American Pyrotechnics
Safety & Education Foundation
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FIREWORKS SAFETY TEACHER'S GUIDE

Grades 4th–8th

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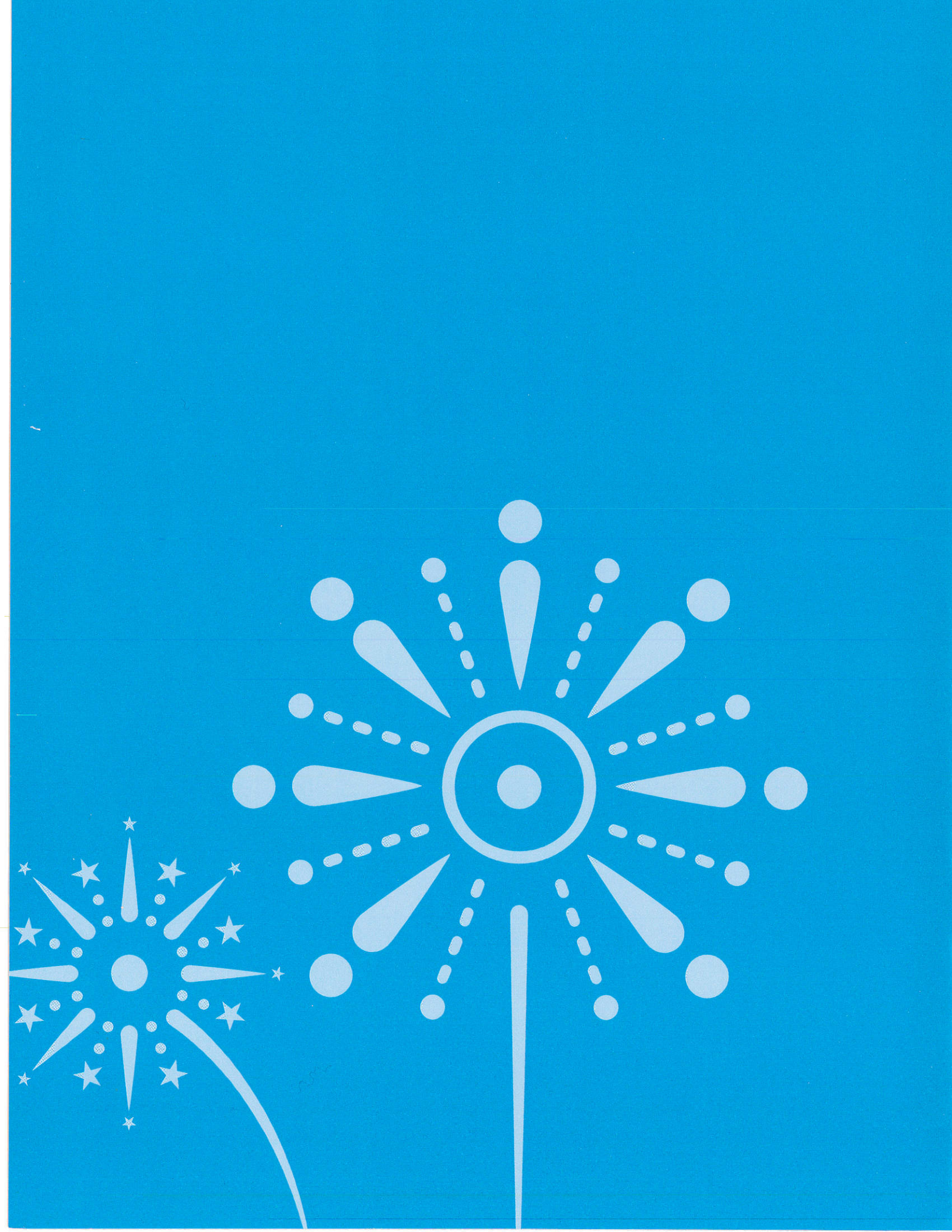

Fireworks Safety Teacher's Guide

Grades 4th–8th

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LESSON 1

The History of Fireworks

ESSENTIAL STANDARD

The student will be able to explain the history of fireworks and how fireworks are used to celebrate holidays and events worldwide.

Learning Targets

The student will be able to:

- discuss the history and development of fireworks in China;
- discuss the ingredients and their properties that make up the crude version of gunpowder;
- explain why hollow bamboo shoots, when ignited, produced a popping noise; and
- list the different occasions that Americans use fireworks to celebrate.

Essential Vocabulary

Alchemy —a medieval chemical science that valuable metals into gold, discovering a single cure for all diseases, and discovering how to live forever.

Black Powder— the explosive powder used in fireworks. It is made up of potassium nitrate, sulfur, and charcoal. This material can be used as a propellant charge, to produce sound, as a constituent of other compositions, or in the ignition fuse or timing system of fireworks. Also known as gun powder.

Elixir—a substance held to be capable of extending life.

Huo Yao—Chinese term for "Fire Drug" or gunpowder.

Multicultural—relating to or including many different cultures.

Saltpeter (potassium nitrate)—a white powder that exists naturally in some soils and that is used especially as a fertilizer, in medicine, and to make gunpowder.

Sulfur—a yellow chemical element that has a strong, unpleasant odor when it is burned and that is used in making paper, gunpowder, medicine, and other products.

How Are Firework Used?

Ask your students who they think were the first people were to use fireworks to celebrate major events?

The Chinese used fireworks to celebrate the most important events in life—a birth, a wedding, a death, holidays, and coronations.

