the wings of the crane

unit two: day one

Atoms Give Me the Warm Fuzzies

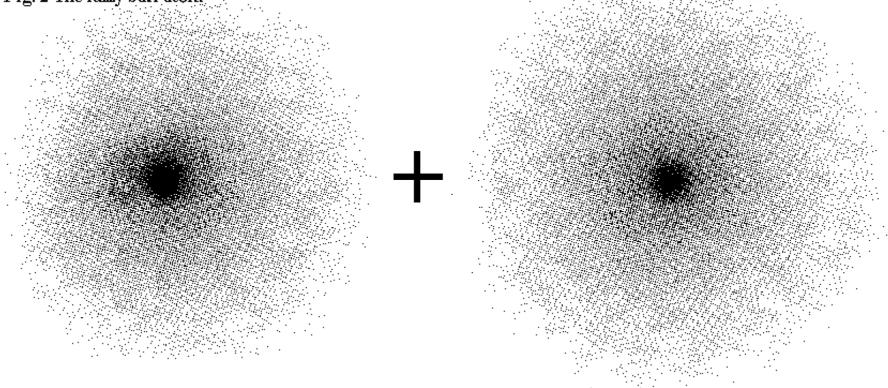
As late as the 19th century, many leading scientists of the day thought that atoms were indivisible blobs of matter, sort of like tiny solid balls, like marbles. Now we know that atoms are far more complex. We also know that under the right conditions certain atoms can be split into smaller atoms (and release tons of energy.)

The basic structure of an atom is that it has little things called neutrons and protons that are stuck together in a ball (called a nucleus) in the middle, with electrons in a bigger fuzzy ball around that. Neutrons and protons are about the same size, and electrons are much much much smaller.

An interesting fact is that although the "cloud" of electrons that surround the nucleus is much much much bigger than the nucleus itself, most of the mass and weight of the atom (more than 99%) is right there in the middle, in the nucleus.

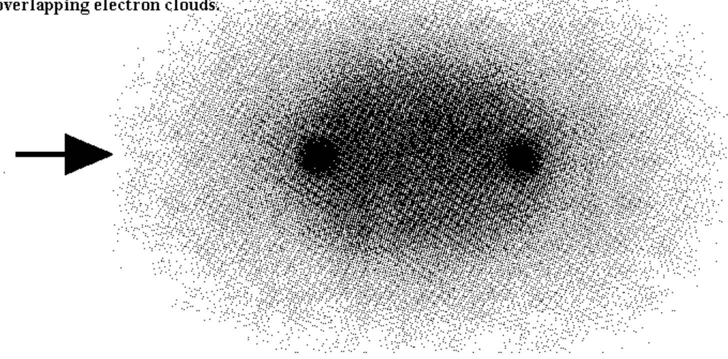
Scientists have found that the nucleus doesn't hold still, it vibrates and jiggles. Everything is in motion, including the electrons, which are in constant twirling motion. And how grateful we should be for their vigor! You'd think all atoms would collapse like popped bubble wrap, but now, the tremendous momentum of the electron throws it into orbit around the nucleus, keeping it at a distance and on the fly.

Fig. 2 The fuzzy ball atom



Electrons can never stop to catch their breath. For one thing, they have no lungs. The electrons form a "cloud" of electron density (thicker in the middle, thinner towards the edges, rather like a nice stick of cotton candy) that tapers off moving away from the nucleus so there is no sharp boundary

Fig. 4 Atoms stick together by overlapping electron clouds.



to an atom. The rapid movement of electrons around the atom leads to their resembling clouds– the probability cloud – of where you might have the best chance of finding the electron if you looked for it. (Kind of like how the blades of a fan make a solid shape around the center of the fan when they go really fast. You might not see individual blades unless you look really carefully, but you can see where blades would be. On an ordinary day spent clouding around the atom, electrons race about at 1,370 miles per second—fast enough to circle the whole earth in 18 seconds.

