Bigger, Better, BOOM!

It Really IS Rocket Science! Part 2

17th through 19th Centuries: Rocketry as a Science

During the latter part of the 17th century, the scientific foundations that apply to all modern rocketry were laid by the English scientist **Sir Isaac Newton** (1642-1727). Newton expressed his understanding of physical motion via three scientific laws. The laws explain how rockets work and why they are able to function in the vacuum of outer space. Newton's laws had a practical impact on the design of rockets. About 1720, a Dutch professor, **Willem Gravesande**, built model cars propelled by jets of steam.

Newton Gravesande

The Sweet Sensation of Speed! Mentos Rocket Cars!

https://www.beamazing.com/Admin/Editor/assets/Product%20Instructions/3825-SodaGeyserCar.pdf

We may not be able to build cars propelled by sizzling steam in the time we have, but we can build cars powered by sizzling soda! The phrase, "Start Your Engines" has never been this fun or foamy.

The whole process is a blast (literally)! From the time they open the package, students will have fun with the Mentos Geyser Rocket Car. Putting the durable plastic car together is simple with the step-by-step instructions, and once they have a 2-liter soda bottle strapped in, the eruption is as simple as pulling a pin. Once the eruption starts, the car rockets across the ground - WOW!

Materials:

- Launch area – An empty parking lot or paved driveway work as great launch areas.
- Geyser Car Kit(s)
- Soda: 2-liter bottles of diet cola soda. *The better choice for the "fuel" is a clear, diet soda*
- *since it contains no sugar and dyes and won't be sticky when it dries. Watch out for stains with any kind of soda.*
- Original MENTOS
- Creativity

OK, But What Makes the Car Go?

Introducing Sir Isaac Newton

Remember, Sir Isaac was an English scientist, writer, philosopher, mathematician, and more who lived between 1642 and1727. In a word, he was really smart! In order to make anything move, everyone has to obey

Newton's Laws of Motion and there are three of them. Simply stated, they are:

1. A Soda Geyser Car standing still will remain standing still; a moving Soda Geyser Car will continue moving in a straight line. These conditions are true unless some outside force is strong enough to make the car move faster or slower, stop, or change directions.

2. To cause the car to move faster or slower, stop, or change directions, the force used has to be stronger than the force the Soda Geyser Car has already.

3. The force of the soda geyser whooshing backward out the Turbo Geyser Tube nozzle is exactly matched by a force pushing the Soda Geyser Car forward. The stronger the backward geyser, the faster the car moves forward!

Your Soda Geyser Car is an ideal lab tool to explore all three of Newton's Laws of Motion, make connections to real rockets, and to see if the great scientist deserves his fame.

Let's see what we can learn.

Shhh! The MENTOS Have Secrets!

The reasons why MENTOS work so well are two-fold: (1) there are tiny, very tiny, pits on the surface of the
candy, and (2) it has considerable weight for its size. Each MENTOS candy has thousands of micro-pits all over the surface. These locations are called nucleation sites and they're perfect places for carbon dioxide bubbles to form. As soon as the MENTOS hit the soda, bubbles form all over the surface of the candy.
Couple this with the fact that the MENTOS candies are heavy and sink to the bottom of the bottle and you've got a double-whammy. When all this gas is released and expands, it pushes the liquid up and out of the bottle in an incredible soda blast. Use a magnifying glass to look closely at the surface of a single piece of MENTOS candy. You might just see the tiny pits on the surface of the candy. Those tiny

First Law of Motion

1. Have students place their car on the flat smooth floor and wait for it to move. If the spot is level, you might be there a while. Did you bring something to eat while you wait? Is there a bathroom nearby? How will you sleep and watch your car at the same time? Face it, unless an outside force is applied, that car will not move from its place.

Newton: 1 Skeptics: 0

2. Build a short ramp out of some books and a piece of cardboard or wood. Place your car at the top of the ramp and let go. How about that?! It rolled down the ramp in a straight line! If there was carpet at the bottom, the car probably stopped quickly. If it was a harder surface, like wood, the car rolled on for

a little ways before stopping. Bottom line, it stopped (or was stopped by a wall or your hand or friction with the floor). In any case, an outside force was needed to stop the car.

Newton: 2 Skeptics: 0

Second Law of Motion

1. Place your car on a hard, level surface without a soda bottle on it. Mark the starting point with a piece of tape. Gently blow on the back of the car (or use a paper plate as a fan) and make it roll forward. Mark the spot where the car stops with a piece of tape.

2. From the same starting point, blow (or fan) even harder and see how much farther the car moves. Mark the stopping point with the tape. You blew (or fanned) harder and the car went further. More force was applied to the same car on the same surface and it went farther. But then, you knew that would happen

Newton: 3 Skeptics: 0

3. Do the same thing (blowing or fanning, marking with tape, etc.) again but have the empty 2-liter bottle on the car this time. When you finish that, load the car with a full bottle of soda and, you guessed it, repeat. Odds are the car moved with the empty 2-liter bottle on it but you either passed out or collapsed from exhaustion from fanning with the loaded soda bottle. It's a no-brainer. Way more force is needed to move the full bottle.

Newton: 5 Skeptics: 0

Third Law of Motion

Testing this law (but you may already know the outcome) means you have to use your Soda Geyser Car with Oh, gee, that's too bad!

1. Go with your adult helper to the approved launch site. Mark a starting line with a piece of tape and mark a finish line 10 m away.

2. Review the launch sequence with your adult helper. Practice is a good thing since setting the car on the same starting point each time is important.

3. When you're ready, load 3 MENTOS into the Turbo Geyser Tube and lock it. You know the drill from here. (See the third activity above for a refresher if you need it.) Just be sure to nail the same starting point for each test. Think about the "speed" your car had as it moved toward the finish line.

4. Now, repeat the run with the exact same set up except use 6 MENTOS this time. The variable you're testing is showing if the geyser is bigger, the car moves faster. This run should cross the finish line much sooner. The Third Law of Motion says a bigger backward push results in a bigger forward push.

Newton trounces Skeptics in a 7-zip shut out!! **Now, do you think this might apply to rockets? How?**

Bigger, Better, Boom!

At the same time as Willem Gravesand was building his steam cars, rocket experimenters in Germany (have students find and mark Germany on a map) and Russia (have students find and mark Russia on a map)began working with rockets of greater and greater mass. Some of these rockets became so powerful that their escaping exhaust flames bored deep holes in the ground even before liftoff.

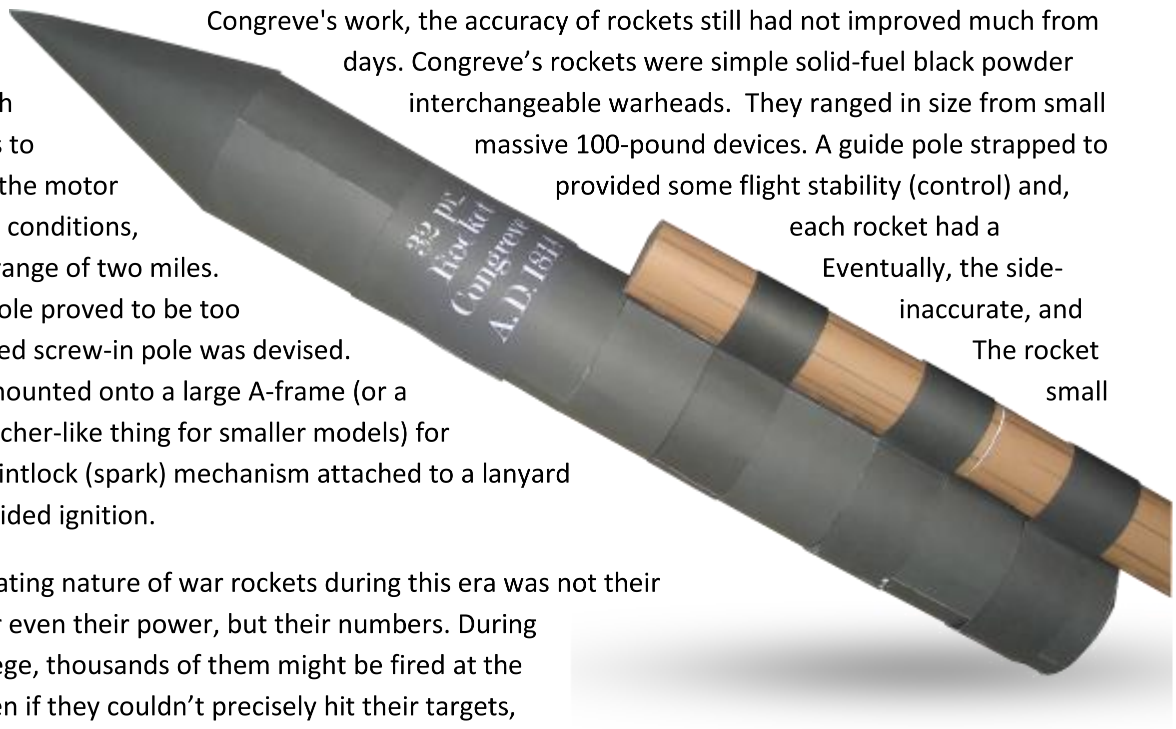
Toward the end of the 18th century and early into the 19th, rockets experienced a brief revival as a weapon of war. The success of Indian (have students find and mark India on a world map)rocket barrages against the British (have students find and mark England on a map) in 1792 and again in 1799 caught the interest of an artillery expert, **Colonel William Congreve**, who set out to design rockets for use by the British military.