The use of fireworks spread to Europe eventually first to celebrate military victories and later in public celebrations and religious ceremonies.

Legend has it that Captain John Smith set off the first fireworks display in the American colonies in Jamestown, Virginia in 1608. He and other settlers used the fireworks to celebrate special events.

Fireworks were used in the very first Fourth of July celebration in 1776.

Ask your students where and how they have seen fireworks used on the 4th of July.

Americans use fireworks year-round to celebrate national holidays, sporting events, and other multicultural events, but the "big day" is still the Fourth of July.

Explain the term multicultural and ask your students to identify multicultural events and holidays where fireworks are used.

Other countries have at least one big "fireworks day" like we do. In Germany, for example, it is New Year's Eve, in France it is Bastille Day, and in England it is Guy Fawkes Day.

Ask your students to name other events and celebrations where they have seen fireworks.

Optional Assignments

1. Research and describe the properties of each: saltpeter (potassium nitrate), sulfur, and charcoal.

2. Write a summary describing a celebration that does not currently include fireworks that you believe would be enhanced by the addition of fireworks. Be certain to include the:

- name and importance of the event; and
- reasons why fireworks would improve the event.

IF YOU LIKE FIREWORKS, THANK THE CHINESE!

Many historians believe that fireworks originally were developed in the second century B.C. in ancient Liuyang, China.

The first "firecrackers" were bamboo stalks that when thrown in a fire, would explode with a bang because of the overheating of the hollow air pockets in the bamboo.

The Chinese believed these natural "firecrackers" would ward off evil spirits.

Use a piece of bamboo to explain this to your students.

According to legend, a Chinese alchemist mixed three ingredients, saltpeter, sulfur, and charcoal to produce a black, flaky powder.

The Chinese named this black powder "huo yao" which means "fire chemical." We call it gunpowder.

The Chinese then filled paper tubes with gunpowder and inserted fuses made from tissue paper to make a firecracker.

Another version of fireworks that the Chinese invented was called "ground rats," which were small tubes filled with the fire chemical that scurried around the floor.

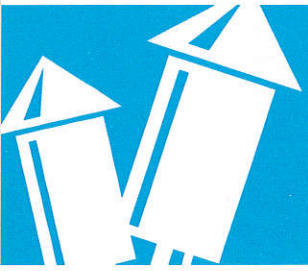
Eventually, the Chinese learned that you can make fireworks react differently depending on how you pack it:

- packing the gunpowder into containers with harder shells produced bombs;
- packing it into a cylinder with one side open produced sprays or fountains of fire and orange sparks; and
- packing the fire chemical in a larger tube, with one end left open, produced hot gas to propel it forward and upward, producing a rocket.

These are the same basic properties used today to create fireworks you see at big celebrations.

LESSON 2

The Safe Use of Fireworks



ESSENTIAL STANDARD

The student will be able to discuss the safe use of fireworks to avoid injury and damage to property.

Learning Targets

The student will be able to:

- locate websites for the U.S. Consumer Product Safety Commission (CPSC), the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF), the U.S. Department Of Transportation (USDOT), and U.S. Customs and Border Protection (CBP);
- explain how fireworks are regulated by local, state, and federal governments;
- locate information on the internet about the regulation of fireworks in his/her state and city (if regulated by local government); and
- describe the safe way to use fireworks.

Essential Vocabulary

Consumer Fireworks—also known as 1.4G Fireworks. Fireworks that are intended for use by the consumer. The permitted usage of consumer fireworks varies by state. Examples are fountains, cones, and firecrackers.

Deflagrate—to burn, especially suddenly and violently.

Detonate—to explode or cause to explode with sudden violence.

Discharge Site—the area immediately surrounding the fireworks mortars used for an outdoor fireworks display.

Display Fireworks (professional)— large fireworks articles designed to produce visible or audible effects for entertainment purposes by combustion, deflagration, or detonation.

Dud—any device in which the fuse or igniter fails to ignite the main pyrotechnic charge. The term, dud, is reported to have originated as an acronym for dangerous unexploded device.

Federal Government—a form of government in which power is shared between a central national government and individual states.

Local Government—government of counties, cities, and towns comprised of locally elected political bodies; the administration of the local affairs of a city, town, or other district by its inhabitants.

Novelty—a device containing small amounts of pyrotechnic and/or explosive composition but does not fall under the category of consumer fireworks. Such devices produce limited visible or audible effects. Examples are snakes, tanks, poppers, and snappers.

Safety Glasses—eyeglasses worn to protect the eyes during a variety of tasks. They are made with shatter-resistant plastic lenses to protect the eye from flying debris.

State Government—a structure similar to the federal government, except on a much smaller scale. The states also have a power-sharing relationship with their local and municipal governments that is much the same as the federal system.

State-approved Fireworks—forty-six of the 50 U.S. States and the District of Columbia allow legal "consumer" fireworks. The definition of consumer fireworks varies from state to state, but can include everything from cone fountains to roman candles to multiple tube "cake" devices to sparklers. Before

using fireworks, find out what is legal in your state by checking the state law summary for your state.

What Kinds Of Fireworks Are Legal In Your Community

Check with your local police or fire departments to learn what kinds of fireworks may be used in your community.

Legal fireworks are sold only at state approved stores or fireworks stands. Legal fireworks will have the manufacturer's name, directions, and warnings.

Illegal or homemade fireworks should never be used. Use of illegal or homemade fireworks can result in serious injuries or death to the user, unintended fires, and damage to property.

