the wings of the crane

unit three: day one

Nuclear Fuel

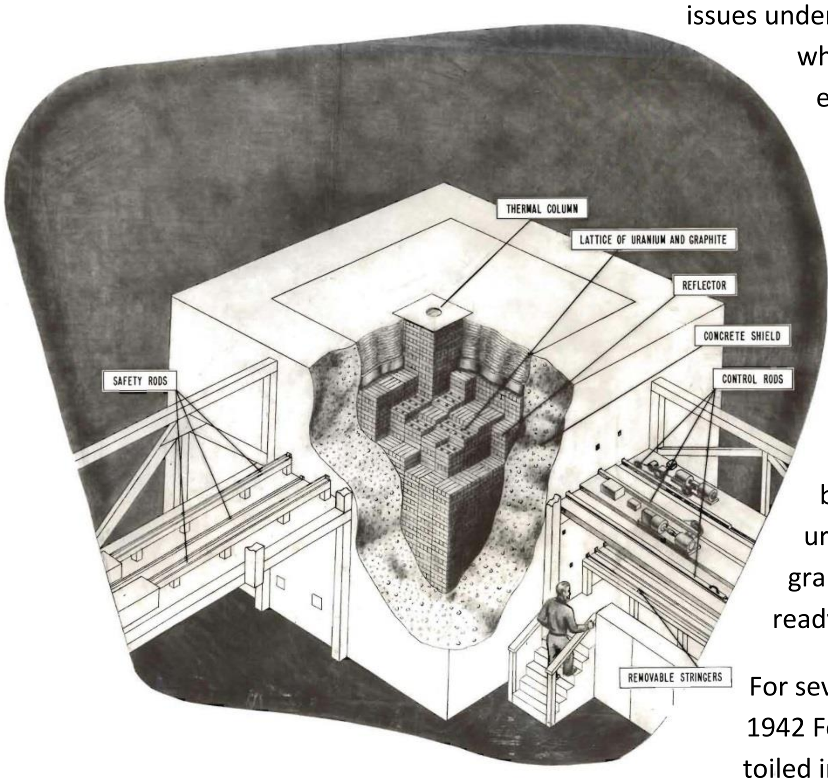
For help during discussion and to show the actual scientists who worked on the project speaking about it have students watch the video at: http://ztopics.com/Chicago%20Pile-1/

In March 1940, a team of scientists working at Columbia University in New York City confirmed the hypothesis put forth by Bohr and Wheeler -- the isotope uranium-235, or U-235, was responsible for nuclear fission. Secrecy was still the top priority despite increased funding and government interest, and scientists picked strange locations in order to conceal their efforts -- many people today are shocked to hear that physicists Enrico Fermi and Arthur Compton used space beneath the stands at Stagg Field, the racket courts at the University of Chicago, to conduct the first nuclear chain reaction in 1942.

This illustration depicts the scene on Dec. 2, 1942 under the west stands of old Stagg Field, where scientist Enrico Fermi and his colleagues achieved the first controlled, self-sustaining nuclear chain reaction. (Photo copyright of Chicago Historical Society)

The Columbia had team tried to initiate a chain reaction using U-235 in the fall of 1941, but failed. All work then moved to the University of Chicago, where, on a squash court situated beneath the university's Stagg Field, where Enrico Fermi and his colleagues built the nuclear reactor or "pile." And finally achieved the world's first self-sustaining controlled nuclear chain reaction.

Though Fermi's team was engaged in the biggest secret project of World War II, they discussed technical issues under a tree on the Main Quad, which they deemed safe from eavesdroppers. In the middle of the day on which they produced the first chain reaction, they took a customary lunch break at Hutchinson Commons.

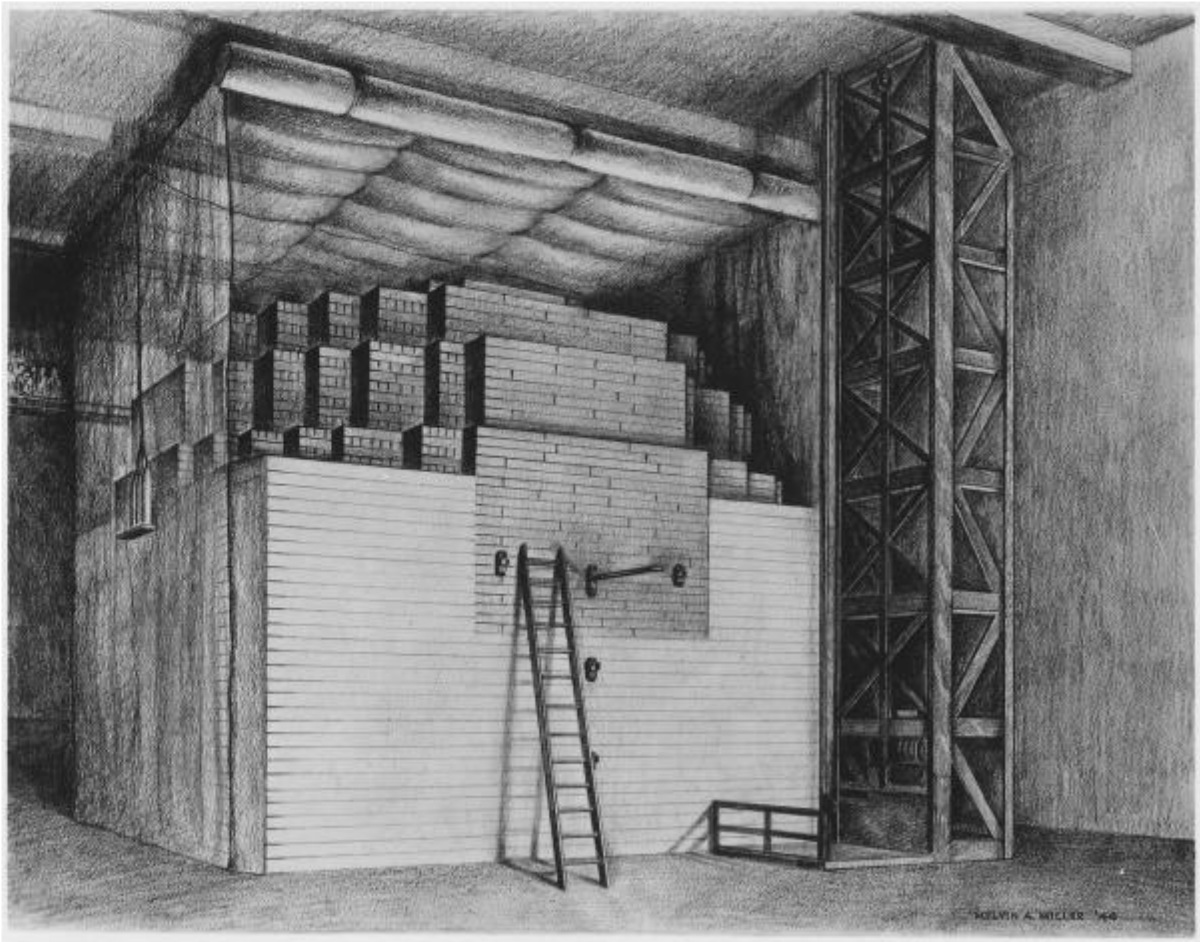


"Don't imagine that they were able to achieve a chain reaction on the first try. They built and rebuilt stacks of uranium, uranium oxide, and graphite 30 times before they were ready for the final test."

For several weeks in the winter of 1942 Fermi's scientists and laborers toiled in the unheated squash court underneath the University of Chicago's abandoned football field, building what was named "Chicago Pile 1." They called it a "pile" because that's what it was: a pile of uranium pellets and graphite bricks, stacked ever-so-precisely. It was so cold most days that technicians and scientists could see their breath. They tried building fires in trash cans, but the room filled with smoke. The pile, which would eventually grow into a spherical shape, was built in meticulous layers, and the men (and one woman) worked in twelve-hour shifts, day and night.

Blocks of ultra-pure graphite numbering about 4,000 and weighing 6 pounds each were carefully manufactured. Uranium spheres the size of baseballs were positioned into 22,000 holes that were carefully drilled in the graphite blocks.

Fermi's pile was remarkable because of its very simplicity; it had no mechanical parts or wires. Instead, the pile consisted of alternating layers of uranium and graphite. Basically, it was just a stage to let the uranium do its thing: emit neutrons that would occasionally strike the nuclei of other uranium atoms, thus splitting off even more neutrons. The graphite served as a moderator, which would slow down the neutrons and make them more likely to strike additional uranium nuclei.



(Wikimedia Commons/U.S. Department of Energy) *An artist's rendering of Chicago Pile 1.*

The pile was to become a giant beehive of neutrons buzzing with atomic life, but scientists could quash this activity by manipulating the pile’s only moving parts: cadmium rods. The element cadmium naturally absorbs neutrons, so when the rods were in place, the nuclear reaction would almost stop. To get the reaction going, scientists could pull the rods out of the pile and let stray neutrons buzz freely, striking more and more uranium nuclei. The team was aiming for criticality, the point at which, if you removed the cadmium rods and let the pile go, the chain reaction would continue exponentially on its own.