Atoms of one material differ from atoms of another material because of the make-up of their nuclei and the number of electrons they have. The nucleus of most atoms consists of two kinds of particles: protons and neutrons. Both the proton and neutron have about the same size and weight. However the proton carries a positive electric charge, while the neutron has no charge at all.

Note that we said the nucleus of most atoms contains both protons and neutrons. The exception is the hydrogen atom, the simplest atom of all. Its nucleus only contains a single proton.

Sweet Atom of Mine

Materials:

- Cotton Candy (4 colors if possible)
- Rice Krispie treats or popcorn balls
- Peanuts, m&ms, sunflower seeds or other appropriate item
- Sprinkles (option)

Let's pause here to imagine, and build, a very basic (and tasty) model of the atom according to what we know/we've learned. Taking what we've talked about and what we've learned from the videos…Can students visualize a nugget of kernels like a popcorn ball (rice krispie treat ball) stuck in the center of a very large ball of cotton candy? (Remember that delicious warm sugar smell and that melt in the mouth texture?...) Now let's imagine that the popcorn ball (rice krispie treat ball) also has peanuts, m&ms or sunflower seeds in it, giving it two different kinds of kernels (particles.) We can think of the popcorn kernels as protons, and the peanuts as neutrons, all tightly held together in the nucleus.

The cotton candy ball represents the space in which the electrons are most likely to be found. However, we know that if the nucleus of an actual atom were actually the size of our popcorn-peanut ball, then the ball of cotton candy would be miles in diameter! A model of a hydrogen atom would consist of a single piece of popcorn with a large cotton candy ball surrounding it. Whereas a uranium model would contain quite a lot of popcorn protons (92 pieces) and many peanut neutrons (146) surrounded by a very large cotton candy sphere. Note: The sum of the particles in the uranium nucleus is 238, which is the atomic mass of uranium.

Now we can wrap our nucleus core in layers of sweet cloudy space (cotton candy) in which we are likely to find our electrons (sprinkles). The number of electrons orbiting an atom's nucleus is equal to the number of protons in the nucleus. **So hydrogen would have how many?** Right, 1! (see how hard it would be to find in that cloudy area, imagine it speeding through!) How about uranium? Yep, 92! Each electron carries a negative charge, and each proton carries a positive charge. Thus the charges balance. -1+1=0. Since neither is stronger than the other, they equal out. The proton-to-electron ratio is always one to one, so the atom as a whole has a neutral charge.

Electrons cannot flit about wherever they please, inside the cloud are layers, shells, or zones around the protons to which they are so attracted. These shells are layered one inside the other and each is able to only fit a set number of electrons. The shell closest to the nucleus only has room for two, the next two beltways have space for eight negative particles each, while the farthest ones out can manage eighteen or more electrons. Once a shell is filled, even the president and his cloud of armored SUVs couldn't nose their way in.

An electron also cannot travel **in between** shells or layers, just as you cannot stand between two steps of a staircase. An electron can, however, switch from one byway to another, assuming there is room.

Have students wrap layers of cotton candy (4 colors if possible) around their 'nucleus.'