The Congreve rockets were highly successful in battle. Used by British ships to pound Fort McHenry (Baltimore, MD, have students find and mark it on the map) in the War of 1812, they inspired **Francis Scott Key** to write about "the rockets' red glare" in his poem, "The Siege of Fort McHenry," which we know today as "The Star-Spangled Banner."

THE STAR-SPANGLED BANNER

September 13, 1814, nineteen British vessels are lined up along the shore. One of them, the HMS Erebus, floats about among the fleet. Down below, under the muffled crack of mortars and cannon, crewmen bring up a strange device from the ship's stores. It's a long, awkward and heavy thing, a thin, whispy wooden rod with a pointed tube of metal strapped to the very end. Through careful maneuvering this device is set up along a slanted wooden ramp that reaches almost to the top deck. Poking its shiny black head out of a hole cut into the ship's side, the weapon lies in wait. The officer in charge waits as more weapons are readied. The order is given, and all at once, the three men manning the ropes give the strings a firm yank. The hammers click loudly in succession, the flashpans giving a nice spark and puff of smoke. Then, suddenly, one of the rockets sputters to life, a jet of smoke and red flame shooting out its rear. The rocket shudders for a second, but quickly leaps from the launch ramp and into the night sky. Two more follow suit in less than a second. Smoky, billowing tendrils of red flame shoot from the sides of the ship as the rockets hurtle towards the enemy. Three successive explosions rock the fort over by the shore, indistinguishable from the countless other blasts that the Navy has brought upon the battlements.

Five bomb vessels and the rocket ship HMS Erebus were the main bombardiers, flinging their explosive payloads out of range of the American cannons. These ships provided the "Rockets' Red Glare and the Bombs Bursting in air" over the Fort. Lawyer Francis Scott Key was aboard one of the marauding ships, the HMS Tonnant, an 80-gun Ship of the Line. From there, he witnessed the entire battle. The siege lasted for 25 hours, and during the entire battle, the fort's garrison flag remained flying. This flag, dubbed "The Star-Spangled Banner" inspired Key to later describe his experience in the patriotic poem "Defence of Fort McHenry". In 1916, President Woodrow Wilson issued an executive order making the first stanza of the song the National Anthem of the United States of America.



Even with Congreve's work, the accuracy of rockets still had not improved much from the early days. Congreve's rockets were simple solid-fuel black powder devices with interchangeable warheads. They ranged in size from small 6-pounders to massive 100-pound devices. A guide pole strapped to the side of the motor provided some flight stability (control) and, under ideal conditions, each rocket had a maximum range of two miles. Eventually, the side-mounted pole proved to be too inaccurate, and so a centered screw-in pole was devised. The rocket would be mounted onto a large A-frame (or a small mortarlauncher-like thing for smaller models) for launch. A flintlock (spark) mechanism attached to a lanyard (rope) provided ignition.

The devastating nature of war rockets during this era was not their accuracy or even their power, but their numbers. During a typical siege, thousands of them might be fired at the enemy. Even if they couldn't precisely hit their targets, the effects of such a rain of rockets could be devastating! All over the world, rocket researchers experimented with ways to improve accuracy.

You see, building an efficient rocket engine is only part of the problem in producing a successful rocket. The rocket must also be stable in flight. A stable rocket is one that flies in a smooth, uniform direction. An unstable rocket flies along an erratic path, sometimes tumbling or changing direction. Unstable rockets are dangerous because it is not possible to predict where they will go. They may even turn upside down and suddenly head back directly to the launch pad!

Making a rocket stable requires some form of control system. Controls can be either active or passive. The difference between these and how they work will be explained later. It is first important to understand what makes a rocket stable or unstable.

All matter, regardless of size, mass, or shape, has a point inside called the center of mass (CM).

Balancing Act

The center of mass is the exact spot where all of the mass of that object is perfectly balanced.

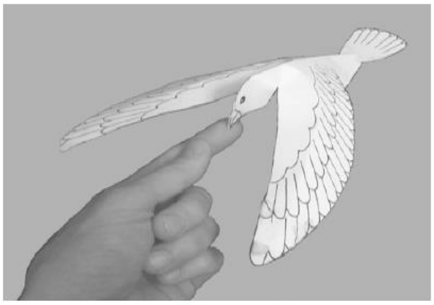
Students can easily find the center of mass of an object such as a ruler by balancing the object on their finger. Have them try it using rulers.

If the material used to make the ruler is of uniform thickness and density, the center of mass should be at the halfway point between one end of the stick and the other. If the ruler was made of wood, and a heavy nail was driven into one of its ends, the center of mass would no longer be in the middle. The balance point would then be nearer the end with the nail.

Now that they've got the idea, let's apply our balancing act to a bird!

Materials:

