energy Administration
Massachusetts Division of Energy Resources
Michigan Energy Office
Michigan Oil and Gas Producers Education Foundation
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U.S. Department of the Interior
Mississippi Development Authority–Energy Division
Montana Energy Education Council
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NASA Educator Resource Center–WV
National Alternative Fuels Training Center–
West Virginia University
National Association of State Energy Officials
National Association of State Universities and Land Grant Colleges
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
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Puget Sound Energy
Roswell Desk and Derrick Club
Roswell Geological Society
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