Use samples of legal consumer fireworks to help students identify what fireworks are legal in your community.

How To Use Legal Fireworks Safely

- Children should never use fireworks without adult supervision.
- Make sure children keep sparklers away from hair, face, and clothing.
- Sparklers that have bamboo sticks are cooler.

DID YOU KNOW?

Even sparklers can reach 1,800° F (982°C). They should only be used outside and with close adult supervision.

Sparklers that have bamboo stems stay cooler than ones with metal stems.

- Always use fireworks outside and away from the house, on a hard flat level surface. This surface should be fireproof and free from leaves, grass, or other debris.
- Have a hose and bucket of water nearby when fireworks are being used.
- Light one firework at a time, and do not put the firework into any glass or metal container.
- Make sure all people in the area are aware that fireworks are being used.
- Keep spectators at a safe distance and point the fireworks away from people and homes.

Fireworks can catch a roof on fire if they land on it.

- Never hold any consumer firework in your hand or have your body over the firework while you are lighting it.
- Wear eye protection, such as safety glasses, while you are setting off the fireworks.
- Light one firework at a time.
- Never pick up a dud or relight a dud. Leave it lying on the ground, wait 15 minutes, and then douse it in a bucket of water.
- Never pick up used fireworks.

Used fireworks can be hot even if they are not smoldering.

- Douse all used fireworks and duds in a bucket of water before putting them in the trash.
- Have the fire department and emergency management system telephone number readily available before beginning to use fireworks.
- Have a first aid kit available should anyone get injured by using fireworks.

Alcohol and Fireworks Do Not Mix

The use of fireworks at holidays and other celebrations means that some adults may be drinking alcoholic beverages. Just like drinking and driving, drinking and fireworks do not mix.

Remind the adults in your home to never drink alcohol if they are setting off fireworks.

It's a great idea to have at least one "designated shooter" for the fireworks. Someone who agrees to abstain from any alcohol consumption prior to the fireworks activities.

Be Considerate Of Your Neighbors

Sometimes fireworks can sound like a gunshot or explosions. Loud noises may be frightening to very young children, the elderly, or persons with certain disabilities.

Inform your neighbors that you will be setting off fireworks so that they will be prepared before you use fireworks in your neighborhood.

Pets And Animals Do Not Like Fireworks As Much As You Do

Pets and other animals have sensitive ears and could be frightened by the loud explosions from fireworks.

Keep pets away from fireworks and do not expose them to the loud noises of a fireworks display.

Pets can panic at the noises and bright flashes of lights causing them to run out of doors, jump from windows, break tethers, and leap fences.

Pets should be kept inside so they do not run away, get lost, or get injured.

Optional Assignments

1. Sketch a site plan for a consumer fireworks display indicating the safe distance measurements between each locations. Include locations for the:

- discharge site within the display area;
- spectator viewing area;
- emergency site with necessary emergency items;
- vehicle parking and foot traffic; and
- any secured areas.

2. View the infographic available on the U.S. Consumer Product Safety Commission website at **http://onsafety.cpsc.gov/blog/2015/06/26/cpsc-science-fireworks-injuries-2015/**. Locate national fireworks injury data for your age group and design an infographic to inform your peers.

LESSON 3

Illegal and Homemade Fireworks

ESSENTIAL STANDARD

The student will be able to discuss the concept of illegal and homemade fireworks for the purpose of avoiding the unintended consequences of these illegal explosive devices.

Learning Targets

The student will be able to:

- locate websites for the U.S. Consumer Product Safety Commission (CPSC), the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF), the U.S. Department of Transportation (USDOT), and U.S. Customs and Border Protection (CBP);
- explain the difference between legal, illegal, and homemade fireworks;
- locate examples of illegal fireworks on the websites of the U.S. Consumer Product Safety Commission (CPSC) and Bureau of Alcohol, Tobacco, Fireworks & Explosives (ATF); and
- explain the indicators that a device may be illegal based on information provided by the ATF.

Essential Vocabulary

Explosive—(technical definition) Any material that is capable of undergoing a self-contained and self-sustained exothermic chemical reaction at a rate that is sufficient to produce substantial pressures on their surroundings, thus causing physical damage. Explosives fall into two classes, detonating and deflagrating.

Federal Offense— any act that is performed in violation of the U.S. laws. Such crimes are prosecuted in federal courts.

Illegal—contrary to the laws or rules; unlawful, banned.

Illegal Fireworks—fireworks that are banned by the federal, state, or local government for use by consumers. Some examples include M-80s, M-100s, M-1000s, quarter sticks, silver salutes, sparkler bombs, and tennis ball bombs.

Legal—permitted by law or regulations.

What Are Illegal Consumer Fireworks?

Consumer fireworks that do not meet the requirements of the U.S. Consumer Product Safety Commission are illegal and dangerous.

Illegal consumer fireworks usually have too much gunpowder and fuses that do not work properly.

Even if you use them correctly, illegal consumer fireworks can cause injuries and even death.

One way to tell if consumer fireworks are legal or illegal is to look for a warning label and the name of the manufacturer. Legal consumer fireworks have warning labels. Illegal consumer fireworks usually don't. Legal consumer fireworks have the name of the manufacturer. Illegal consumer fireworks usually don't.

All homemade consumer fireworks are illegal. People who make consumer fireworks at home are breaking the law. They are not trained to make fireworks. Many persons making homemade fireworks have been seriously injured, losing eyes, arms, legs, and even their lives.