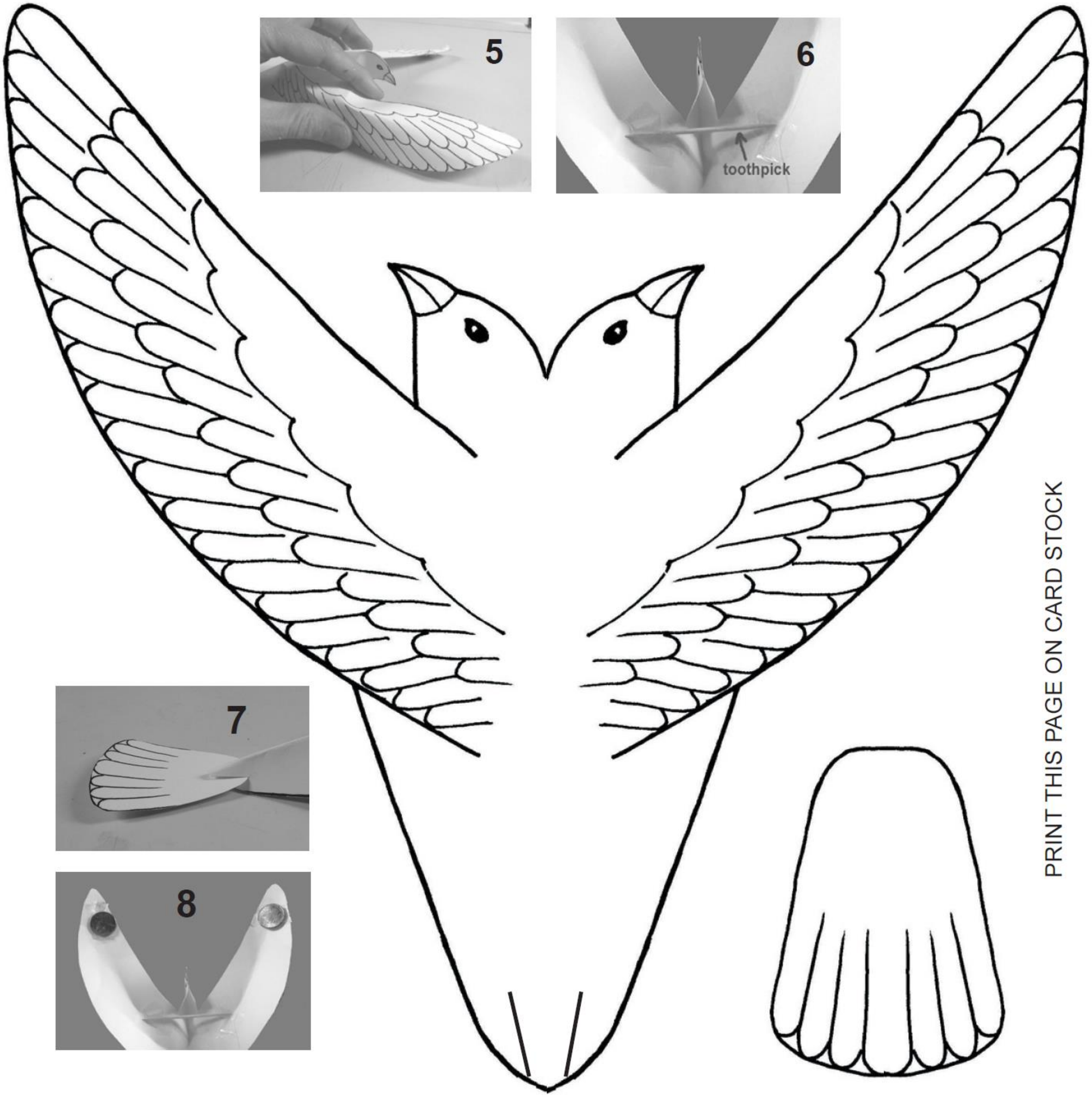
- Pennies
- Toothpicks
- Clear Tape
- Coloring Supplies
- Glue Sticks
- Printouts on cardstock



BALANCING BIRD TOY

<u>You will need</u>:
• two pennies, a toothpick, clear tape, glue stick (optional: coloring supplies)

1) Do any coloring you want to do. 2) Cut out bird and tail. Make sure to cut along the wing lines that go into the body area. 3) Fold the bird in half. 4) Apply glue stick to inside of the forward half of head (eye and beak area) and stick halves together. (Note: Beak can be reinforced with clear tape if it seems too flimsy.) 5) Make a slight crease along the lengths of the wings, to stiffen them. 6) Tape toothpick to underside of wings, across the center, (like the cross bar of a kite). 7) Insert tail piece and secure with tape on the underside. 8) Roll two pieces of tape and apply one to each penny. Stick pennies on the undersides of the ends of the wings and then check balance. Adjust the pennies if necessary to make the bird balance well. Once pennies are in the right place, secure them with a little more tape.



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Rocking & Rolling

The center of mass is important in rocket flight because it is around this point that an unstable rocket tumbles. As a matter of fact, any object in flight tends to tumble. Let's test it!

If students (under supervision and carefully) throw a stick what happens? It tumbles end over end. Throw a ball? It spins in flight. The act of spinning or tumbling is a way of becoming stabilized in flight.

A Frisbee will go where you want it to only if you throw it with a deliberate spin. So what happens if you don't? Have students try throwing a Frisbee without spinning it. If they succeed, they will see that the Frisbee flies in an erratic path and falls far short of its mark.

Although a poorly passed football may still fly to its mark even if it tumbles rather than rolls, a rocket will not.

Feeling Stable

The Englishman **William Hale** developed a technique called **spin stabilization**, in which the escaping exhaust gases expanded through small vanes at the bottom of the rocket, causing it to spin much as a bullet does in flight. Variations of this principle are still used today.

Rockets continued to be used with success in battles all over the European continent. However, in a war with Prussia (have students find and mark Prussia on a map), the Austrian rocket brigades met their match against newly designed artillery pieces. Breech-loading cannon with rifled barrels and exploding warheads were far more effective weapons of war than the best rockets. Once again, rockets were relegated to peacetime uses such as fireworks.

20th Century and Beyond: Modern Rocketry

In 1898, a Russian schoolteacher, **Konstantin Tsiolkovsky** (1857-1935), proposed the idea of space exploration by rocket. In 1903, Tsiolkovsky published a report entitled ***Exploration of the Universe with***

JULES VERNE - FICTION INSPIRES FACT

The dream of traveling through space was brought to life by French science fiction writer Jules Verne.

In his novel *De la Terre á la Lune* (From the Earth to the Moon) and its sequel Round the Moon, Verne used a giant cannon to fire a manned projectile at the Moon.

Although not a rocket, the projectile had some interesting parallels with the future Apollo Moon program. It was called the Columbiad and contained a crew of three. It was fired at the Moon from Florida.

The Apollo 11 capsule was named Columbia, contained a crew of three, and was launched from Florida. Verne correctly described how the crew would feel "weightless" on their voyage.

Of course, the crew would not have survived the initial acceleration of the cannon firing. Nevertheless, Verne, an early space exploration visionary, fired the imaginations of many would-be rocketeers and future astronauts.

Rocket Propelled Vehicles. In it, he suggested the use of liquid propellants for rockets in order to achieve greater range. Tsiolkovsky stated that the speed and range of a rocket were limited only by the exhaust velocity of escaping gases. Is he right?

Balloon rockets

Find an excellent explanatory/demonstration video of this activity here:
http://www.scienceoffcenter.org/science/162-balloon-rockets

Materials Per Rocket

- A balloon
- String (kite string and dental floss work well, but feel free to experiment!)
- A straw
- Scissors
- Tape
- A Paperclip

The students' task is to design an efficient balloon rocket which will be propelled along a length of nylon fishing line or dental floss. The efficiency of the rocket will be tested in two ways:

- How far the rocket goes along the nylon fishing line
- How fast the rocket goes in the first 5 meters.

Put students into pairs. Teams are to use only the simple materials they've been given in their test—balloons, drinking straws, adhesive tape and nylon fishing line.

When you blow up a balloon and let it go, it flies around the room out of control. But add a guidance system and you no longer have a crazy flying party favor. Now, it's a rocket!

So how do you make a guidance system? First, grab a straw. If it is a bendy straw, use scissors to cut off the bendy part so you only have the boring straight part left.

Next, we need some string. Dental floss and kite string work well, but it's never bad to experiment and learn. Students might find something that works even better!

Have students take one end of the string and feed it through the straw until it pops out of the other end. You may want to have them tie a paperclip onto the end to prevent the string from sliding back through the straw.

Now that their string is through the straw, have them grab their balloon and blow it up. Make sure to remind them to hold the end closed to no air escapes. Now, have them ask their partner to place the straw on the side of your balloon and attach the straw using tape.

Looks like we're nearly ready to launch! Make sure they stretch their string out and hold it tight on both ends. Have them take a look at their balloon to make sure they have it at the right end. They want the nozzle of their rocket (the part they used to blow up their balloon) pointing towards them so the balloon can fly away from them. Ready? 3...2...1...BLAST OFF!

So this is fun, but really this balloon zipping along on a string is nothing like a real rocket, right?

Actually, our balloon rocket works the same as a real rocket! The balloon rocket is a simple model for how rockets work and allows us to investigate Newton's Laws of Motion. In particular, Newton's Third Law of Motion which states: "For every action, there is an equal, but opposite reaction."

So what does this mean? Because we are talking rockets, let's think about what has to happen to make that rocket launch. Inside a big NASA rocket, a chemical reaction will occur to produce an expulsion of gas in the rocket engine. The gas expands and the rocket pushes it out. In return, the gas pushes on the rocket making it rise into the sky.

Our balloon is very similar. When we blow up our balloon the air inside pushes against the ballon and the balloon also pushes back against the air. When we let go, the balloon is able to squeeze all that air out, but the air also pushes back against the balloon causing to fly around the room, or if we've attached a guidance system, across the room in a straight line.