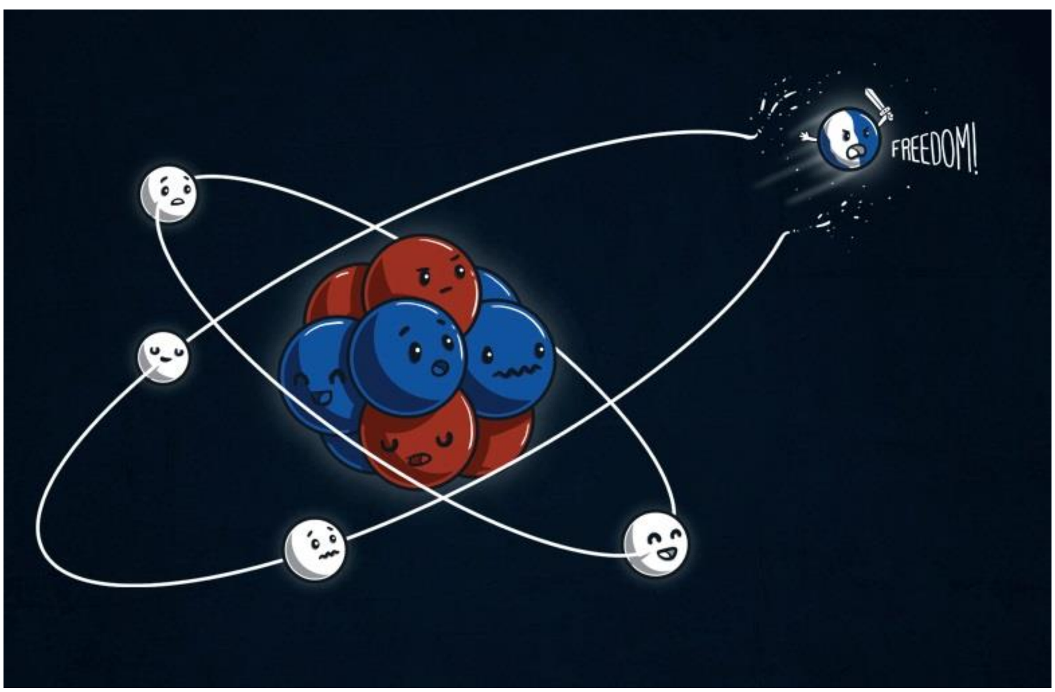
Option: Explore the Lawrence Berkeley National Laboratory: The Particle Adventure! Fundamentals of Matter and Force with students to get a clearer understanding and visual explanations of particle decay. http://particleadventure.org/decays-and-

Spitting Out Particles

Right around the turn of this century, scientists observed that certain atoms undergo mysterious transformations. For example, atoms of radium (a rare metallic element) turn into atoms of radon (a rare gaseous element). Equally as surprising, the radium atom emits a teeny tiny particle, called an alpha particle, when the change takes place. This alpha particle consists of two neutrons and two protons (pop! There go two peanuts and two popcorn kernels out of our models). It is identical to the nucleus of a helium atom.

A stream of alpha particles is called an alpha ray.

We now know that this transformation is an example of radioactive decay, a process whereby one atom breaks apart to form one or more smaller atoms. Radium atoms decay into radon atoms and alpha particles spontaneously. In other words, every so often an atom in a chunk of radium metal will decide, on its own, to break apart. There are many other atoms that will break apart spontaneously. Scientists call these substances naturally radioactive.



When an atom breaks apart, the decay process also gives off energy. In certain circumstances, it is possible to capture this energy in the form of heat, then use the heat to generate electricity. This is the principle of operation of all the nuclear-powered electricity generating plants that are at work today.

So, a nucleus that emits radiation is, of course, radioactive, and the act of emitting particles is known as radioactive decay. There are three types of particles: alpha, beta, and gamma. Alpha particles are positively charged, beta particles are negatively charged, and gamma particles have no charge. The particles also have increasing levels of **energy**. Alpha has the lowest energy, beta has a bit more, and then gamma is the fastest and most energetic of all the **emission** particles.

Radioactive Decay

To visualize and model what happens when a nucleus decays. Radioactive decay is accompanied by the emission of radiation (alpha, beta, or gamma.) **Radioactivity** occurs when an atomic **nucleus** breaks down into smaller particles.

Materials:

• Pennies (1 per student)

• Balloons (1 per student)

Number of Players/Students:

Full class (10- 20 students)

Key Definition to remember: The half-life of a substance is the time that it takes for one-half of the substance to react or change in some way.

a : the time required for half of the atoms of a radioactive substance to become disintegrated

b : the time required for half the amount of a substance (as a drug, radioactive tracer, or pesticide) in or introduced into a living system or ecosystem to be eliminated or disintegrated by natural processes

This activity will work better with a large group.