Leave the manufacturing of all fireworks to the professionals!

What Are The Names of Some Illegal Consumer Fireworks?

- **M-80s, M-100s, M-1000s, Quarter Sticks, Silver Salutes**—tubes that are often red or silver in color, with a fuse and no manufacturer's identification or warning label. These devices contain large amounts of explosive powder, and they can go off as soon as the fuse is lit.
- **Cherry Bomb**—round devices, often red in color, with a fuse protruding from the sphere.
- **Tennis Ball Bomb**—improvised devices with explosive powder inside a tennis ball with a fuse.

It is also illegal to alter legal fireworks to make a more powerful explosive device by tying them together or packing them into a container.

How Can You Spot Illegal Consumer Fireworks?

Consumer fireworks are probably illegal if:

- it resembles a roll of coins with a fuse out the top or side;
- it consists of a cardboard tube or oddly shaped item wrapped in brown paper and is filled with an explosive material;
- it is red, silver, or brown in color;
- it may be one to six inches long and up to an inch or more in diameter; and
- it is sold on the street or out of someone's vehicle.

How Can You Spot Legal Consumer Fireworks?

Fireworks are probably legal if:

- it has the name and place of business of the manufacturer, packer, distributor, or seller;
- it shows the name of the country in which it was manufactured;
- there are warning labels, prominently located on the front of the package, written in English; and
- it has the U.S. Department of Transportation designation: "DOT Consumer Fireworks 1.4G."

Illegal fireworks are not only dangerous, if you buy them, you can be arrested, fined and sent to jail.

Optional Assignments

1. Use the information found at the government websites provided below to prepare a public safety awareness message to communicate the unintended consequences of using illegal fireworks.

- Consumer Product Safety Commission **http://www.cpsc.gov/**
- Bureau of Alcohol, Tobacco, Firearms, and Explosives **http://www.atf.gov/**
- Department of Transportation **http://www.dot.gov/**
- Customs and Border Protection **http://www.cbp.gov/**

2. Invite a guest who has been personally involved with an illegal fireworks-related incident to share their experience with the class. For example:

- an individual who has been injured or has experienced property damaged as a result of an illegal fireworks accident;
- a fire fighter, police officer, or medical provider who has provided rescue assistance to victims of an illegal fireworks accident; or
- a state or federal employee whose job responsibility is to stop the importation or making of illegal fireworks.

LESSON 4

The Science of Fireworks

ESSENTIAL STANDARD

The student will be able to discuss the science underlying fireworks.

Learning Targets

The student will be able to:

- explain the science of fireworks;
- distinguish among various categories of fireworks;
- discuss the key characteristics of various categories of fireworks; and
- describe the function of each internal component of a firework.

Essential Vocabulary

Aerial—occurring in the air or atmosphere.

Aerial Shell—a fireworks device designed to be launched into the air for use in a fireworks display.

Chemical Composition—all pyrotechnic and explosive composition contained in a fireworks device. Inert materials (such as clay used for plugs or organic matter used for density) are not considered to be part of chemical composition.

Chemical Energy—the energy released or absorbed in a chemical reaction during the decomposition or formation of compounds.

Fireworks—any composition or device for the purpose of producing a visible or an audible effect by combustion, deflagration, or detonation, and that meets the definition of consumer fireworks or display fireworks. A firework contain black powder, mortar, stars, shell, bursting charge, and a delay fuse.

Fuel—a material used to produce heat or power by burning.

Oxidizing Agent—one used to support the combustion of a rocket propellant.

Propellant—fuel plus oxidizer used to make something (such as a rocket) go forward.

Pyrotechnics—controlled exothermic chemical reactions that are timed to create the effects of heat, gas, sound, dispersion of aerosols, emission of visible electromagnetic radiation, or a combination of these effects to provide the maximum effect from the least volume.

Stimulus—something that rouses or stirs to action.

What Goes In To Making A Fireworks Display?

Fireworks are a type of explosive.

Some fireworks, like firecrackers, explode making a loud noise and quick flash of light. Other fireworks produce color, light, or smoke effects by rapidly burning, rather than the blast effect produced by military and blasting explosives.

A lot of science goes into making individual fireworks and fireworks displays. Chemistry, physics, and engineering all play a role in the fireworks displays that delight the spectators.

Ask you students to describe the fireworks displays they have seen. What sounds and sights did they hear and see?

There are also elements of art and music used to produce the spectacular—and perfectly timed—effects that we see at many Fourth of July programs.

Fireworks displays use computers that can take over the firing of the individual devices to provide precision that is difficult to achieve by people lighting the individual fireworks.

The Science Of Fireworks

You have to have the right chemicals to make good fireworks. All fireworks need two things to work: a chemical that is oxygen rich (called an oxidizer) mixed with a fuel (something that burns, such as sulfur or charcoal).

At a specific temperature, well above the boiling point of water, the chemicals react to release heat and produce color, light, and sound effects.

Ask your students if they know the boiling point of water, both Fahrenheit and Celsius.

The chemicals can be mixed together to produce different effects. For example, smoke is often produced by burning fireworks. When fireworks are used indoors, they are manufactured to produce a minimum amount of smoke. They are called theatrical fireworks.

FIRECRACKERS

A firecracker contains black powder—a mixture of potassium nitrate, sulfur, and charcoal—or flash powder (containing an oxidizer with aluminum powder as a fuel) that is wrapped tightly in paper. When the fuse is lit, it creates a small explosion that produces a flash of light and an audible "bang."