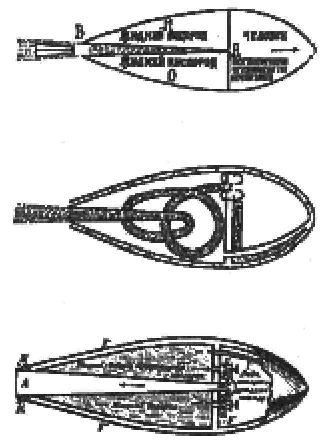
See how far you can make your balloon rocket fly and have fun experimenting!

Discussion

1. 1 Compile class results of the two tests and chart them.
2. 2 Which design features are important in making a balloon rocket?
3. 3 What caused the motion of the rocket?
4. 4 How well would their rocket go in space? Explain.
5. 5 How would they design their rocket to test whether altering the size of the jet (where the air comes out of the balloon) has an effect on the speed of the rocket? Try it!

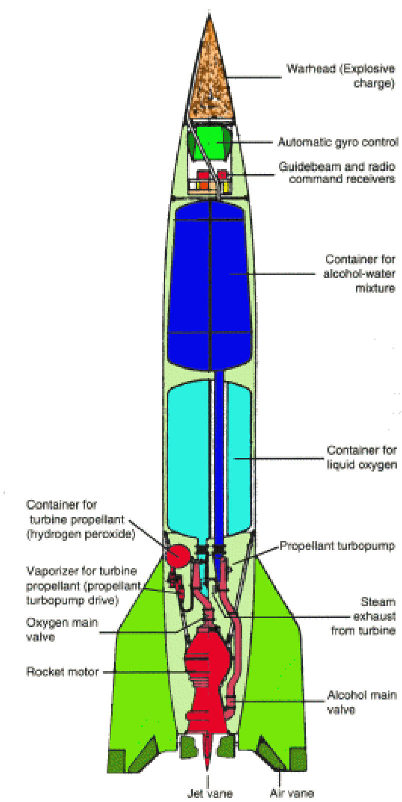
The balloon rocket moved forwards (the reaction force) because air was forced out of the balloon in the opposite direction (the action force). What were your rockets’ speed and range limited by?

Rocket Man!



Tsiolkovsky Rocket Designs

For his ideas, careful research, and great vision, Tsiolkovsky has been called the **Father of Modern Astronautics**.



German V-2 (A-4) Missile

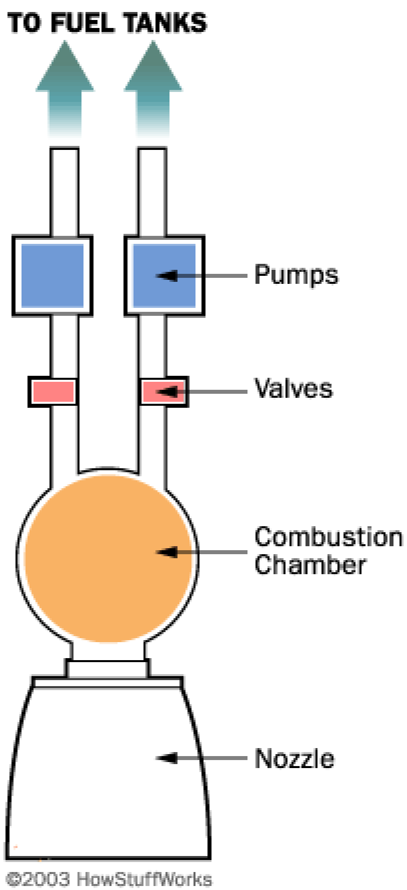
Early in the 20th century, an American, **Robert H. Goddard** (1882-1945), conducted a variety of practical experiments in rocketry. He was interested in a way of achieving higher altitudes than were possible for lighter-than-air balloons. He published a pamphlet in 1919 entitled ***A Method of Reaching Extreme Altitudes***, a mathematical analysis of what is today called the **meteorological sounding rocket**.

Goddard's earliest experiments were with solid-propellant rockets. A solid fuel rocket has its fuel and oxidant mixed together as fine powders and then pressed in to a solid 'cake'. Once it has been lit it will carry on burning until it is used up. The result is that huge amounts of high pressure, high temperature exhaust is thrown out but that it carries with it massive amounts of energy in the form of gas pressure and heat. All of this goes to waste.

In 1915, Goddard began to try various types of solid fuels and to measure the exhaust velocities of the burning gases. While working on solid-propellant rockets, Goddard became convinced that rocket efficiency would be greatly improved by using liquid fuel. No one had ever built a successful liquid-propellant rocket before. Doing so was much more difficult than building solid-propellant rockets. Fuel and oxygen tanks, turbines, and combustion chambers all would be needed.

In spite of numerous difficulties, Goddard achieved the **first successful flight with a liquid-propellant** rocket on March 16, 1926 at at 20 Upland Street, Auburn, Massachusetts (have students locate and mark it on the map). Fueled by liquid oxygen and gasoline, the rocket flew for only two and a half seconds, climbed 12.5 meters/41 feet, and landed 56 meters/184 feet away in a cabbage patch. By today's standards, the flight was unimpressive. But like the first powered airplane flight by the Wright brothers in 1903, Goddard's gasoline rocket was the forerunner of a whole new era in rocket flight. Rocket engine design, including pumping mechanisms, cooling strategies and steering arrangements are what make liquid-propellant rockets so complicated.

The basic idea is simple. In most liquid-propellant rocket engines, a fuel and an oxidizer (for example, gasoline and liquid oxygen) are pumped into a combustion chamber. There they burn to create a high-pressure and high-velocity stream of hot gases. These gases flow through a nozzle that accelerates them further (5,000 to 10,000 mph exit velocities being typical), and then they leave the engine. The following highly simplified diagram shows you the basic components.



This diagram does not show the actual complexities of a typical engine. For example, it is normal for either the fuel or the oxidizer to be a cold liquefied gas like liquid hydrogen or liquid oxygen. One of the big problems in a liquid-propellant rocket engine is cooling the combustion chamber and nozzle, so the cold liquids are first circulated around the super-heated parts to cool them. All of this pumping and cooling makes a typical liquid propellant engine look more like a plumbing project gone haywire than anything else.

All kinds of fuel combinations get used in liquid propellant rocket engines. For example:

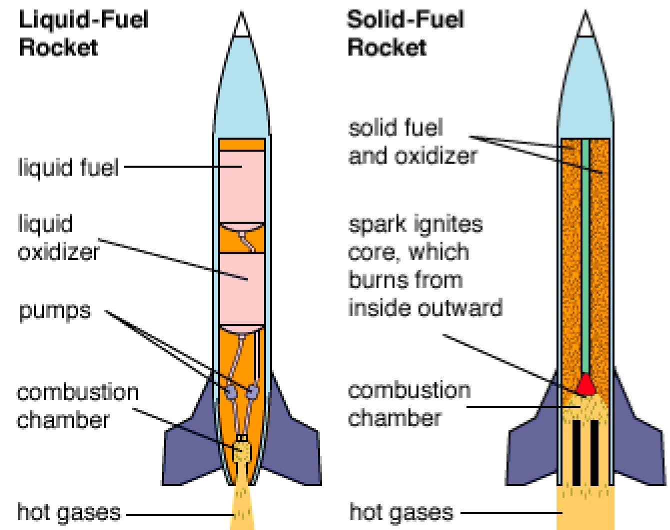
- **Liquid hydrogen and liquid oxygen** - used in the Space Shuttle main engines
- **Gasoline and liquid oxygen** - used in Goddard's early rockets
- **Kerosene and liquid oxygen** - used on the first stage of the large Saturn V boosters in the Apollo program
- **Alcohol and liquid oxygen** - used in the German V2 rockets

The Future of Rocket Engines

We are accustomed to seeing chemical rocket engines that burn their fuel to generate thrust. There are many other ways to generate thrust however. Any system that throws mass would do. If you could figure out a way to accelerate baseballs to extremely high speeds, you would have a viable rocket engine. The only problem with such an approach would be the baseball "exhaust" (millions of high-speed baseballs at that) left streaming through space. This small problem causes rocket engine designers to favor gases and atoms for the exhaust product.