Procedure:

1. Start by having each student blow up the balloon (but not tie it) and hold it in one hand.
2. At 30-second intervals, have the students flip their coins.
3. Those students whose coins come up tails will have a radioactive decay. They can release their balloon any time within the 30-second interval.
4. Those students whose coins come up heads will repeat steps 2 and 3 at 30-second intervals.
5. Stop when all the radiation has been released, that is, when all the nuclei have “decayed.”

Analysis and Results: Record the number of students that “decay” during each half life and then graph the results. Record where the “radiation” landed and whether it “hit” any of the students.

Assessment:

1. Have the students discuss the results shown in their graphs.

2. Could they predict exactly when they were going to decay? Why or why not?
3. What is the effect of the radiation (the balloon) from one atom "hitting" another atom?
4. Can they predict where the radiation will go?

Extension: You may identify one student and then have all the others try to guess in which interval that student's 'nucleus' will decay. Do this a number of times with different students and record the flip number where the designated nucleus decayed. With many trials, a graph of these results should look the same as a graph of the half-life results.

The Radioactive Decay of 'Candium'

Key Definition to remember: The half-life of a substance is the time that it takes for one-half of the substance to react or change in some way.

a : the time required for half of the atoms of a radioactive substance to become disintegrated

b : the time required for half the amount of a substance (as a drug, radioactive tracer, or pesticide) in or introduced into a living system or ecosystem to be eliminated or disintegrated by natural processes

This activity is meant to show that by eliminating random kernels, the process of radioactive decay can be simulated.

Materials: Data Analysis sheet for each student (included)

128 un-popped popcorn kernels, M&M's (aka 'candium'), Skittles, coins or poker chips with stickers on one side may also be used. Note: M&M's move the pace of the game quicker than popcorn kernels.

This lab will simulate radioactive decay. By eliminating random kernels, the process of radioactive decay can be simulated.

Procedure:

1. Select a cup with kernels in it

2. Carefully "spill" the kernels onto the table. Do not drop them since the kernels have a tendency to bounce. Spread them out widely.

3. Each kernel has a "point" on it. If the kernel points towards the front of the room IN ANY WAY, it is still "good" and you place it back into the cup.

4. The kernels that point towards the back of the room IN ANY WAY is "decayed" and is pushed off to the side.

5. An option is to have any kernels that are pointing EXACTLY to the sides of the room will have their fate decided by paper-rock-scissors, best 2 out of 3.

6. Count how many kernels are still good and record that in your data table.

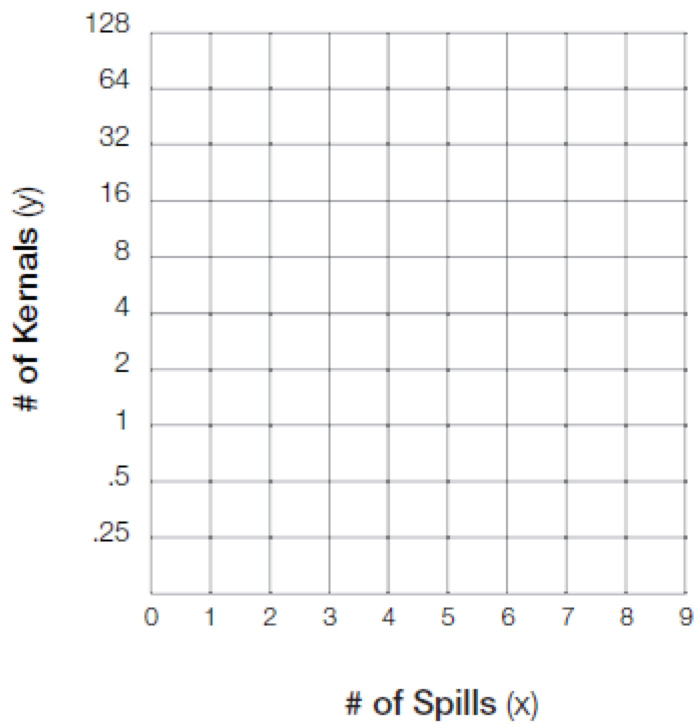
7. Repeat the procedure until all kernels have decayed.