Birthplace of the Atomic Age, the Squash Court under the West Stands of Stagg Field, University of Chicago.

The team built the pile slowly; with each new layer Fermi would withdraw the cadmium rods and take a count of neutrons before placing the control rods back in the pile. As the workers and scientists milled more and more graphite, their faces grew black as coal miners'. Neighbors complained about the noise, not just from tools, but from the men singing to distract themselves from the monotonous work. The pile grew into a black igloo, 25 feet across at its equator and 20 feet tall from pole to pole. After 17 days of adding layers, Fermi knew the pile was big enough to reach criticality.

Couldn't they do this in the woods?

Chicago Pile 1 was never meant to be under the University of Chicago's former football field. Project managers originally wanted the full experiment to run in the Red Gate Woods, southwest of the city. But builders at Red Gate went on strike, so Compton and Fermi faced a decision: abandon the experiment, or move it. Fermi told Compton he felt confident that the pile could be built safely and effectively in the squash court under Stagg field.

This first nuclear reactor, called the "Chicago Pile-1" had no cooling mechanism to guard against a runaway chain reaction. Fermi felt that the risk of a runaway chain reaction was low given the design. Thus, he was comfortable going forward with the test without a cooling system, even though it was conducted in the heart of Chicago, Illinois. Luckily, Fermi was not wrong and the experiment was a complete success, rather than one of the worst disasters in U.S. history.

The Chicago-Pile-1, or CP-1 for short, itself was named such because the reactor was more or less a pile of items stacked on top of one another, primarily made of uranium pellets, separated by graphite blocks, and rods coated with cadmium used to control the reaction. The pile of blocks was held together by wood. The reaction itself was controlled by pulling in or pushing out the rods, which would have the effect of increasing or decreasing the neutron activity due to the fact that the cadmium coated rods absorbed neutrons. So as the rods were withdrawn, the nuclear reaction could increase until the critical point when it would become self sustaining.

The final pile consisted of 40,000 graphite blocks that enclosed 19,000 pieces of uranium metal and uranium oxide fuel. The scientists of what was then called the Metallurgical Laboratory, or "Met Lab," had

The giant is buried

The following year Chicago Pile 1 was moved out to Red Gate woods, where it was intended to be in the first place. There, scientists reshaped it as a cube and renamed it Chicago Pile 2. When its physicist guardians felt they had learned all they could from the pile, they buried it in the woods. This burial site is on public land and even has a gravestone to befuddle unsuspecting hikers and other passersby. It reads:

The world's first nuclear reactor was rebuilt at this site in 1943 after initial operation at the University of Chicago. This reactor (CP-2) and the first heavy-water moderated reactor (CP-3) were major facilities around which developed the Argonne national laboratory. This site was released by the laboratory in 1956 and the US atomic energy commission then buried the reactors here.

arranged the graphite in layers within a 24-foot-square wooden framework.

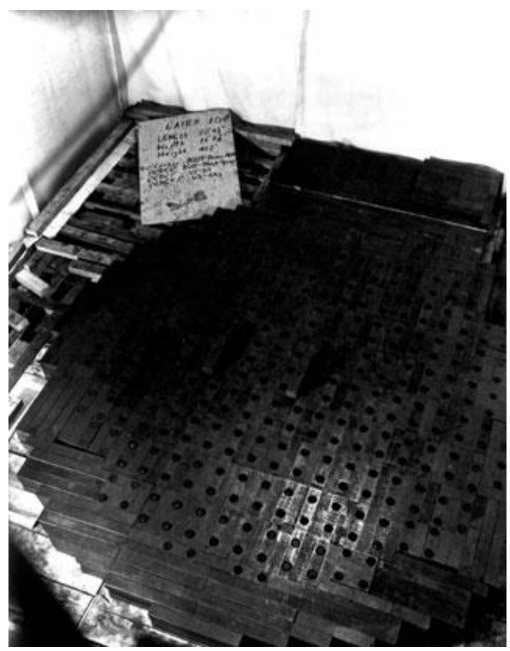
The completed pile contained 771,000 pounds of graphite, 80,590 pounds of uranium oxide and 12,400 pounds of uranium metal when it went critical. It cost about $2.7 million to produce and build. The pile took the form of a flattened ellipsoid which measured 25 feet wide and 20 feet high.

We're Cooking!

On Dec. 2, 1942, Fermi ordered the last cadmium control rod removed from the pile, took a measurement, and declared the pile to be self-sustaining. And then, for a nerve-wracking 15 minutes, he let the reaction run its course while the neutron counters beeped out of control.

There are several accounts of this, one of the best being in Richard Rhodes' *The Making of the Atomic Bomb*, which includes this eyewitness account from Herbert Anderson: "First you could hear the sound of the neutron counter, the clickety clack, clickety clack. Then the clicks came more and more rapidly and after a while they began to merge into a roar."

Fermi and his team celebrated the achievement with muted enthusiasm. One of the scientists had brought a bottle of Chianti (wine) and they passed it around, drinking out of paper cups. According to Rhodes' account, no one made a toast. No one said much of anything at all.



Eugene Wigner, another physicist on the project, recalls his realization of the far-reaching consequences of the event.

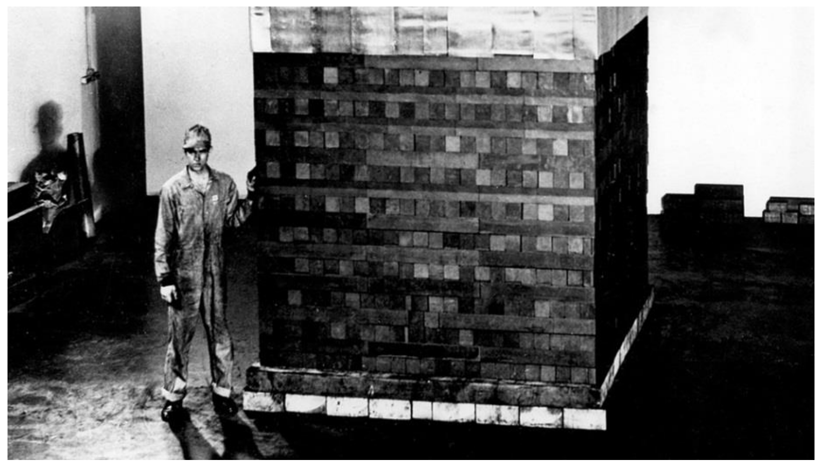
"Even though we had anticipated the success of the experiment, its accomplishment had a deep impact on us," he wrote in an account detailed by Rhodes. "For some time we had known that we were about to unlock a giant; still, we could not escape an eerie feeling when we knew we had actually done it."

The Atomic Age had begun at 3:25 p.m. on Dec. 2, 1942—quietly, in secrecy, on a squash court under the west stands of old Stagg Field, the University's abandoned football stadium, at the University of Chicago. That initial chain reaction was too weak to power even a single light bulb. It nevertheless transformed the world.

Did You Know? Along with not having a cooling system, the Pile-1 also had no radiation shielding. Possibly as a result of this, Fermi died at the age of 53 of stomach cancer, just twelve years after constructing the Pile-1. Two graduate students who worked on the Pile-1 also subsequently died of cancer.

Taste the Power

Challenge students to design their own nuclear reactor and build a 'model' of the layers of the CP-1 using materials such as Candy Blox and pretzel rods/sticks for the control rods. Or with other edible construction materials such as wafer cookies, ex. chocolate might represent the uranium enriched blocks.



Note: Non-edible materials such as regular Legos, K'Nex, Keva, or other brands/styles of building materials may also be used/used instead.

Have students choose a color of Blox to represent each element, ex. yellow might be wood, green might be 'Graphite' and red or blue could be uranium.

Graphite bricks should form the base of the pile. Beginning with layer 6, alternate courses of graphite containing uranium metal and/or uranium oxide fuel should be separated by layers of solid graphite blocks.

The uranium containing briquettes, slightly richer in uranium, should be/were concentrated in the central area and surrounded on either side with graphite

Day One K-8 Standard Alignment

K

7.T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their use.

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

These standards will be met and reinforced during discussion of the roles of the materials in the creation of Chicago Pile 1 and how each one had a specific use and while students are building their own model pile style nuclear reactors.

1

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3

- 7.T/E.4a Recognize the connection between scientific advances, new knowledge, and the availability of new tools and technologies.
- 7.T/E.2a Recognize that new tools, technology, and inventions are always being developed.

These standards will be met and reinforced through the discussion as we recognize how science is always seeking for the answers to endless questions and that as we gain new understanding (through experiments, tests, etc) more questions are formed, answers and technology are developed, etc.

4

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5

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- 7.T/E.2a Recognize that new tools, technology, and inventions are always being developed.

These standards will be met and reinforced through the discussion as we determine how science is always seeking for the answers to endless questions and that as we gain new understanding (through experiments, tests, etc) more questions are formed, answers and technology are developed, etc.