Goddard's experiments in liquid-propellant rockets continued for many years. His rockets became bigger and flew higher. He developed a **gyroscope system for flight control** and a **payload compartment for scientific instruments**. **Parachute recovery systems** were employed to return rockets and instruments safely. Goddard, for his achievements, has been called the **Father of Modern Rocketry**.

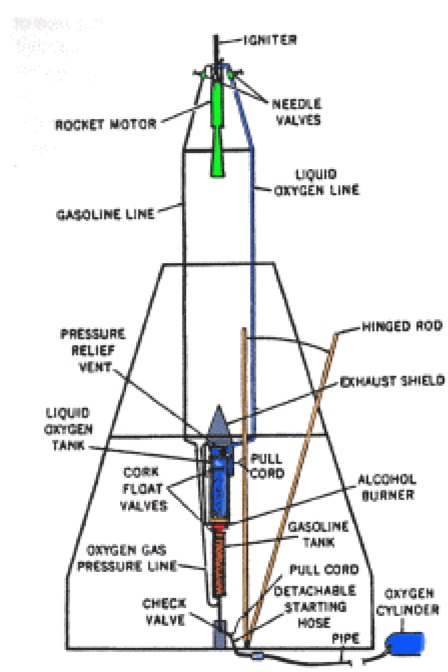
In 1923 a third great space pioneer, **Hermann Oberth** (1894-1989), published a book entitled ***The Rocket into Interplanetary Space***. His book became the handbook for amateur rocketeers. Because of Oberth's work, many small rocket societies sprang up around the world. In Germany, the formation of one such society, the **Verein fur Raumschiffahrt**(**Society for Space Travel**), led to the development of the **V-2 rocket**, which was used against London during World War II. In 1937 Oberth and other German engineers and scientists assembled in Peenemunde on the shores of the Baltic Sea (have students find and mark Peenermund/the Baltic Sea on the world map). There the most advanced rocket of its time was built and flown under the direction of **Wernher von Braun**. For his achievements, Oberth has been called the **Father of Space Flight**.



The V-2 rocket (in Germany called the A-4) was small by comparison to today's rockets. It achieved its great thrust by burning a mixture of liquid oxygen and alcohol and was able to lob a one-ton warhead 50 miles high and hundreds of miles down range. The rocket fuselage was made of thin, collapsible metal that was inflated with the introduction of fuel into the tanks. Once launched, the V-2 was a formidable weapon that could devastate entire city blocks.

Fortunately for London and the Allied forces, the V-2 came too late in the War to change its outcome. Nevertheless, by the War's end, German rocket scientists and engineers had already laid plans for advanced missiles capable of spanning the Atlantic Ocean (have students find and the Atlantic on the world map and trace the path the rockets could have flown). and landing in the United States. These missiles would have had winged upper stages but very small payload capacities.

With the fall of Germany, many unused V-2 rockets and components were captured by the Allies. Many German rocket scientists came to the United States, while others went to the Soviet Union. The German



Dr. Goddard's 1926 Rocket

scientists who came to the U.S., including Wernher von Braun and Georg von Tiesenhausen, were amazed at the progress Goddard had made.

Both the United States and the Soviet Union realized the potential of the rocket as a military weapon and began a variety of experimental programs. The U.S. site chosen by von Braun and his colleagues was Redstone Arsenal in Huntsville, Alabama,((have students find and mark Huntsville, AL on the world map) the site at which NASA's Marshall Space Flight Center stands today. The United States first began developing its space program with high-altitude atmospheric sounding rockets, one of Goddard's early ideas. Later, a variety of medium- and long-range intercontinental ballistic missiles were developed. These became the starting point of the U.S. space program. Missiles such as the **Redstone**, **Atlas**, and **Titan** would eventually launch astronauts into space.

On the night of October 4, 1957 Americans watched with rapt attention and deep unease as a small, shiny point of light moved quickly across the night sky. Looking like a little shooting star, it was a tiny satellite launched that day by the Soviet Union. It was the first manmade object to reach space. Sputnik I, as it was called, a name meaning “companion,” orbited the earth once every 96 minutes, weighed 183 pounds, and emitted sound signals at regular intervals from the two radios it carried. Those bleeps, used to monitor Sputnik’s location and progress, sounded as an alarm bell to Americans. The Russians were demonstrating in the most public possible way that they were ahead of the United States in claiming space. This shocked and terrified Americans. It was the first successful entry in a race for space between the two superpower nations and made the world afraid.

Immediately following the collective international gasp that greeted Sputnik 1 in 1957, Premier Khrushchev gave Sergei Korolev and his design team approximately one month to outdo their triumph just in time for the fortieth anniversary of the Russian Revolution. Sputnik 2 would send a live passenger into orbit. When most people think of the space program, it's images of stalwart, clear-eyed astronauts roaring into the skies on rockets of destiny that come to mind.

However, some scientists believed humans would be unable to survive the launch or the conditions of outer space, so engineers viewed flights by animals as a necessary precursor to human missions. Less than a month after Sputnik 1 flew, the Soviets followed with the launch of Sputnik 2 carrying a dog named Laika on board.

Laika, which means "barker" in Russian, was a three-year old, stray mutt who was rounded up off the streets of Moskow and trained for space travel. She weighed thirteen pounds and had a calm demeanor. She was placed in her restrictive module several days in advance and then right before launch, she was covered in an alcohol solution and painted with iodine in several spots so that sensors could be placed on her. The sensors were to monitor her heartbeat, blood pressure, and other bodily functions to better understand any physical changes that might occur in space.

Though Laika's module was restrictive, it was padded and had just enough room for her to lay down or stand as she wished. She also had access to special, gelatinous, space food made for her.

On November 3, 1957, Sputnik 2 launched from Baikonur Cosmodrome (now located in Kazakhstan near the Aral Sea-**map it!**). The rocket successfully reached space and the spacecraft, with Laika inside, began to orbit the earth. The spacecraft circled the earth every hour and forty-two minutes, traveling approximately 18,000 miles per hour. As the world watched and waited for news of Laika's condition, the Soviet Union announced that a recovery plan had not been established for Laika. With only three weeks to create the new spacecraft, they did not have time to create a way for Laika to make it home. The de facto plan was for Laika to die in space.

Just before the launch, one of the scientists, Vladimir Yazdovsky, took Laika home to play with his children. "I wanted to do something nice for her," he wrote in his own account of the mission. "She had so little time left to live."

Though all agree Laika made into space and successfully lived through several orbits, there is a question as to how long she lived after that. Some say that the plan was for her to live for several days and that her last food allotment contained poison to put her to sleep. Others say she died four days into the trip when there was an electrical burnout and the interior temperatures rose dramatically. And still others say the most proof points to the theory that she died slowly and painfully five to seven hours into the flight from stress and heat.

"…what Soviet Mission Control did not mention was that the hurried, untested design of Sputnik 2 had lost a heat shield during launch. The fan's sensors indicated almost immediately that it couldn't keep the tiny capsule at 15 degrees Celsius. Within minutes, the carbon monoxide absorbing device became woefully inadequate for a breathing rate [from her sensors] that indicated panic. Deep black lines in the

tickertape came in to Mission Control in the jagged geometry of soundless cries. The famous heart monitor dutifully recorded that Laika's doggy heart rate increased threefold and so an underling was ordered to splice in and play, in an endless loop, a recording of another dog's heart, any dog's heart, lickety-split. What was not recorded was what Laika thought while slowly dying, alone in space.

It took five full hours for her to die. Some of the scientists removed their headphones and turned away from the paper graphs spewing from the console. Finally someone yelled "It's over." Someone else pulled the paper and folded it, and put it in an envelope marked Laika, which was then put in a locked box on which was written TOP SECRET, to be looked at later."