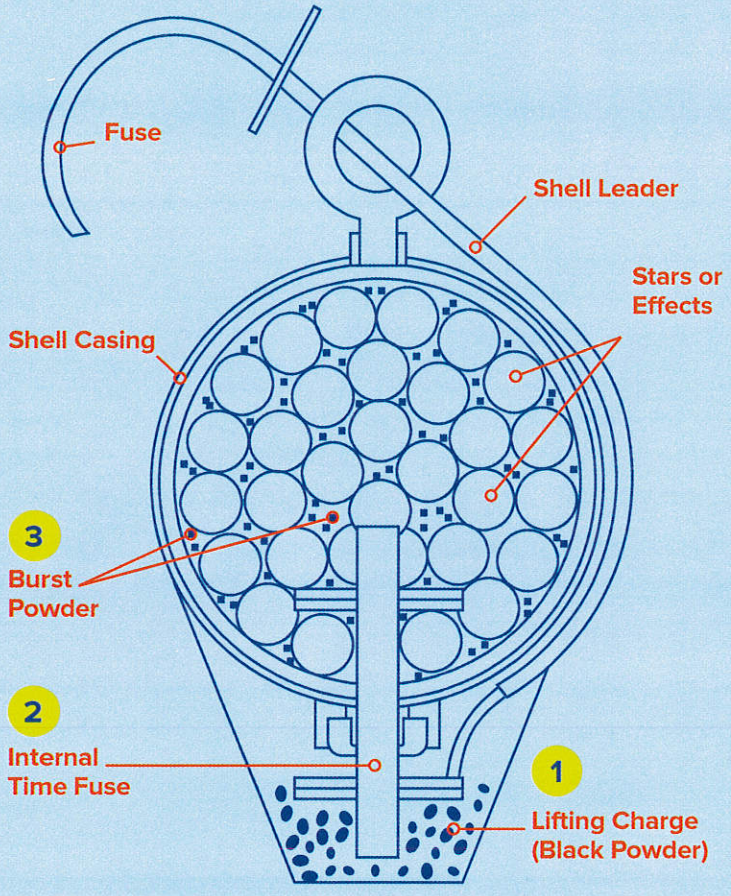
SPARKLERS

Sparklers contain a fuel, an oxidizer, iron or steel powder, and a binder that are mixed together, coated on a wire, and burn for a short period of time giving off very bright and showery light and beautiful sparks.

FOUNTAINS

Fountains are devices that are placed on the ground, and the user lights a fuse to start the fireworks effects. Fountains produce a shower of color and sparks that may rise several feet or more into the air. Some fountains produce a mild "crackling" noise effect, and audible "whistle" effect, and white or color smoke.

CONTENTS OF AN AERIAL SHELL



Up, Up & Away With Aerial Fireworks

An aerial firework has several basic component parts:

1. a propelling charge to lift the device or a component in the device into the air;
2. an internal fuse that is lit when the propellant burns and then releases the fireworks effects high in the air; and
3. a bursting charge, which is ignited by the internal fuse and causes a device to explode high in the air, producing a noise and bright light.

Aerial Fireworks Consist of Two Basic Types — Shells And Rockets:

- Shells are fired from a launching tube. An aerial shell rises into the air and bursts a few seconds later, releasing light and color effects. Some shells are designed to produce multiple bursts in the sky.
- Mines are shells that produce a trail of colored fire as rise into the air.
- Multiple-tube devices, known as "cakes," include multiple shells that fire one right after the other and produce a barrage of color and light into the air.
- When rockets are ignited the entire device rises into the air. When the rocket reaches its highest point in flight, it bursts.

Discuss with your students the difference between a tube and a rocket.

How Fireworks Make Colors

Ask you students that colors they have seen in fireworks displays.

Fireworks contain various chemicals that when heated to high temperatures give off light to get rid of the excess energy. Each chemical produces a different color.

RED	Strontium compounds
BLUE	Copper compounds
GREEN	Barium compounds
YELLOW	Sodium atoms
VIOLET	Strontium and copper
WHITE	Aluminum or titanium metal
ORANGE	Calcium salts
GOLD	Sodium atoms

Other chemicals are used for special effects.

EFFECT	ELEMENT
Sparklers	Aluminum
Glitter Effects	Antimony
Deepens Colors	Calcium (not used in consumer fireworks)
Temperature Varying Sparks	Iron
Glow in the Dark Effects	Phosphorous (banned in consumer fireworks)
Silver Sparks	Titanium
Smoking Effects	Zinc (not used in consumer fireworks)
Crackling Effects	Bismuth oxide, copper oxide

What Is Inside Aerial Fireworks?

Black Powder —the propellant, which is made of potassium nitrate, sulfur, and charcoal.

Mortar (launching tube) —the outer cylinder chamber made of heavy cardboard, rigid plastic or metal.

Stars —the pyrotechnic pellets that burn and create the colors and effects. They can be as small as a pea and as large as a tennis ball in large, professional fireworks.