6

- 7.T/E.3 a Compare the intended benefits with the unintended consequences of a new technology.
- 7.T/E.3 b Explore how the unintended consequences of new technologies can impact society.

These standards will be met and reinforced through the discussion as we discuss and compare the intended consequences of nuclear reactors (ex. possible new 'clean' form of endless energy, exciting new understandings of how particles function and work and greater understanding, finding answers to questions about the universe and how it works, etc) with the unintended (weapons of mass destruction—both intended and way more powerful than anticipated, use of those weapons, modern forms of them). We will discuss how both sides have impacted the world and society, ex. nuclear power plants with energy, lives saved, lives lost, nuclear power plant meltdowns, constant fear of nuclear attack, controls of the science and research and who can have access, threats of nuclear war, etc.

7

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8

- 1.3.22 Describe the benefits and hazards of nuclear energy.
- 1.6.5 Study and identify the major historical achievements of modern nuclear physicists related to the discovery of atomic particles

These standards will be met and reinforced through the discussion as we discuss and compare the intended consequences of nuclear reactors (ex. possible new 'clean' form of endless energy, exciting new understandings of how particles function and work and greater understanding, finding answers to questions about the universe and how it works, etc) with the unintended *(weapons of mass destruction—both intended and way more powerful than anticipated, use of those weapons, modern forms of them). We will discuss how both sides have impacted the world and society, ex. nuclear power plants with energy, lives saved, lives lost, nuclear power plant meltdowns, constant fear of nuclear attack, controls of the science and research and who can have access, threats of nuclear war, etc.*

day two

Moving On

Development of a nuclear bomb, using U-235 as the fuel, proceeded quickly.

Because of its importance in the design of a nuclear bomb, let's look at U-235 more closely. U-235 is one of the few materials that can undergo induced (forced) fission. Instead of waiting more than 700 million years for uranium to naturally decay, the element can be broken down much faster if a neutron runs into its nucleus. The nucleus will absorb the neutron without hesitation, become unstable and split immediately.

As soon as the nucleus captures the neutron, it splits into two lighter atoms and throws off two or three new neutrons (the number of ejected neutrons depends on how the U-235 atom happens to split). The two lighter atoms then emit gamma radiation as they settle into their new states. There are a few things about this induced (forced) fission process that make it interesting:

The probability of a U-235 atom capturing a neutron as it passes by is fairly high. In a bomb that is working properly, more than one neutron ejected from each fission causes another fission to occur. It helps to think of a big circle of marbles as the protons and neutrons of an atom. Imagine about 100 marbles lying on a flat surface and roughly forming a circle. What would happen if you took another marble and threw it at them? They would fly all around in different directions and groups. That is exactly what happens in nuclear fission. The filled circle is like an atom's nucleus. The marble being thrown is like a "neutron bullet".

If you shoot one marble -- a single neutron -- into the middle of the big circle, it will hit one marble, which will hit a few more marbles, and so on until a chain reaction continues.

The process of capturing the neutron and splitting happens very quickly, on the order of picoseconds (0.000000000001 seconds).

Marbleous Math App: Marble Math

Have students practice basic math skills on the classroom iPad by rolling or dragging their marble through a series of mazes to complete problems. Unlock new marbles, collect bonuses and dodge obstacles as you reinforce core concepts in pursuit of a high score. Who knew math could be this much fun?

Marble Math is a fun, engaging way to practice and reinforce core math concepts in support of classroom learning. The object of the game is to solve a variety of math problems by collecting numbers and bonuses as you navigate a series of mazes with your marble. But watch out math whizzes! You'll need to be focused and nimble to avoid the obstacles in your path.

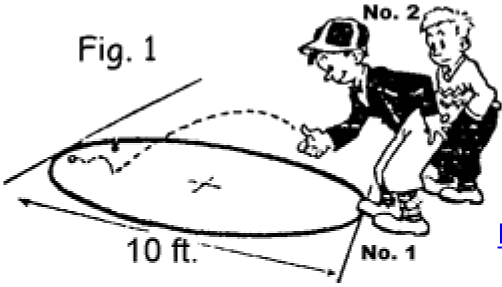
In order for these properties of U-235 to work, a sample of uranium must be **enriched**; that is the amount of U-235 in a sample must be increased beyond naturally occurring levels. Weapons-grade uranium is composed of at least 90 percent U-235.

Action? Reaction! Nuclear Marbles!

Children were playing marbles as long ago as 4000 BC in Ancient Egypt, and the game has fallen in and out of fashion ever since.

The Ring Game

This is the most famous version of Marbles, the one you see kids playing on TV and in the movies, and soon, hopefully in your own backyard.

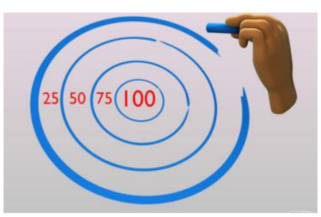


Find another explanation, complete with pictures, at http://www.landofmarbles.com/marbles-play.html

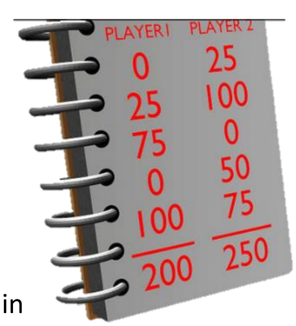
Or find an excellent guide with helpful 10 second videos at http://www.wikihow.com/Play-Marbles

It is critical to keep marbles out of the hands and mouths of small children. You should only play the game with children over the age of five or six—and even then under strict supervision. Older kids should be okay with supervision.

Draw a ring on the ground or a piece of poster board, etc., either with a pen, tape, a piece of chalk or with a stick in the dirt.



Math Skill Practice: **Draw four circles.** Draw each one inside the other to create a target effect. The innermost circle is worth the most points - 100. The next circle going outward is worth 75 points, the next is worth 50 and the outer circle is worth 25 points. The size of the circle should be at least 30 cm (12") across. Of course, the values are up to you. If you'd like a teeny tiny circle inside the 100 to be worth a million, go on ahead. Students must keep track of their points. You can also make some of the circles symbols, such as +, -, x, /, and students must make their rolls into math problems to see who can earn the most points. Each marble that lands in a circle earns the number of points marked in that circle. Landing outside the circles scores nil.



Set up your marbles. You can do this however you like. A plus sign is fairly standard, but you can also make a circle or just scatter them randomly. Use at least 13 marbles (an odd number to determine the winner).

Draw a starting line just outside the ring. Each player puts a few marbles into the ring and the goal is to shoot the marbles, from the starting line, out of the ring.

To choose the player who goes first, each player should shoot a marble from the starting line toward the ring; the player whose marble is closest to the edge of the ring gets to go first. The next closest is the second shooter, and so on. The players should pick up these marbles to shoot again when the game begins.

The first player knuckles down at the starting line and shoots his or her marble toward the ring in an effort to hit a marble out of the ring. If the player hits both his or her marble and the target marble out of the ring, he or she gets to keep the marble and shoot again—only this time he or she has to shoot from where his or her shooter rests. If a player shoots a target marble out, but his or her shooter stays in, he or she can get the shooter back by replacing it with another marble.

Tell your kids to be clear on the rules about taking marbles before they play. Some kids want to have their marbles back, while other kids feel the reward is to win other kids' marbles. This could be a big source of conflict if the kids don't state the rules in advance.

Kids get very attached to their favorite shooters, so you can bet they are going to want their "Taw" back! However, if his or her shooter stays in, the player is out and must put all the won marbles back in the ring. If a player doesn't hit any marbles out of the ring and his or her shooter stays in, the shooter can be replaced with another marble but the player is out altogether until the next game. If the player misses and the shooter goes outside the ring, the shooter stays where it is but the shooter loses his or her turn. On the next play, the player must shoot from where his or her shooter rested on the previous play.

Adding up the points. Add the points for all three marble shoots to reach the player's score. At the end of the turn, the marbles are picked up to leave the field clear for the next player. If you do choose to leave the marbles, make it so if they're knocked out, they're not counted. Only marbles that are left at the end of both turns have value. This makes the game more competitive!

Go for another round. When everyone has had a turn, start the next round, adding on the scores. The winner is the player with the highest total score at the end of the game.

Knuckles Down

There is an art to shooting a marble and it's done like this: Curl your fingers and rest the marble on the crook of your index finger. With your knuckles facing downward, place the knuckle of your index finger on the ground and use your thumb to flick the marble out of the crook—and watch the marble fly. You'll have to practice a few times until you get it right.

Day Two K-8 Standard Alignment

K

K.G.1 b) describe the relative positions of objects using terms such as above, below, beside, in front of, behind, and next to.

K.MD.1. Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.

These standards will be met and reinforced when students play marbles and have to describe the locations of their marbles, where they need to stand etc. We will compare marbles and the results of our throws to see if having a larger/smaller or heavier/lighter marble makes a difference in our scores and throws.

1

1.G.2. Compose two-dimensional shapes

1.G.3. Partition circles and/or rectangles into two and four equal shares

These standards will be met and reinforced when students play marbles and have to help draw and design the circle/target court and divide it evenly into rings for different point levels.