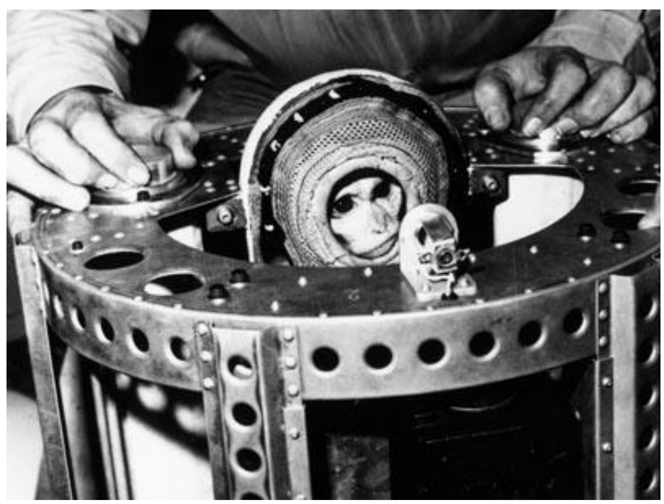
Animals in Space!

Laika, was the first animal to orbit Earth. However, Laika was not the first animal in space. The United States and the U.S.S.R. had been putting animals atop rockets since 1947.

In the early days of rocket science, no one knew what the effects of weightlessness would be. Animals—mainly dogs, monkeys and chimps — were used to test the safety and feasibility of launching a living being into space and bringing it back unharmed.

Since then, animals have continued to play an important role in understanding the impact of microgravity on many biological functions. Astronauts have studied all kinds of animals—wasps, beetles, tortoises, flies, worms, fish, spiders, rabbits, bees, ants, frogs, mice, crickets, rats, newts, snails, urchins, moths, brine shrimp, jellyfish, guinea pigs, butterflies, scorpions and cockroaches.

However, we know she certainly did not live beyond six days into trip, because on the sixth day, the batteries in the spacecraft died and all life-support systems failed. Sputnik-2, which weighed half a ton and was reportedly launched to commemorate the 40th Anniversary of the Bolshevik Revolution, continued to circle the earth for 163 days. During that time, it completed 2,370 orbits and traveled approximately 100 million kilometers. On April 14, 1958, the spacecraft...carrying the body of its valiant little pioneer...fell out of orbit and burned up during re-entry into the Earth's atmosphere. Since there was no recovery procedure for true orbital flights in 1957, Laika is the only creature knowingly sent into space to die. Her death sparked animal rights debates across the planet. In Russia, Laika and all the other creatures that made space flight possible are remembered as heroes.



Subsequent missions in the Soviet space program that carried dogs were designed to be recovered; the only two other dogs who died in space, did so in an accident, when Korabl-Sputnik 3 disintegrated upon re-entry into Earth's atmosphere in 1960. And Laika has a statue and plaque at Russia's Star City (the Russian training facility for cosmonauts) honoring the animal bold enough to go where no one had gone before, but unable to comprehend that she'd never make it back.

In November of 1997, a plaque commemorating the contributions of Laika and other animals that were studied in the space program was unveiled at the Institute for Aviation and Space Medicine at Star City, just outside Moscow (have students find and mark Moscow on the world map).. The monument itself pays tribute to the fallen Russian cosmonauts, but in a corner is the image of a small mongrel dog...ears standing straight. A year later, one of the former lead scientists who had worked on the Soviet "animals-in-space" program expressed his deep regrets regarding Laika:

"The more time passes, the more I'm sorry....

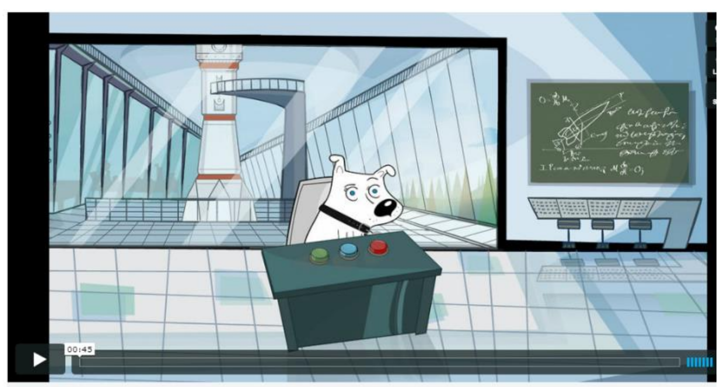
We shouldn't have done it....

We did not learn enough from the mission to justify the death of the dog."

Image: Detail of “Laika”, by Phineras X Jones. Prints available from the artist.

Laika’s compelling story is told in graphic novel form in *Laika* by Nick Abadzis Nick Abadzis masterfully blends fiction and fact in the intertwined stories of three compelling lives. Along with Laika, there is Korolev, once a political prisoner, now a driven engineer at the top of the Soviet space program, and Yelena, the lab technician responsible for Laika's health and life. This intense triangle is rendered with the pitch-perfect emotionality of classics like *Because of Winn Dixie, Shiloh,* and *Old Yeller.* No one can walk away from this book untouched.

LAIKA, a short 8:48 minute long film from Avgousta Zourelidi, is a more light-hearted re-imagining of the true story about the first dog in space and what may have happened to her on her momentous journey.
An intelligent creature, curious and proud she fulfills her duty taught to her by the scientists back on earth. Laika daydreams of her life before space travel and her humble beginnings on the streets of Moscow. Have students watch it at http://vimeo.com/54536669.



Have students compare and contrast the different versions of her story. What did they learn from each? Which is their favorite? What were some things that were the same in each story? What were some of the differences they noticed? How does each version contribute to the way they understood the story? Which version is the most "true?" Why do humans sometimes give story versions of real events happier endings than what really happened?

Debate it!

Even today, the debate on animal research has been a highly sensitive topic in the media. While animal testing by scientists has been fraught with controversy still, it's a fact that animals are captured for experiments, 4.1 million experiments were conducted on animals in 2012. Heated debates rage between those who do and those who do not support such experiments. Humanity has always been caught in dualities. While there is a positive side to one aspect, the negative side also exists. Help students discover both sides of the coin in this activity.

Present students with a debate where they must face problem situations that require the application of persuasive language skills. NASA and other scientific groups have asked them to present their arguments on the question, "Should animals be used for research and testing? Why or why not?" What are points in favor? What are opposing points? Have we achieved milestones in curing diseases by testing and killing meek animals? Are such medical breakthroughs worth their lives? If animals can't speak, does it mean we can use them as we wish, just because we're powerful?

For example, do students agree or disagree with the following opinions?

- "Which is worse, a human or an animal dying? Humans are worth more than animals."
- "It isn't as bad as testing it on humans and not knowing the outcome."
- "That is hurtful and not necessary!"
- "Animal testing saves millions of lives every year."
- "Animals have feelings and don't talk. They can't say no. We should not take advantage of that because it's the wrong thing to do."

- Various dangerous diseases like herpes simplex, hepatitis B, polio, rabies, malaria and mumps have been treated owing to medications developed from tests on animals.
- “Testing products for humans on animals never works because we are not animals, close is not good enough. What better way to find out if things effect humans is testing it on humans. Use people who are in prison for life.”
- Results through medical research on animals has led to improvement in medical procedures like blood measurement, lung diseases diagnosis, heart diseases diagnosis and various pacemaker technologies.
- One of the most important techniques in medical surgery, anesthesia has been developed after it has been tested on animals.
- “It's not even a debate, who would trade the life of a sibling or friend for that of an animal? It's not worth it. Humans have astronomical potential, whereas even though animals have feelings and it hurts them, it’s a low price to pay for the things they are providing.”
- “It would be even more inhumane than it is now to use humans as test subjects in laboratories. These animals allow us to develop cures for diseases or other medical issues we have. I think it's worth it.”
- “Many animals in laboratories are deliberately bred to have painful defects. Because it’s for science doesn’t mean that it is right!”
- “New drugs like the HPV vaccine (developed in dogs and cows) have been very effective at cutting cancer rates, Herceptin (tested in mice) is one of the best cancer drugs we have. Even scanning techniques are improving, with help from animal studies.”
- “"The history of cancer research has been the history of curing cancer in the mouse. We have cured mice of cancer for decades, and it simply didn't work in humans."