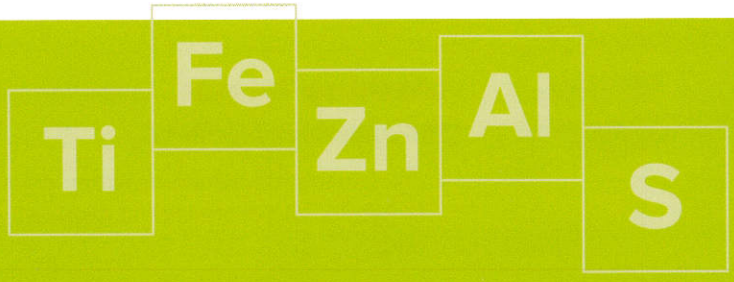
Shell —a hollow sphere made of cardboard hemispheres, pasted paper and packed with stars and black powder bursting charge.

Bursting charge —this is black powder inside the middle of the shell that ignites the firework effects.

Delay Fuse —allows a time delay after "lift-off" before the bursting charge opens up the shell and lights the fireworks effects.

Noises in Fireworks

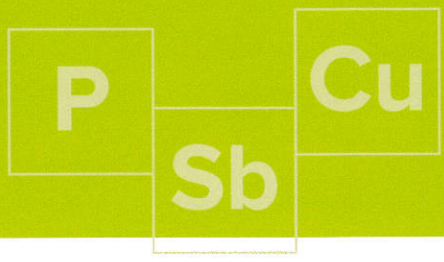
When the stimulus—like impact or fire—come in contact with a firework composition, it triggers a chemical reaction that produces heat and gas at very high pressures in the firework container, finally causing an explosion that produces a loud bang.



Optional Assignments

1. Using scientific principles, explain the effect of changing the temperature of the chemical composition of black powder on the rate at which a reaction occurs.

2. Considering the science involved in producing fireworks, brainstorm and describe another possible application of this science to benefit the advancement of society.



LESSON 5

THE ENGINEERING OF FIREWORKS:

How Fireworks are Put Together

ESSENTIAL STANDARD

The student will be able to explain the two sides of the fireworks industry: consumer fireworks and display fireworks.

Learning Targets

The student will be able to:

- discuss the difference between consumer fireworks and professional display fireworks; and
- develop a plan for a safe, outdoor consumer fireworks event.

Essential Vocabulary

Break powder—a mixture of black powder and other materials that helps explode the shell.

Fuse—a cord that is lit at one end and burns down to ignite something at the other end. Fuses on fireworks often use black powder.

Electric Match—a set of special coated wires used to ignite fireworks. An electric match connects a shell's fuse to the firing system.

Lats—panels connecting electric matches to the equipment that runs a fireworks display.

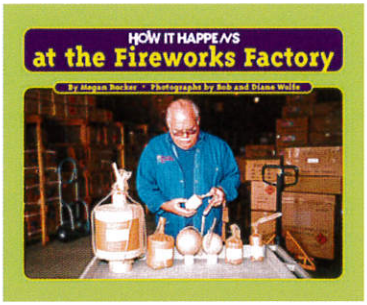
Mortar—a tube from which certain aerial devices are fired into the air.

Mortar Rack—sturdy wooden or metal frames used to support mortars in an upright position usually above ground.

Pellet—a usually small rounded, spherical, or cylindrical body.

Shell—the main body of a firework.

Star—small pellets, made of black powder and chemicals, that burn to make a firework's flame and color. Stars can be many shapes, such as balls or cubes.



Selected Readings from *How it Happens at the Fireworks Factory* by Megan Rocker

Duplicate and distribute to students for individual reading assignment.

How Are Fireworks Made?

Have you ever wondered display fireworks are made with multiple explosions, patterns and colors? Here's how as explained in *How it Happens at the Fireworks Factory*:[1]

STARS AND INSERTS

Imagine you are watching a fireworks display. Each fireworks you see is made up of multiple explosions. These are created by igniting (setting on fire) many small pellets made of black powder mixed with chemicals. Different chemicals can make the explosions different colors.

These pellets can be different shapes (like balls, cubes, or tubes) depending on the type of firework. Some pellets are called stars. To make round stars, black powder, chemicals, and water are placed in tubs that spin very quickly. This rolls the mixture into small balls.

Other pellets are called inserts. To make them, a mixture of black powder and chemicals is poured into paper tubes or holes on a metal rack. The rack is placed in a special machine that presses down hard on it. This forms the mixture into the shape of the holes.

ASSEMBLY

The stars and inserts are placed inside a plastic or cardboard container to make a firework, also known as a shell. Shells can be many different shapes and sizes. The number and arrangement of stars or inserts inside them can be different, too. This is one way to create the variety you see in a fireworks display.

Not all inserts are loaded directly into containers. Tube-shaped inserts are often encased in thick cardboard covers first. The covers sometimes have holes drilled in them. These holes can help create sound effects (like humming or whistling) when the fireworks explode. They can also hold a fuse—a cord that is ignited to make the insert explode.

After being covered, the inserts are arranged in a container. A filling is scooped into the empty space in the container to hold the inserts in place. Next, the worker pours in rice hulls coated with black powder. This mixture is called break powder. When it is lit, it will help the shell explode and ignite the inserts. After the break powder is added, a lid with a fuse is put on.

The next step is to strengthen the shell. First, it is wrapped in string. Then a worker spreads paste on a sheet of paper and wraps it around the shell. The worker finishes putting the paper on and sets the shell aside to dry.

FUSES

There are many different kinds of fuses. Some are short and others are long. Some burn slowly, while others burn very quickly. These things control how long it will take a shell to explode once the fuse is lit. Sometimes more than one fuse is need to do this.

1 Megan Rocker, *How it Happens at the Fireworks Factory*, 1st edition.

Kinds of Fireworks

PROFESSIONAL DISPLAY FIREWORKS

There are two kinds of fireworks sold in the United States: "display fireworks" and "consumer fireworks."