2

2.G.1. Recognize and draw shapes having specified attributes

2.G.3. Partition circles and/or rectangles into two, three, or four equal shares,

These standards will be met and reinforced when students play marbles and have to help draw and design the circle/target court and divide it evenly into rings for different point levels.

3

3.G.2. a) Partition shapes into parts with equal areas.

3.G.2. b) Express the area of each part as a unit fraction of the whole. (For example, partition a shape into 4 parts with equal area, and describe the area of each part as 1/4 of the area of the shape.)

These standards will be met and reinforced when students play marbles and have to help draw and design the circle/target court and divide it evenly into four rings for different point levels as well as making the circle symmetrical.

4

7.11.1 Describe the position of an object relative to fixed reference points.

7.11.2 Identify factors that influence the motion of an object.

These standards will be met and reinforced when students play marbles and have to describe the locations of their marbles in relation to the score rings and determine what factors contributed to their result, ex. it hit another marble and slowed down, the surface is rough, the throw was not/too hard, etc.

5

5.G.4 Classify two-dimensional figures into categories based on their properties, ex. symmetrical, asymmetrical

7.11.1 Predict how the amount of mass affects the distance traveled given the same amount of applied force.

These standards will be met and reinforced when students play marbles and have to help draw and design the circle/target court and divide it evenly into four rings for different point levels as well as making the circle symmetrical. Students will have to predict which marbles will work the best, ex. whether they think a larger one with more mass will work best, or a smaller one with less mass, and test their theories, using the same amount of force to throw them.

6

7.10.1 Compare potential and kinetic energy.

7.10.3 Recognize that energy can be transformed from one type to another.

These standards will be met and reinforced during discussion of what happens in the nuclear reactor and how potential energy is both in the marbles and the atoms and then it is transformed into kinetic by the throw/the neutron bombardment respectively.

7

7.11.4 Investigate how Newton's laws of motion explain an object's movement.

7.11.4 Recognize how a net force impacts an object's motion.

These standards will be met and reinforced during discussion of what happens in a nuclear reactor (the atoms don't move until the neutrons hit them, the neutrons don't stop until they hit an atom, etc.) and when students play marbles and have to describe and determine what factors contributed to their result, ex. it hit another marble and slowed down, the surface is *rough and the force of friction acted to slow the marble down, the throw was not/too hard, another marble hit their marble that was at rest and knocked it out, etc.*

8

1.3.2 Analyze nuclear reactions.

0.5.1 Illustrate with visual displays or models the source, uses, advantages, and disadvantages of energy resources, i.e. nuclear.

These standards will be met and reinforced through the discussion and nuclear reactor marble model. We will discuss the advantages and disadvantages of depending on nuclear power for energy and the advantages and disadvantages of the marble model to illustrate what is happening inside a nuclear reactor.

day three

Manhattan Project Organization

Secret sites were selected across the United States that would aid in the bomb's completion, including Oak Ridge, Tenn. (Site X) and Hanford, Wash. (Site W). **(Have students mark them on the map, and the following.)** These locations were massive facilities meant for uranium and plutonium production. Los Alamos, New Mexico, was chosen as the site that would be the central hub of the Manhattan Project.

Los Alamos, along with the sites in Tennessee and Washington State, were remote locations picked for maximum security, but you wouldn't know it if you saw pictures of them during peak production. The desolate New Mexican mesa in Los Alamos, for instance, was essentially turned into a small city, with laboratories, offices, dining halls and housing for everyone involved in the project. The government worked hard on gathering the best scientific minds in the country, and for nearly three years between the fall of 1942 and the bombing of Hiroshima on Aug. 6, 1945, thousands of people worked through the challenges of constructing an atomic weapon. Entirely in secret.

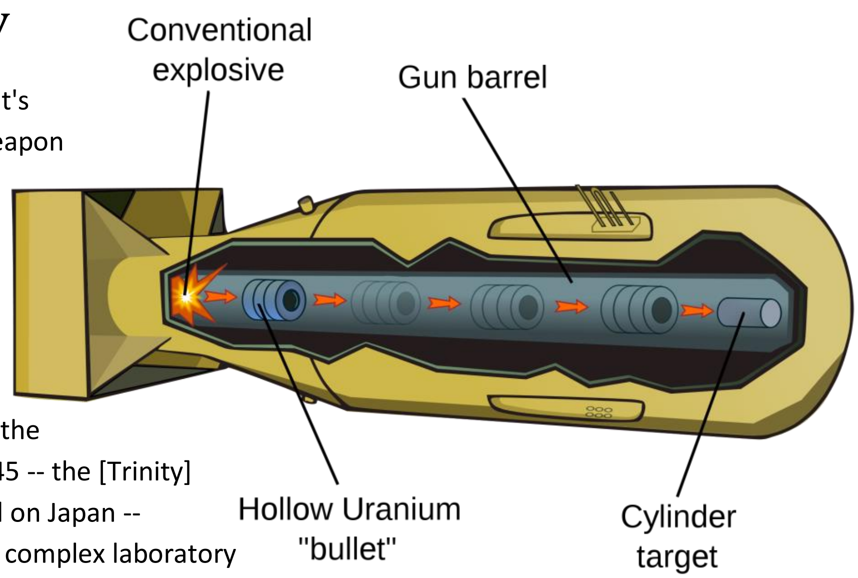
Simple housing for the workers involved in the Manhattan Project at Los Alamos, N.M.
Keystone/Getty Images

Security at Los Alamos was extremely tight, as people were hardly allowed to contact family members and friends for their entire stay at Site Y. Guards were tough on clearance issues, and barbed wire surrounded the entire complex. The Manhattan Project was enveloped in so much secrecy, in fact, that some people didn't even know the nature of their own work until they heard news of the bomb exploding over Hiroshima.

Two types of nuclear bombs were designed at Los Alamos -- an implosion bomb and a gun-triggered bomb. After major improvements were made on the implosion device, a site was finally chosen to test the first nuclear bomb. Alamogordo, a desert range about 210 miles south of Los Alamos, was nicknamed "Trinity" for the testing of a plutonium bomb design. At 5:30 a.m. on July 16, 1945, the bomb was detonated, creating a massive blast and temporarily blinding several of the observing scientists: the Atomic Age had begun.

Less than a month later, the United States used the implosion bomb and the untested gun-triggered bomb in order to coerce the Japanese into surrender.

Nuclear Bomb Delivery



It's one thing to build a nuclear bomb. It's another thing entirely to deliver the weapon to its intended target and detonate it successfully. This was especially true of the first bombs built by scientists at the end of World War II. Writing in a 1995 issue of Scientific American, Philip Morrison, a member of the Manhattan Project, said this about the early weapons: "All three bombs of 1945 -- the [Trinity] test bomb and the two bombs dropped on Japan -- were more nearly improvised pieces of complex laboratory equipment than they were reliable weaponry."

The delivery of those bombs to their final destination was improvised almost as much as their design and construction. The USS Indianapolis transported the parts and enriched uranium fuel of the Little Boy bomb to the Pacific island of Tinian on July 28, 1945. The components of the Fat Man bomb, carried by three modified B-29s, arrived on August 2. A team of 60 scientists flew from Los Alamos, N.M., to Tinian to assist in the assembly. The Little Boy bomb -- weighing 9,700 pounds (4,400 kilograms) and measuring 10 feet (3 meters) from nose to tail **(have students measure out this distance)** -- was ready first. On August 6, a crew loaded the bomb into the Enola Gay, a B-29 piloted by Col. Paul Tibbets. The plane made the 750-mile (1,200-kilometer) trip to Japan **(mark out the flight on a map)** and dropped the bomb into the air above Hiroshima, where it detonated at exactly 8:12 a.m.

8/6/45: Excerpt from public statement by President Truman. This was the first time he publicly gave a reason for using the atomic bomb on Japan:

"The Japanese began the war from the air at Pearl Harbor. They have been repaid many fold.

"If they do not now accept our terms they may expect a rain of ruin from the air, the like of which has never been seen on this earth." (*Public Papers of the Presidents, Harry S. Truman, 1945*, pg. 197, 199).

On August 9, 1945 (8/9/45) the nearly 11,000-pound (5,000-kilogram) Fat Man bomb made the same journey aboard the Bockscar, a second B-29 piloted by Maj. Charles Sweeney. Its deadly payload exploded over Nagasaki just before noon.

8/9/45: Excerpt from public statement by President Truman. This was the second time he had publicly given reasons for using the atomic bomb on Japan:

"The world will note that the first atomic bomb was dropped on Hiroshima, a military base. That was because we wished in this first attack to avoid, insofar as possible, the killing of civilians. But that attack is only a warning of things to come. If Japan does not surrender, bombs will have to be dropped on her war industries and, unfortunately, thousands of civilian lives will be lost.

"Having found the bomb we have used it. We have used it against those who attacked us without warning at Pearl Harbor, against those who have starved and beaten and executed American prisoners of war, against those who have abandoned all pretense of obeying international laws of warfare. We have used it in order to shorten the agony of war, in order to save the lives of thousands and thousands of young Americans.