Note-taking

This is essential to debating as well as to success in school. But students aren't (let’s face it) very good at taking notes. Teachers are always saying that students need to take notes, but there are very few situations in school where students actually need to *use* the notes for something- even when the teacher says the notes will help on the test, they often don't. One of the many nice things about debate as a teaching strategy is that it creates an incentive system for students to take notes. The better their notes, the more they'll win. As you can see with the refutation method, students are expected to refer specifically to the argument they're about to answer. They need to have it written down to answer it. As debates get more complex, with multiple students in the discussion, students need better skills to track arguments as they develop (or don't) in discussions and debates. So, they learn to be better note-takers. Tip: Graphic organizers with multiple columns are essential for taking notes in a situation where ideas are being exchanged, developed, and refuted.

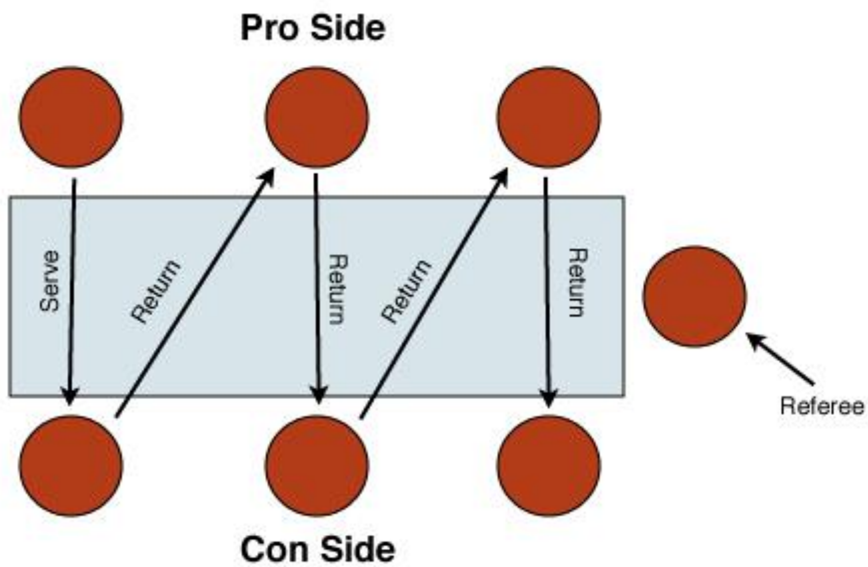
For Tennis Debates, students will be assigned to a team of three.

Student Instructions:

Each team of three will debate another team of three. I (the teacher) will announce the topic and give you a team number. Once you get the topic and receive your team number, go to your designated table. Take your notes with you, because you’ll be able to use them while preparing.

After the topic is announced, the referee will flip a coin to determine which team will be pro and which will be con. Then, all teams have 10 minutes to work together, preparing their arguments and ideas from their notes.

Once the preparation period is over, the first student from the pro team “serves” by making an argument for their side. Then, the other side “returns” the serve by refuting the argument. The process continues until the ball reaches the last player or until one team drops the ball (see rules).



Normally, games are played to 5 points.

RULES FOR TENNIS DEBATES

1. A team can only score a point when they have “served” the ball and the other side drops the ball.

2. If the team that serves drops the ball, the serve goes to the other side.

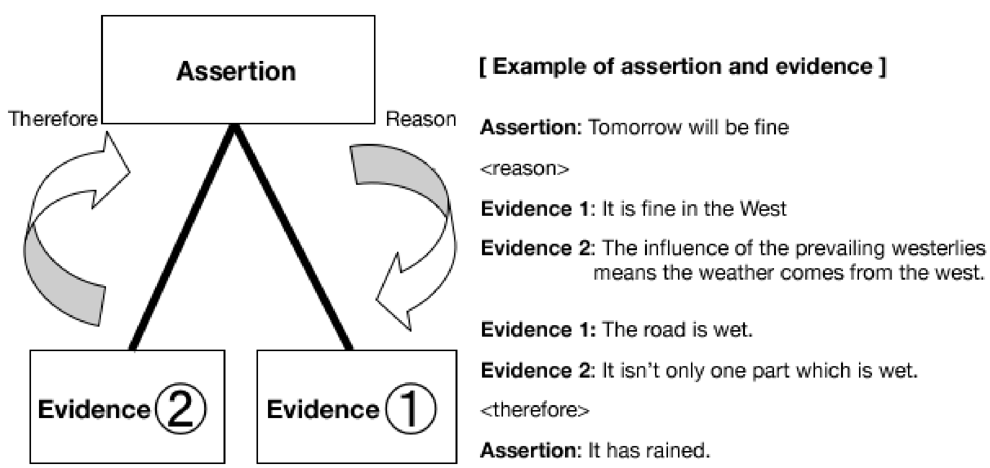
3. The serve rotates between players. Once you’ve served, the next serve for your team goes to the player on your left. (ADVICE: Often it helps to actually have a "ball" for each table so it's easier to keep track of who's talking)

4. A team is said to drop the ball when any of the following rules have been violated.

• Players must respond within 15 seconds.

•Players **must not** repeat a point that has already been made without adding anything new.

•Older players must use A-R-E to construct their arguments. *Assertion, reasoning, and evidence. An assertion is a statement that something is so. Reasoning is the "because" part of an argument, and evidence is the "for example" part, that supports the reasoning. It's*



used to validate or support the reasoning.

•Older players must use 4-Step Refutation when answering arguments from the other side. *Step one is "They say..." That's the part where you refer to the argument you're about to answer. Step two is "But..." That's where you make your counter. You can make a counter-assertion ("They say the Backstreet Boys are a good band, but they're not.") or attack the reasoning or evidence that's been offered ("They say that the Backstreet Boys are a good band because they're popular, but just because you're popular, that doesn't mean you're good."). Step three is "Because..." This is the part where you offer reasoning (and evidence, if possible!) to support your counter-argument. Step four is "Therefore..." This is where you make your conclusion - essential summarization.*

Sample Pros:

- Various dangerous diseases like herpes simplex, hepatitis B, polio, rabies, malaria and mumps have been treated owing to medications developed from tests on animals.
- Results through medical research on animals has led to improvement in medical procedures like blood measurement, lung diseases diagnosis, heart diseases diagnosis and various pacemaker technologies.
- One of the most important techniques in medical surgery, anesthesia has been developed after it has been tested on animals.
- Animal research has been also able to benefit cats and dogs in certain ailments. Moreover, nutrition of cats and dogs has been improved after repeated animal tests.

Note-taking

This is essential to debating as well as to success in school. But students aren't (let's face it) very good at taking notes. Teachers are always saying that students need to take notes, but there are very few situations in school where students actually need to *use* the notes for something- even when the teacher says the notes will help on the test, they often don't. One of the many nice things about debate as a teaching strategy is that it creates an incentive system for students to take notes. The better their notes, the more they'll win. As you can see with the refutation method, students are expected to refer specifically to the argument they're about to answer. They need to have it written down to answer it. As debates get more complex, with multiple students in the discussion, students need better skills to track arguments as they develop (or don't) in discussions and debates. So, they learn to be better note-takers. Tip: Graphic organizers with multiple columns are essential for taking notes in a situation where ideas are being exchanged, developed, and refuted.

Spacey Pudding: Astronaut Food - The Science Lesson

Now that we're done debating, it's time for a sweet treat inspired by the FeelsLikeHome blog at http://www.feelslikehomeblog.com/2013/09/how-to-make-astronaut-pudding/.

This activity is a fun way to demonstrate to kids the challenges of living and working in space, where every single thing must be brought in aboard a space capsule.

Everything that astronauts eat in space is freeze dried, dehydrated, or vacuum sealed in pouches. Because water is heavy, they can haul more dehydrated foods to space than they could normal foods. Because they "make" their own water aboard the International Space Station (henceforth ISS), they can simply rehydrate the foods just before they eat.

Watch this video "Dining on the Space Station" with your kids.
http://www.feelslikehomeblog.com/2013/09/how-to-make-astronaut-pudding/

In it, a real astronaut aboard the ISS shows the pantry, chooses food items (beef stew, asparagus, green beans with mushrooms, and lemonade), and then rehydrates and warms them to eat. He also talks about how they get potable water and mixes up a drink.