Professional display fireworks are those spectacular fireworks you see at a professional show and are under the supervision of a trained pyrotechnician. Pyrotechnicians have to have a state professional license, as well as a permit from the local government to set off fireworks.

A display company not only makes fireworks, but it also puts on fireworks displays. The following describes how a company sets up a fireworks display as described in *How it Happens at the Fireworks Factory*:

The first step in doing this [setting up a fireworks display] is to plan what the display will look like. The planner must decide how many and what kinds of fireworks to use, when each will be fired, and sometimes how to match the explosions with music. This can be a complicated task, and as it is often done on a computer.

Shooting off fireworks is a dangerous job done by a crew of specially trained workers. An average 15-minute display can take about 6 hours to set up, so the workers have to get there early. When they arrive at the display site, they use a detailed plan to arrange the equipment.

The shells are launched out of tubes called mortars. In this display, the mortars used for the main part of the show will be set up on a truck. Others, including those used for the finale (end of show) will be arranged in racks on the ground.

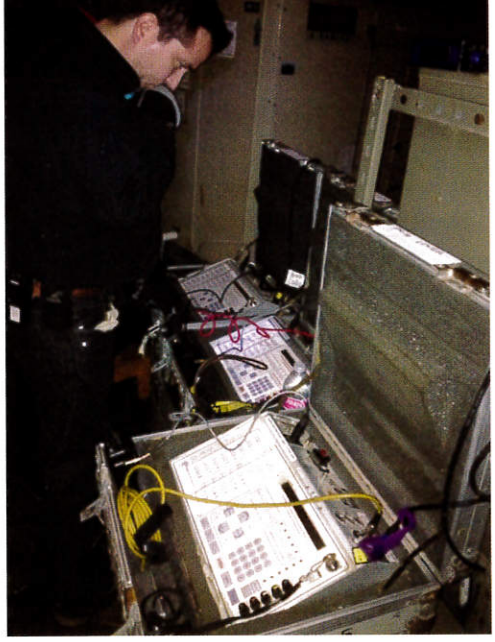
Metal rods hammered into the ground hold the racks steady during the display. Next the shells are unpacked from boxes. Each shell is set on top of its mortar.

Every shell has a set of special wires called an electric match attached to its fuse. A worker connects the electric match to the firing system. There are about 300 shells in this set of racks, which means a lot of wires! They will all be straightened out and placed under the platform before the show begins.

The electric matches are wired into firing panels called lats. A cable connects the lats to the equipment that runs the displays. After all the wiring is done, the shells are loaded into the mortar tubes.

Some fireworks displays are run entirely by computers. Others need an operator to tell the firing system when to fire the shell. The operator may follow a written plan or receive instructions over a radio. When the operator presses a button on the equipment, it sends an electrical signal through a lat to one of the electric matches. This creates a spark that ignites the shell's fuse, creates an explosion, and launches the firework into the air.

As the shell is launched, another fuse on it has begun burning. This fuse will ignite the break powder and stars or inserts, making the shell explode in the air and creating the familiar colors and noise of a fireworks display.



CONSUMER FIREWORKS

The other type of fireworks are the smaller-in-size consumer fireworks that are sold at stands and stores for celebrating holidays such as the Fourth of July. Consumer fireworks are regulated by both the state and federal government, and in some cases, by city and county governments.

Optional Assignments

1. Using sketches and/or pictures, illustrate the difference between a firecracker, a fountain, and a rocket.

- For each of the three fireworks, describe its key characteristics such as noise, sound effect, light, color, smoke effect, speed, and distance.
- For each key characteristics list all safety behaviors to be observed.

2. Invite a guest who has a career in fireworks to share their experience with the class. For example, an individual who:

- is in the professional display fireworks business may share information on creating a fireworks show; or
- sells consumer fireworks may share information pertaining to the regulation and safe use of fireworks.

3. Recommended reading for the student:

- ***How it Happens at the Fireworks Factory*** by Megan Rocker.

American Pyrotechnics Safety & Education Foundation

CELEBRATE SAFELY

Celebrate Safety Learning Standards

Grades 4th – 8th

American Pyrotechnics Association's Safety and Education Foundation
Fireworks Safety Curriculum, Grades 4th–8th
Standards: Centers for Disease Control and Prevention

Celebrate Safely!

American Pyrotechnics Association's Safety and Education Foundation
Fireworks Safety Curriculum, Grades 4th–8th

Standards: for Disease Control and Prevention

http://www.cdc.gov/healthyyouth/sher/standards/index.htm

The Centers for Disease Control and Prevention, Division of Adolescent and School Health developed these health education standards grades Pre–K through twelve.

Standard 1. The student will comprehend concepts related to health promotion and disease prevention to enhance health.

Standard 2. The student will analyze the influence of family, peers, culture, media, technology, and other factors on health behavior.

Standard 3. The student will demonstrate the ability to access valid information and products and services to enhance health.

Standard 4. The student will demonstrate the ability to use interpersonal communication skills to enhance health and avoid or reduce health risks.

Standard 5. The student will demonstrate the ability to use decision-making skills to enhance health.

Standard 6. The student will demonstrate the ability to use goal-setting skills to enhance health.

Standard 7. The student will demonstrate the ability to practice health-enhancing behaviors to avoid or reduce health risks.

Standard 8. The student will demonstrate the ability to advocate for personal, family, and consumer health.