"We shall continue to use it until we completely destroy Japan's power to make war. Only a Japanese surrender will stop us." (*Public Papers of the Presidents, Harry S. Truman, 1945*, pg. 212).

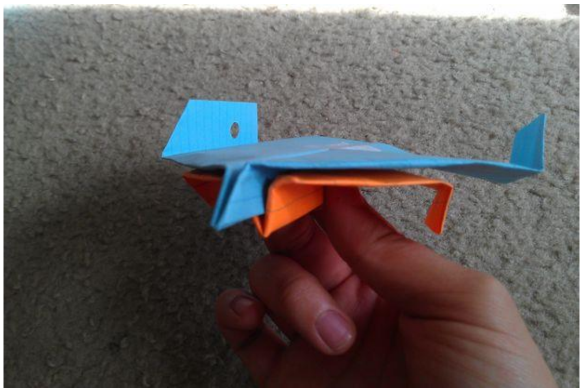
Rather than wait to see if the Hiroshima bomb would bring surrender, the atomic bombing order to the Army Air Force stated, "Additional bombs will be delivered on the above targets as soon as made ready by the project staff." (Leslie Groves, Now It Can Be Told, pg. 308).

8/10/45: Having received reports and photographs of the effects of the Hiroshima bomb, Truman ordered a halt to further atomic bombings. Sec. of Commerce Henry Wallace recorded in his diary on the 10th, "Truman said he had given orders to stop atomic bombing. He said the thought of wiping out another 100,000 people was too horrible. He didn't like the idea of killing, as he said, 'all those kids'." *(John Blum, ed., "The Price of Vision: the Diary of Henry A. Wallace, 1942-1946", pg. 473-474).*

It's Not Delivery (actually, it is!)

Today, the delivery method used in Japan -- gravity bombs carried by aircraft -- remains a viable way to deliver nuclear weapons. But over the years, as warheads have decreased in size, other options have become available. Many countries have stockpiled a number of ballistic and cruise missiles armed with nuclear devices. Most ballistic missiles are launched from land-based silos or submarines. They exit the Earth's atmosphere, travel thousands of miles to their targets and re-enter the atmosphere to deploy their weapons. Cruise missiles have shorter ranges and smaller warheads than ballistic missiles, but they are harder to detect and intercept. They can be launched from the air, from mobile launchers on the ground and from naval ships.

Bomber Planes: You Dropped a Bomb on Me!



Have you ever wanted to have your own personal bomber? Well now students can make their own-out of paper! This paper airplane glides along even after it has dropped a package on its target. The bomb is dropped because of drag, weight, and downforce therefore making a very formidable paper bomber! So let's get ready for the air delivery!

The following origami bomber instructions will be the basis for students to participate in a bomb drop accuracy, distance flown, and time in the air competition. Practice going through the instructions and have students build a practice plane and test fly them before dividing them in groups or having them work individually for the competition. They may modify the base design for the competition.

The students must use the paper given to them, though they may choose to use one or two sheets per paper airplane. Allow the students to work on their paper airplanes for as long as you see fit. All competitors should have the same amount of time to complete their airplanes.

Distance Test Rules

For the distance category, each student throws his or her paper airplane while the teacher records distances in feet and inches. All distances must be measured from the starting line to the point where the plane first touches the ground or floor -- not the final resting place if it slides. Each student/team member has up to three chances to get his or her best distance.

Time in Air Test Rules

For the time in air category, each student throws his or her airplane while the teacher times the flights with an accurate stopwatch. Report the times in seconds and hundredths of a second. (Example: 2.45 seconds.) Each student has up to three chances to get his or her longest "time in air."

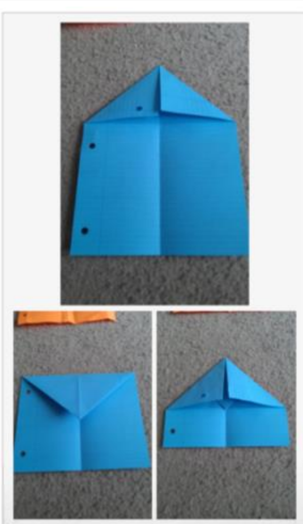
Bomb Drop Accuracy Test Rules

For the bomb drop accuracy category, each student throws his or her airplane over the ‘target’ and the location is marked. Each student has up to three chances to hit the target.

Announcing the Winners
When all the results are in, determine three winners: the student or team who makes the airplane that flies the farthest, the student or team who makes the airplane that flies the longest time, and the student or team that got closest to the bullseye or hit the bullseye the most times (if multiple teams get on the exact same spot you can have a 'drop off' or simply count the number of times the team accurately hit it.)

Step 1: Materials

You will need two pieces of paper, and some scissors.



Step 2: Bomber-Fold One

Take one of your pieces of paper and fold it in half "hot dog style" (longways). Then, open it back up.

Step 3: Bomber-Folds Two, Three, And Four

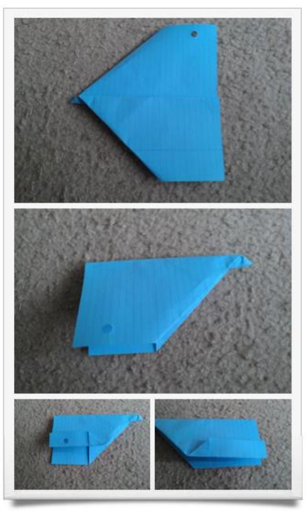
Next, fold the top corners down to the center crease. Then, fold the top of the paper down. Finally, fold the top two corners down again.

tep 4: Bomber-Fold Five

Fold the paper backward.

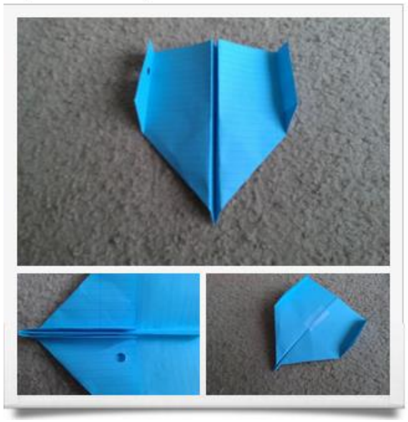
Step 5: Bomber-Wings And Fins

Fold down the wings of the airplane. Then, fold up the tips of the wings to make fins.

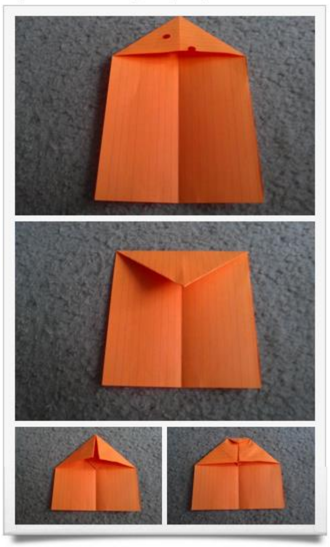


Step 6: Unfold And Adjust

Unfold the bomber. You may have to adjust some of the folds on the bottom of the airplane. Add tape to the top to secure it.



Step 7: Bomb-Preparations

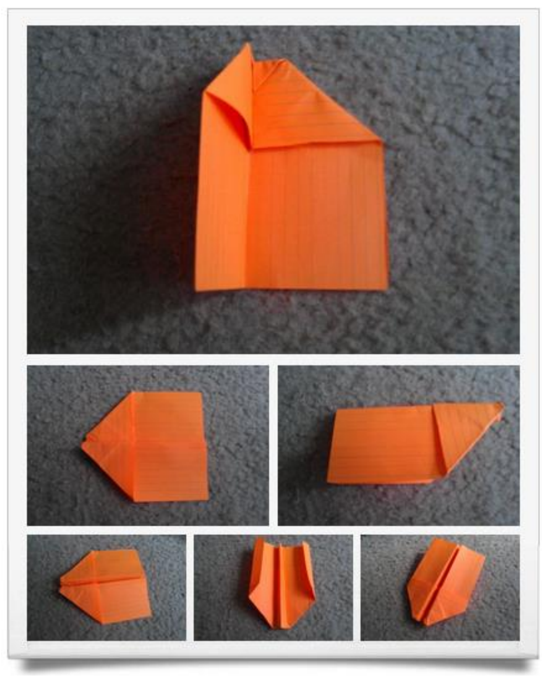


Take your other piece of paper and fold it down "hamburger style" (shortways). Then, unfold it and cut along the crease to get two smaller pieces of paper. You will only need one.

Step 8: Bomb-Fold One

Fold the paper in half "hot dog style" (longways), then unfold it.

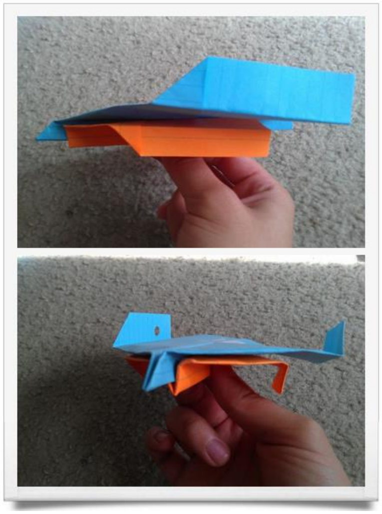
Step 9: Bomb-Folds Two, Three, Four, And Five



Fold the top two corners down. Next, fold the top of the paper down, and fold the top two corners down again. Finally, fold the top tip of the paper down. Doing this adds weight to the bomb in order to pull it away from the main airplane.