Here are some things to point out in the video:

- They really have a lot of food choices. There are other videos on YouTube that talk about astronaut food choices and many other resources online. Research the options with your kids and create a lunch or dinner menu together. Make that meal at home, but consider how the astronaut version might look and taste.
- The food warmer is built inside a suitcase. Draw or discuss how it might work.
- What does potable mean? He talks about the potable water dispenser. What do you think they do with non-potable water?
- He adds 50 mL of hot water to his asparagus. How much is 50 mL? Measure it to find out.
- He adds 250 mL of room temperature water to his lemonade. Measure that (and add some powdered drink mix from the grocery store).
- The refrigerator aboard ISS is a little bigger than a shoebox. What would your kids choose to keep cold if your fridge were that teeny?
- Why are the scissors on a string?
- His asparagus floated away somewhere. Imagine that!

- Did you notice that everything has velcro on it? Every time he puts something down (his drink, his green beans, an empty package), he makes sure it's stuck to the table with velcro. If you look closely, you can see the white Velcro tape under the packages. Velcro was actually invented for the space program in the 1960's. Why do you think they use Velcro in space?

- He doesn't mention is specifically, but astronauts eat almost all of their foods with a spoon. Try eating one of your meals with only a spoon!

- He says the garbage comes to a fiery end. What does that mean?

These videos are awesome, too:

- A tour of the food console from an astronaut and a cosmonaut: https://www.youtube.com/watch?v=_4aWoZPEd2w&feature=youtube

- This tour of the ISS from Sunita Williams, the woman who holds the record for the longest space flight is an awesome space video for kids to watch. She explains how to go to the bathroom in space, how to brush your teeth, how to eat, and lots of other things. It's incredibly memorable. https://www.youtube.com/watch?v=doN4t5NKW-k&feature=youtube

Astronaut Pudding requires a few simple ingredients:

- Instant pudding mix
- Powdered milk or creamer
- Water
- Quart-sized zip top bags
- Measuring spoons
- A measuring cup
- Straws (optional)
- Freeze-dried fruit (optional)

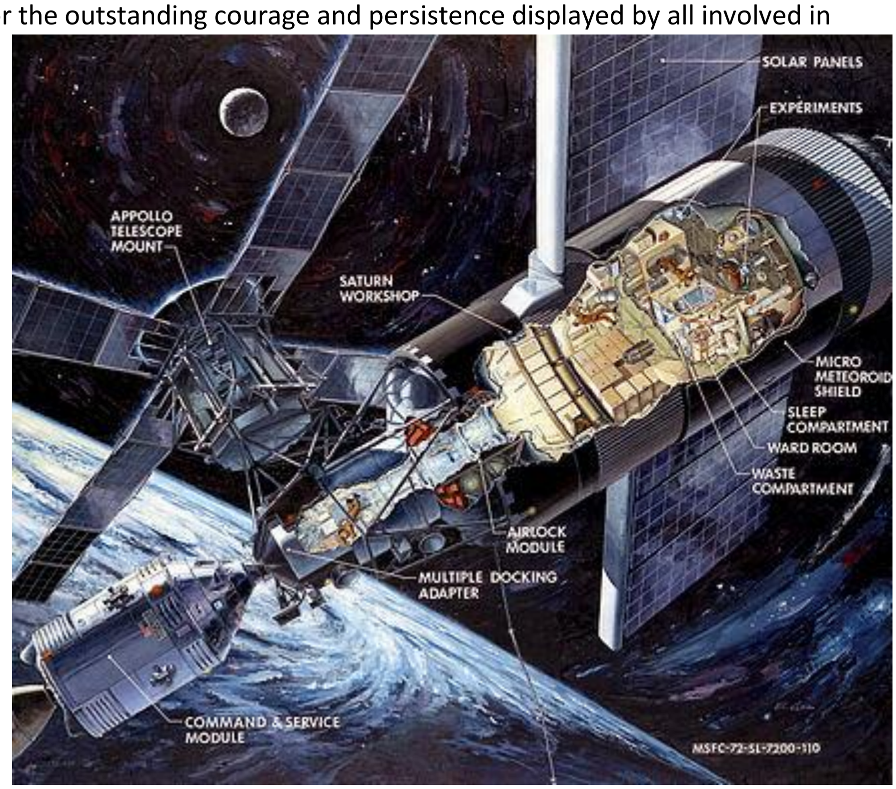
1. Have students measure out 1 tablespoon plus 2 teaspoons of dry pudding mix and put it into their plastic bag.
2. Then have students add 1 tablespoon plus 2 teaspoons of powdered milk to their bag. Mix it up. This is how the package would arrive at the space station.
3. You probably won't have a fancy potable water dispenser, so have students use a measuring cup. They should pour in just under 1/2 cup of water and seal the bag.
4. Double check that the bag is sealed, and then have students squish, squeeze, and mix the pudding until it's all blended and starts to set up.
5. Cut the corner off of the bag and have students squeeze it into their mouth, astronaut-style, or don't cut it and have them use a straw.
6. Freeze-dried fruit is the perfect accompaniment for our astronaut snack, after all freeze drying was invented for the space program!

Moving Up, Moving On

A few months after the first Sputnik, the United States followed the Soviet Union with a satellite of its own. **Explorer I** was launched by the U.S. Army on January 31, 1958. In October of that year, the United States formally organized its space program by creating the **National Aeronautics and Space Administration** (**NASA**). NASA is a civilian agency with the goal of peaceful exploration of space for the benefit of all humankind.

The Soviet Union led the Space Race in the early days. But the U.S. persisted and gradually captured the lead, culminating with its Apollo Program to the Moon, which captured the imagination of the entire world. Who can forget John F. Kennedy's daring pronouncement, "We will go to the Moon during this decade...not because it is easy but because it is hard..." or Neil Armstrong's words from the Moon's Tranquility Base, "That's one small step for man, one giant leap for mankind." **A fun little animated short related to what might happen at a future moon landing is found here,** http://vimeo.com/71196739

The Apollo moon rocket is among the largest rockets ever designed to fly into space. Standing as high as a skyscraper, the vehicle literally made the ground shake underfoot when the engines were ignited for liftoff. And they lit the skies as Apollo ascended from Cape Canaveral toward Earth orbit. America continued its flights to the Moon throughout the decade of the 1970's, developing, with each new mission, new confidence and new technology. Perhaps the most spectacular mission of all was Apollo 13, always to be remembered for the outstanding courage and persistence displayed by all involved in what could have been one of America's darkest hours as astronauts faced death.



Rockets have been used to launch many post-Apollo piloted missions, including Skylab (Skylab was a space station launched and operated by NASA and was the United States' first space station. Skylab orbited the Earth from 1973 to 1979, and included a workshop, a solar observatory, and other systems.), and the many Space Transportation System (STS) missions. Rockets have also launched unpiloted military satellites, communications' satellites, weather satellites, Earth observing satellites, planetary spacecraft, planetary surface rovers, the Hubble Space Telescope, and so on.

Since the earliest days of discovery and experimentation, rockets have evolved from simple gunpowder devices into gigantic vehicles capable of traveling into interplanetary space. It might be interesting to hear the thoughts of those earliest rocket pioneers, with their fire arrows and spinning spheres, if they could be brought through time and shown where their discoveries have led.

Rockets have certainly opened an important door to the universe.

Rewind & Review Rockets with YOU!

Have students go on a journey through time as we explore the history of man's greatest achievement - breaking through the space barrier. For a quick and memorable review of what you have discussed with students and other key points in rocket history have students go to Tiki Toki and explore (http://www.tiki-toki.com/timeline/entry/90841/A-Brief-History-of-Rockets-and-Space-Travel#vars!date=1255-09-14_15:05:26!) the time line A BRIEF HISTORY OF ROCKETS AND SPACE TRAVEL. **What do they remember from before? Did they learn anything new they didn't know? Share and discuss.**

The timeline was created by Crank, publishers of the app Junior Astronaut: Breaking Through The Space Barrier available for iPad. Built with source material from NASA and WIKIPEDIA. From mass, weight and gravity to an introduction on aerodynamics, Junior Astronaut is *Packed full of Science*.

Option: Map Markers

Place: ________________

Person: ______________

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Samples of Sources and Resources

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