Preventing childhood injuries and health problems is a part of Standard 2 and Standard 7.

It is hope that schools will use this curriculum as part of the injury prevention and safety standards to prevent injury and deaths from the unsafe or illegal use of fireworks.

Standards: Grade 4th

Next Generation Science Standards http://www.nextgenscience.org	**4-PS3-2 Energy** Students who demonstrate understanding can make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents
Common Core State Standards for Mathematics http://www.corestandards.org/Math	**4.MD Measurement and Data** Represent and interpret data. **4.G Geometry** Draw and identify lines and angles, and classify shapes by properties of their lines and angles.
Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects http://www.corestandards.org/ELA-Literacy	**Reading Standards for Informational Text K–5** **Key Ideas and Details** (1) Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. **Writing Standards K–5** **Text Types and Purposes** (3) Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences. **Speaking and Listening Standards K–5** **Comprehension and Collaboration** (2) Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally. **Language Standards K–5** **Vocabulary Acquisition and Use** (4) Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 4 reading and content, choosing flexibly from a range of strategies.

Standards: Grade 5th

Next Generation Science Standards http://www.nextgenscience.org	**5-PS1-4 Matter and Its Interactions** Students who demonstrate understanding can conduct an investigation to determine whether the mixing of two or more substances results in new substances.
Common Core State Standards for Mathematics http://www.corestandards.org/Math	**5.MD Measurement and Data** Represent and interpret data. **5.G Geometry** Graph points on the coordinate plane to solve real-world and mathematical problems.
Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects http://www.corestandards.org/ELA-Literacy	**Reading Standards for Informational Text K–5** **Key Ideas and Details** (1) Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. **Writing Standards K–5** **Text Types and Purposes** (3) Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences. **Speaking and Listening Standards K–5** **Comprehension and Collaboration** (2) Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally. **Language Standards K–5** **Vocabulary Acquisition and Use** (4) Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 5 reading and content, choosing flexibly from a range of strategies.

Standards: Grade 6th

Next Generation Science Standards http://www.nextgenscience.org	**MS-PS1-2 Matter and Its Interactions** Students who demonstrate understanding can analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. **MS-PS1-4 Matter and Its Interactions** Students who demonstrate understanding can develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
Common Core State Standards for Mathematics http://www.corestandards.org/Math	**6.SP Statistics and Probability** Summarize and describe distributions.
Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects http://www.corestandards.org/ELA-Literacy	**Reading Standards for Informational Text 6–12** **Key Ideas and Details** (1) Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. **Writing Standards 6–12** **Text Types and Purposes** (3) Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences. **Speaking and Listening Standards 6–12** **Comprehension and Collaboration** (2) Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study. **Language Standards 6–12** **Vocabulary Acquisition and Use** (4) Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 6 reading and content, choosing flexibly from a range of strategies.

Standards: Grade 7th

Next Generation Science Standards http://www.nextgenscience.org	**MS-PS1-2 Matter and Its Interactions** Students who demonstrate understanding can analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. **MS-PS1-4 Matter and Its Interactions** Students who demonstrate understanding can develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
Common Core State Standards for Mathematics http://www.corestandards.org/Math	**7.SP Statistics and Probability** Draw informal comparative inferences about two populations.
Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects http://www.corestandards.org/ELA-Literacy	**Reading Standards for Informational Text 6–12** **Key Ideas and Details** (1) Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. **Writing Standards 6–12** **Text Types and Purposes** (3) Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences. **Speaking and Listening Standards 6–12** **Comprehension and Collaboration** (2) Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study. **Language Standards 6–12** **Vocabulary Acquisition and Use** (4) Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 7 reading and content, choosing flexibly from a range of strategies.

Standards: Grade 8th

Next Generation Science Standards http://www.nextgenscience.org	**MS-PS1-2 Matter and Its Interactions** Students who demonstrate understanding can analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. **MS-PS1-4 Matter and Its Interactions** Students who demonstrate understanding can develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
Common Core State Standards for Mathematics http://www.corestandards.org/Math	**8.SP Statistics and Probability** Investigate patterns of association in bivariate data.
Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects http://www.corestandards.org/ELA-Literacy	**Reading Standards for Informational Text 6–12** **Key Ideas and Details** (1) Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text. **Writing Standards 6–12** **Text Types and Purposes** (3) Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences. **Speaking and Listening Standards 6–12** **Comprehension and Collaboration** (2) Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation. **Language Standards 6–12** **Vocabulary Acquisition and Use** (4) Determine or clarify the meaning of unknown and multiple-meaning words or phrases based on grade 8 reading and content, choosing flexibly from arrange of strategies.

CELEBRATE SAFELY CURRICULUM

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- Tenney L. Davis, *The Chemistry of Powder & Explosives*, (1943)
- John A. Conkling, *Chemistry of Pyrotechnics, Basis Principles and Theory*, (1985)
- Jack Kelly, *Gunpowder*, (2004)
- Robert Temple, *The Genius of China, 3000 Years of Science, Discovery & Invention*, (2007)
- Megan Rocker, *How it Happens at the Fireworks Factory*, (2004)
- Consumer Product Safety Commission (CPSC)
  www.cpsc.gov/safety-education/safety-education-centers/fireworks/
- Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF)
  www.atf.gov/explosives/fireworks

Other online resources

- www.history.com/news/fireworks-vibrant-history
- science.howstuffworks.com/innovations/everyday-innovations/fireworks.htm
- www.americanpyro.com