Step 10: Bomb-Wings And Fins

Fold the paper in half with all previous folds on top. Next, fold down the wings. Finally, fold fins facing DOWNWARD this time. This will create excess downforce and also help the bomb fall more smoothly.



Step 11: Attaching The Bomb And Flying

To attach the bomb, simply slide it onto the bottom of the main airplane Then, gripping the bomber by the central spine, release the airplane. The bomb will be pulled off of the main plane, and gently glide to the ground as the bomber continues on.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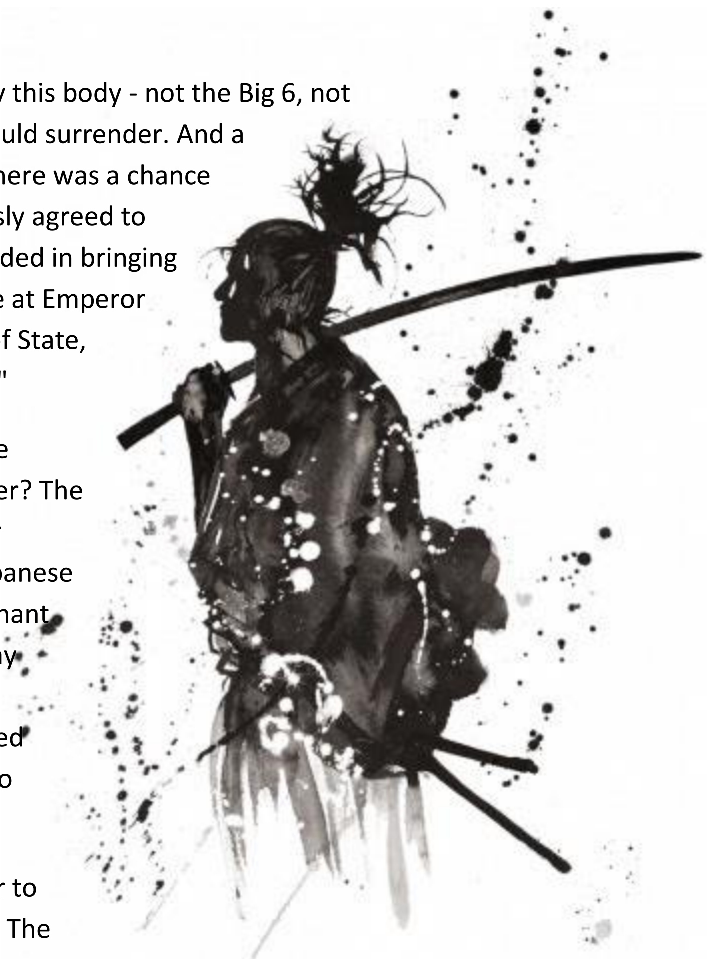
Never Surrender!

Japan had received what would seem to have been overwhelming shocks. Yet, after two atomic bombings, massive conventional bombings, and the Soviet invasion, the Japanese government still refused to surrender. The key concern for the Japanese military was loss of honor, not Japan's destruction.



August 14, some military leaders in the Cabinet (It was only this body - not the Big 6, not even the Emperor - that could rule as to whether Japan would surrender. And a unanimous decision was required) were still arguing that there was a chance for victory, but then that same day, the Cabinet unanimously agreed to surrender! Where none of the previous events had succeeded in bringing the Japanese military leaders to surrender, surrender came at Emperor Hirohito's request: "It is my desire that you, my Ministers of State, accede to my wishes and forthwith accept the Allied reply."

What made the Emperor's "desire" more powerful than the absolute revulsion the military leaders felt toward surrender? The Emperor was believed to be a god by the Japanese. As War Minister Anami said after he agreed to surrender, "As a Japanese soldier, I must obey my Emperor." Surrender was so repugnant to Anami that he committed hara-kiri (ritual suicide) the day after he signed the surrender document. Where fear and reason had failed, religious devotion to the Emperor enabled the military leaders to overcome their samurai resistance to surrender.

Prior to August 1945, it was unprecedented for an Emperor to express a specific policy preference directly to the Cabinet. The role of the Emperor was to sanction decisions made by the Cabinet, whether he personally approved of them or not. As a god, he was considered to be above human politics.

Make an Origami Samurai Helmet:

The Samurai helmet is a traditional Japanese origami model which has been folded for many hundreds of years as a symbol of strength and honor.

Using a square of origami, newspaper, or brown paper bag material, etc, have students follow the instructional video at http://videos.kidspot.com.au/videos/lhyet7ft/how-to-make-an-origami-samurai-helmet

Day Three K-8 Standard Alignment

K

7.T/E.2 Apply engineering design and creative thinking to solve practical problems.

7.T/E.2 Invent designs for simple products.

These standards will be met and reinforced as students participate in the bomb drop paper airplane challenge. Students will be tasked with modifying and testing their origami airplanes to overcome challenges, improve designs, and meet the competition criteria in order to try and win.

1

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These standards will be met and reinforced as students participate in the bomb drop paper airplane challenge. Students will be tasked with modifying and testing their origami airplanes to overcome challenges, improve designs, and meet the competition criteria in order to try and win.

3

7.T/E.4 Evaluate an invention or prototype that solves a problem and determine ways to improve the design.

7.T/E.5 Apply a creative design strategy to solve a particular problem.

These standards will be met and reinforced as students participate in the bomb drop paper airplane challenge. Students will be tasked with modifying and testing their origami airplanes to *overcome challenges, improve designs, and meet the competition criteria in order to try and win.*

4

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5

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These standards will be met and reinforced as students participate in the bomb drop paper airplane challenge. Students will be tasked with modifying and testing their origami airplanes to overcome challenges, improve designs, and meet the competition criteria in order to try and win.

6

7.T/E.1 Identify the tools and procedures needed to test the design features of a prototype.

7.T/E.2 Evaluate a protocol to determine if the engineering design process was successfully applied.

These standards will be met and reinforced as students participate in the bomb drop paper airplane challenge. Students will be tasked with modifying and testing their origami airplanes to overcome challenges, improve designs, and meet the competition criteria in order to try and win (aka successfully engineering their planes and bombs.)

7

SPI 7.T/E.1 Identify the tools and procedures needed to test the design features of a prototype.

SPI 7.T/E.2 Evaluate a protocol to determine if the engineering design process was successfully applied.

These standards will be met and reinforced as students participate in the bomb drop paper airplane challenge. Students will be tasked with modifying and testing their origami airplanes to overcome challenges, improve designs, and meet the competition criteria in order to try and win (aka successfully engineering their planes and bombs.)

8

7.T/E.1 Identify the tools and procedures needed to test the design features of a prototype.

7.T/E.2 Evaluate a protocol to determine if the engineering design process was successfully applied.

These standards will be met and reinforced as students participate in the bomb drop paper airplane challenge. Students will be tasked with modifying and testing their origami airplanes to overcome challenges, improve designs, and meet the competition criteria in order to try and win (aka successfully engineering their planes and bombs.)

day four

What If? Preserving the Past

http://www.huffingtonpost.com/national-trust-for-historic-preservation/why-we-should-preserve-th_b_5679376.html *By Denise Ryan, Director of Public Lands Policy, National Trust for Historic Preservation*

The Manhattan Project, the secret research mission to develop an atomic weapon ahead of Germany and bring an end to World War II, was one of the 20th century's most ambitious feats of science and engineering. And, it also proved to be one of the darkest moments. Few events have affected as many aspects of American life as deeply as the Manhattan Project. It irrevocably altered the global standing of the United States and set the stage for the Cold War. It sparked innovations in medicine, science, and technology. And, of course, the deadly force of the atomic bomb humbled us all.

In many respects, the Manhattan Project ushered in the modern era of war. The creation and use of these early weapons of mass destruction raised profound ethical questions, which today remain as challenging and urgent as in 1945.

As a nation, we need to grapple openly and objectively with the Manhattan Project's complex legacy.

To do so, some people believe a place for reflection, education and interpretation is needed. Legislation before Congress would establish the Manhattan Project National Historical Park, an assembly of three locations central to the development of the atomic bomb: Hanford, Wash., site of the first full-scale nuclear reactor; Oak Ridge, Tenn., home to the first uranium enrichment plant; and the laboratory and related sites at Los Alamos, N.M. The Los Alamos site is now featured in the WGN America television drama "Manhattan."

Early in 2014, the Manhattan Project National Historical Park was included in legislation that passed the U.S. House of Representatives. The Senate version of the bill has been ready for a floor vote in since June of 2013. In August of 2014, the National Trust is supporting the inclusion of this bill in a package of other public lands bills to be considered by the Senate in the Fall of 2014.

Have students consider the following arguments for critics and proponents of the project. What do they think? Who do they agree with? Why?

Some critics of this legislation have expressed concern that the creation of the Manhattan Project National Park would somehow inappropriately celebrate the atomic bomb and the destruction of Hiroshima and Nagasaki at the close of World War II.

Others believe the opposite to be true. Opening up and preserving these sites as a national park could provide an opportunity for Americans to consider the Manhattan Project in its full scope and complexity. It would encourage the sort of thoughtful reflection on the dangers of these weapons and consideration of the best way to avoid glorifying the bomb or using it in the future.

A new national park, managed by the Department of Energy and the National Park Service, would encourage visitors to consider the Manhattan Project's many ethical, cultural and scientific implications. The inclusion of these three primary sites eloquently reflects the project's scale, and also captures the frenetic, round-the-clock effort to create an atomic weapon ahead of the enemy.

At the Hanford site, visitors would stand amid thousands of interconnecting aluminum tubes of the B Reactor which produced the plutonium for the "Fat Man" bomb. They could visit the secret, government-constructed boomtown at Oak Ridge where more than 80,000 people once worked to enrich uranium. At the V Site in Los Alamos, where the bomb was assembled for testing, visitors could contemplate the consequences of its detonation at Hiroshima and Nagasaki. Such firsthand experience provides a tangible, in-person understanding that is a very different experience from merely reading about this history.

The US National Park Service exists in part to help citizens and visitors interpret the lessons of US national history. For nearly 100 years, the Park Service has been the guardian of our nation's stories -- both uplifting and challenging stories -- at many of its most important cultural sites.

To cite an example, the agency has earned the respect of many in the Asian-American and Pacific Islander community for its sensitive interpretation of another World War II site, the Minidoka National

Historic Site in Idaho. At its peak, Minidoka imprisoned more than 9,000 Japanese, many of them U.S. citizens. Preserving the camp does not glorify this painful chapter of American history; on the contrary, it reminds us of this dangerous period in American history when fear governed our actions.

Likewise, perhaps preserving the laboratories where scientists created the atomic bomb would underscore the great responsibilities that come with great scientific achievement, and it would better prepare us to navigate the complex moral terrain of our own era's technological advances.

We did more than split the atom at Oak Ridge, Los Alamos, and Hanford. We stepped forward into a new era, one in which science granted us extraordinary power to improve our world -- or to destroy it.

What do students think? Should we have national parks and national memorials of these kinds of events and projects such as the Manhattan Project?

.Also: German physicists came close to developing an atomic weapon, but Hitler cut back their research, choosing to concentrate efforts on developing rockets, the V-1 and V-2, instead. **Have students debate the possible outcome of the war if the Germans had developed and used atomic weapons.**

Power Up!

In this online game, learners must purchase power plants for their city. They must balance the need for adequate power against the environmental impact of different power plants and stay within their limited budget. The game introduces many kinds of power plants to choose from (oil, coal, nuclear, solar, wind, hydro). Since the game only shows a random selection of three of these power sources at a time, the game changes each time they play.

Have students go to: http://www.kineticcity.com/controlcar/activity.php?act=4&virus=enervia

Nuclear Power Today

Nature provides many examples of the amazing properties and energy of the atom. The sun, being a nuclear reactor, is one example. Radioactivity is another.

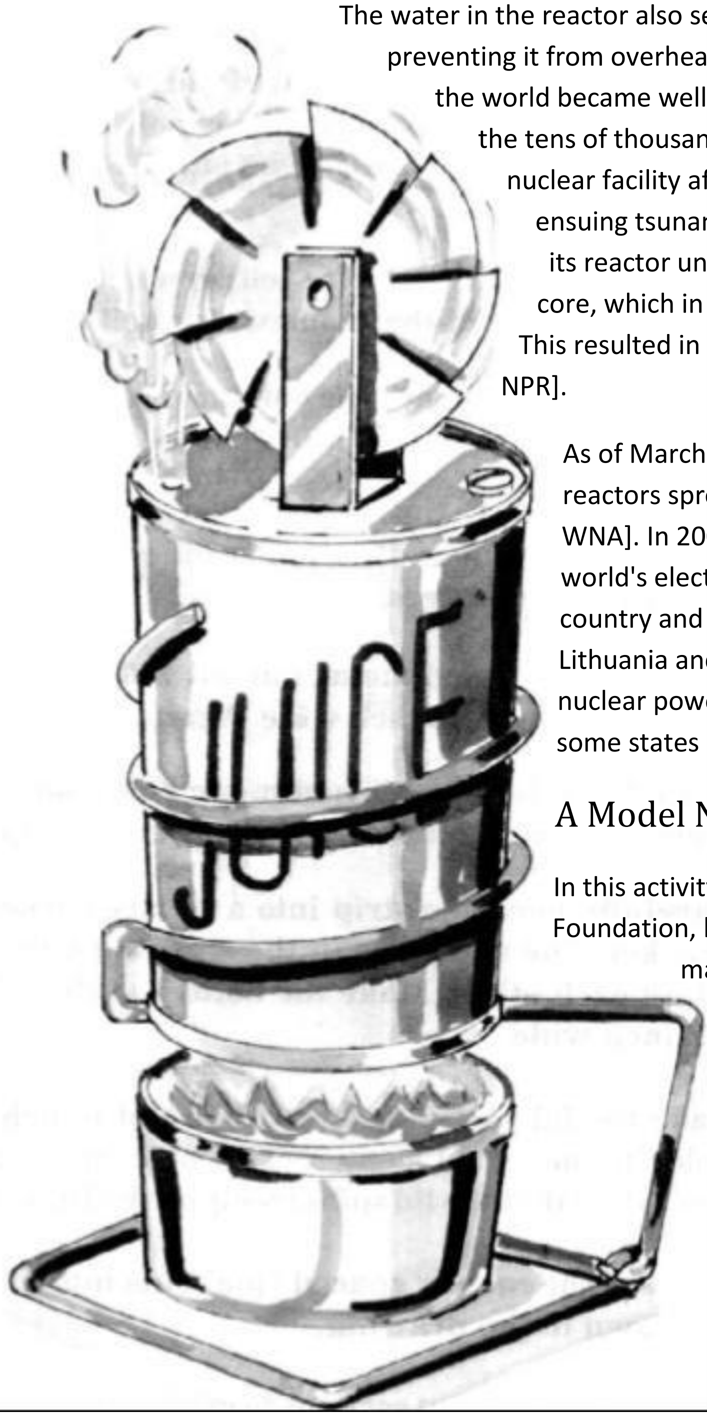
Most of the nuclear power produced in the world today comes from the controlled splitting (fission) of radioactive uranium in reactors that transform uranium's nuclear energy into heat. Heat, in turn, creates steam for turbines to generate electricity, to propel ships, to drive industrial processes.

As a fuel, uranium has a distinct advantage over coal, oil, and gas. The latter three, are in limited supply. On the other hand, the known reserve of uranium would provide the world with energy for centuries to come. It represents a heat source that, when properly safeguarded and controlled, is safe and does not significantly affect our environment.

An understanding of nuclear energy is essential if citizens are to deal intelligently with questions on energy options . . . questions we face as a nation and as a world community.

Today, the nuclear power plant stands on the border between humanity's greatest hopes and its deepest fears for the future. On one hand, atomic energy offers a clean energy alternative that frees us from the shackles of fossil fuel dependence. On the other, it summons images of disaster: quake-ruptured Japanese power plants belching radioactive steam, the abandoned dead zone surrounding Chernobyl.

But what happens inside a nuclear power plant to bring such marvel and misery into being? Imagine following a volt of electricity back through the wall socket, all the way through miles of power lines to the nuclear reactor that generated it. You'd encounter the generator that produces the spark and the turbine that turns it. Next, you'd find the jet of steam that turns the turbine and finally the radioactive uranium bundle that heats water into steam. Welcome to the nuclear reactor core.



The water in the reactor also serves as a coolant for the radioactive material, preventing it from overheating and melting down. In March 2011, viewers around the world became well acquainted with this reality as Japanese citizens fled by the tens of thousands from the area surrounding the Fukushima-Daiichi nuclear facility after the most powerful earthquake on record and the ensuing tsunami inflicted serious damage on the plant and several of its reactor units. Among other events, water drained from the reactor core, which in turn made it impossible to control core temperatures. This resulted in overheating and a partial nuclear meltdown [source: NPR].

As of March 1, 2011, there were 443 operating nuclear power reactors spread across the planet in 47 different countries [source: WNA]. In 2009 alone, atomic energy accounted for 14 percent of the world's electrical production. Break that down to the individual country and the percentage skyrockets as high as 76.2 percent for Lithuania and 75.2 for France [source: NEI]. In the United States, 104 nuclear power plants supply 20 percent of the electricity overall, with some states benefiting more than others.

A Model Nuclear Power Plant Steam Turbine

In this activity from the Thomas A. Edison, Edison Innovation Foundation, learners build a model of a power plant using simple materials. The activity specifically refers to a nuclear reactor, but it is a good model for the way a coal, oil, natural gas, or geothermal power plant works. The main difference is whether the burning can of Sterno represents Uranium breaking down (nuclear), fossil fuels burning (coal, oil natural gas), or energy from the earth's crust (geothermal). Also, in a real plant the turbine wheel is attached to a generator, and that's how electricity would be generated.

Materials List (per student)

- A small unopened can of your favorite fruit juice
- An empty soup can
- A clean finishing nail
- A wire coat hanger
- A can of Sterno canned heat
- An eye dropper
- Two small sheet metal screws
- Tinsnips
- Hammer

The core of a nuclear reactor (the part that contains the uranium) generates heat as the chain reaction takes place. Nuclear power plants boil water with this heat. They then use the resulting steam to drive turbines that, in turn, drive electric generators. In this way, the energy emitted by the splitting atoms is converted into electricity.

This simple model will show you how a steam turbine operates. Here's how to build it:

1. Use the nail to punch two small holes in the top of the fruit juice can. The holes should be on opposite sides of the top, about 1/4 inch from the edge.

2. Pour all of the fruit juice out of the can (maybe you'd like to take a juice break at this point). Remove the paper label, then rinse the can out with water as best you are able.

3. Plug one of the two holes (either one) with a sheet metal screw. And that's our water boiler.

4. Now carefully remove the bottom of the soup can with a can opener, and set it aside.

5. Using a pair of tinsnips, cautiously cut along the length of the can and flatten out the metal. Look out for those sharp edges!

6. From the flattened metal, cut out a strip about 4-l/2 inches long and l/2 inch wide. Again, work with care.

7. With the finishing nail, hammer a hole about l/4 inch from each end of the strip and one in the very center.

8. Carefully bend the strip into a square-cornered U bracket. The end holes in the strip must line up opposite each other. Make the bottom of the U about l/2 inch wide.

9. Take the lid you set aside earlier and punch a small hole in the exact center. The hole must be large enough so that the lid spins freely on the finishing nail.

10. Make eight equally spaced pie cuts into the can lid as shown in the drawing.

11. Gently bend the cut sections to create an eight-bladed turbine wheel.

12. Using the finishing nail as an axle, assemble the fan inside the U bracket.

13. Locate the bracket on the can so that when steam shoots from the opening, it will hit the flat part of the blades. Now mount the bracket on the can with the other sheet metal screw. To keep the turbine wheel centered, wrap some tape on the axle on both sides of the wheel.

14. Fashion a simple support stand out of the coat hanger, as illustrated. The stand must support the juice can about four inches over the open Sterno can.

15. Use the eye dropper to fill the can about l/3 full with water.

16. Light the Sterno and place it under the boiler. In a few minutes, the water will boil and steam will spin the turbine.

Day Four K-8 Standard Alignment

K

RL.K.6a Assess how point of view or purpose shapes the content and style of a text.

RI.K.8. With prompting and support, identify the reasons an author gives to support points in a text.

These standards will be met and reinforced as we read from, discuss , and analyze the article by Denise Ryan, Director of Public Lands Policy, National Trust for Historic Preservation. We will talk about what influences she may have personally, how they may have shaped her format and points, what she's trying to do by writing that article, and what reasons she gives to support her points. We'll determine what kind of article it is, ex. is it strictly factual, giving us her opinion, trying to persuade, etc. And students will give their opinions on whether they agree or disagree with what they determine her central message to be.

1

RL.1.6a Assess how point of view or purpose shapes the content and style of a text.

RI.1.8. Identify the reasons an author gives to support points in a text.

These standards will be met and reinforced as we read from, discuss , and analyze the article by Denise Ryan, Director of Public Lands Policy, National Trust for Historic Preservation. We will talk about what influences she may have personally, how they may have shaped her format and points, what she's trying to do by writing that article, and what reasons she gives to support her points. We'll determine what kind of article it is, ex. is it strictly factual, giving us her opinion, *trying to persuade, etc. And students will give their opinions on whether they agree or disagree with what they determine her central message to be.*

2

RI.2.6. Identify the main purpose of a text, including what the author wants to answer, explain, or describe.

RI.2.8. Describe how reasons support specific points the author makes in a text.

These standards will be met and reinforced as we read from, discuss , and analyze the article by Denise Ryan, Director of Public Lands Policy, National Trust for Historic Preservation. We will talk about what influences she may have personally, how they may have shaped her format and points, what she's trying to do by writing that article, and what reasons she gives to support her points. We'll determine what kind of article it is, ex. is it strictly factual, giving us her opinion, trying to persuade, etc. And students will give their opinions on whether they agree or disagree with what they determine her central message to be.

3

RI.3.8. a Delineate and evaluate the argument and specific claims in a text, including how an author uses reasons and evidence to support particular points in a text.

RI.3.6. Distinguish their own point of view from that of the author of a text.

These standards will be met and reinforced as we read from, discuss , and analyze the article by Denise Ryan, Director of Public Lands Policy, National Trust for Historic Preservation. We will talk about what influences she may have personally, how they may have shaped her format and points, what she's trying to do by writing that article, and what reasons she gives to support her points. We'll determine what kind of article it is, ex. is it strictly factual, giving us her opinion, trying to persuade, etc. And students will give their opinions on whether they agree or disagree with what they determine her central message to be.

4

RI.4.8. Explain how an author uses reasons and evidence to support particular points in a text.

RI.4.6. a Assess how point of view or purpose shapes the content and style of a text.

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5

RI.4.6. a Assess how point of view or purpose shapes the content and style of a text.

RI.5.8. Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).

These standards will be met and reinforced as we read from, discuss , and analyze the article by Denise Ryan, Director of Public Lands Policy, National Trust for Historic Preservation. We will talk about what influences she may have personally, how they may have shaped her format and points, what she's trying to do by writing that article, and what reasons she gives to support her points. We'll determine what kind of article it is, ex. is it strictly factual, giving us her opinion, trying to persuade, etc. And students will give their opinions on whether they agree or disagree with what they determine her central message to be.

6

RH.6-8.8. Distinguish among fact, opinion, and reasoned judgment in a text.

RH.6-8.6. Identify aspects of a text that reveal an author's point of view or purpose (e.g., loaded language, inclusion or avoidance of particular facts).

These standards will be met and reinforced as we read from, discuss , and analyze the article by Denise Ryan, Director of Public Lands Policy, National Trust for Historic Preservation. We will talk about what influences she may have personally, how they may have shaped her format and points, what she's trying to do by writing that article, and what reasons she gives to support her points. We'll determine what kind of article it is, ex. is it strictly factual, giving us her opinion, trying to persuade, etc, and what in the article specifically shows us that it is that type of article. And students will give their opinions on whether they agree or disagree with what they determine her central message to be.

7

RH.6-8.8. Distinguish among fact, opinion, and reasoned judgment in a text.

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8

RH.6-8.8. Distinguish among fact, opinion, and reasoned judgment in a text.

RH.6-8.6. Identify aspects of a text that reveal an author's point of view or purpose (e.g., loaded language, inclusion or avoidance of particular facts).

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Unit 3 Academic Vocabulary Guide

K

- United States of America
- Human
- Leader
- Globe
- President
- Difference
- Story
- Respect
- Parts
- Size

1

- Past
- Present
- Future
- Rights
- Responsibilities
- History
- Investigate
- Symbol

2

- Events
- History
- Conflict
- Decision
- Symbol
- Government
- Distance
- Duty
- Authority

3

- Tools
- Weapons
- Global
- Force
- Division
- Fact
- Effect
- Summarize
- Factor
- Threatened
- Conclusion
- Area

4

- Population
- Document
- Missions
- Political
- Energy
- Accuracy
- Audience
- Drawing conclusions
- Range
- Relationship

5

- Radiation
- Dissipate
- Bias
- View
- Solution
- Plane
- Justify
- Visual
- Image
- Implied
- Point of View

6

- Energy
- Control
- Cause and effect
- Bias
- Technological
- Point of view
- Relevant
- Stressed
- Power
- Similarity
- Atmosphere

7

- Diffusion
- Physical process
- Impact
- Respiration
- Function
- Mood
- Stress
- Interaction with texts

8

- Human impact
- Sector of a circle
- International
- Social norms
- Absolute
- Variation
- Neutron
- Proton
- Electron
- Exothermic
- Atom

Wings of the Crane Unit 3 Sample Supply List

Day One

- Access to video links
- Building materials: materials such as Candy Blox and pretzel rods/sticks for the control rods. Or with other edible construction materials such as wafer cookies, ex. chocolate might represent the uranium enriched blocks. Non-edible materials such as regular Legos, K'Nex, Keva, or other brands/styles of building materials may also be used/used instead.

Day Two

- Marbles
- Materials to make circles (ex. chalk, tape, posterboard)
- Paper
- Pencils

Day Three

- Access to video links
- Paper
- Printed targets
- Scorekeeping materials, ex. paper & pencils

Day Four

- small unopened **cans** of your favorite fruit juice or flavored water, etc
- empty soup cans
- clean finishing nails
- wire coat hangers
- cans of Sterno canned heat
- eye droppers
- small sheet metal screws
- Tinsnips
- Hammers