Data:

SPILLS		0	1	2	3	4	5	6	7
Expected Kernels Remaining based on previous sample size		128	64						
Kernels Remaining		128							
Summary	Total / %								

Data Analysis:
1. Make a graph with spills on the x axis and kernels remaining on the y axis.
2. On the same graph, plot expected kernels remaining on the y axis.
3. How accurate does your graph represent decay?
4. Each spill represents a "half-life." How many kernels were eliminated during the first half-life?
5. How many kernels were eliminated during the second half-life?
6. For each successive half-life, does the number of kernels increase, decrease or remain the same?
7. What percentage of kernels were eliminated during the first half-life (100x #decayed kernels / 128)?
8. What percentage of kernels were eliminated during the second half-life (100 x #decayed kernels / amount remaining after 1st half-life)?
9. For each successive half-life, does the percentage of kernels eliminated increase, decrease or remain the same?
10. Suppose a popcorn company spilled one million kernels on the factory floor. Can you estimate how many kernels will be pointing east in some way?
11. If your answer to #10 was yes, about how many will point east? If your answer was no, why not?

12. Inside the batch of one million kernels, there is a magical blue popcorn kernel, which follows the same laws as regular kernels. Can you predict which way the magic blue kernel will be pointing after it spills?
13. If your answer to #12 was yes, which way will it point? If your answer was no, why not?
14. Does half-life depend on the mass of the sample?
15. Does half-life predict when individual elements or atoms decay, or only the probability that those elements will decay?



Teacher's Answers to Data Analysis

Data Analysis:

1. Make a graph with spills on the x axis and kernels remaining on the y axis.
A. Graphs will vary
2. On the same graph, plot expected kernels remaining on the y axis.
A. Every graph should show exponential decay.
3. How accurate does your graph represent decay?
A. The graphs should be similar
4. Each spill represents a "half-life." How many kernels were eliminated during the first half-life?
A. About 64 kernels should decay (maybe more or less)
5. How many kernels were eliminated during the second half-life?
A. About 32 kernels should decay (maybe more or less)
6. For each successive half-life, does the number of kernels increase, decrease or remain the same?
A. The number of decayed kernels decreases
7. What percentage of kernels were eliminated during the first half-life (100

x #decayed kernels / 128)?
A. About 50%
8. What percentage of kernels were eliminated during the second half-life (100 x #decayed kernels / amount remaining after 1st half-life)?
A. About 50%
9. For each successive half-life, does the percentage of kernels eliminated increase, decrease or remain the same?
A. The percentage is about 50% for each half-life
10. Suppose a popcorn company spilled one million kernels on the factory floor. Can you estimate how many kernels will be pointing east in some way?

A. That can be estimated

11. If your answer to #10 was yes, about how many will point east? If your answer was no, why not?
A. About 500 thousand will point east (or any other random direction)
12. Inside the batch of one million kernels, there is a magical blue popcorn kernel, which follows the same laws as regular kernels. Can you predict which way the magic blue kernel will be pointing after it spills?
A. No way to predict the blue kernel's direction
13. If your answer to #12 was yes, which way will it point? If your answer was no, why not?
A. An individual kernels direction is completely random.
14. Does half-life depend on the mass of the sample?
A. Half-life is independent of mass.
15. Does half-life predict when individual elements or atoms decay, or only the probability that those elements will decay?

A. Half-life only predicts probability and that probability is always 1:1 between staying and decaying.

Common student questions concerning radioactive decay:
If mass is conserved, how do radioactive atoms decay?
The term decay, which insinuates destruction, is a small misnomer. Radioactive elements transmute, or change, into more stable nuclei. Imagine 238 marbles in a box. If you take some marbles out of the box, the total number of marbles remains 238. The only difference is some of the marbles are in your hand. In the nucleus, the marbles being held represent the radiation (particles) that escapes, but the mass remains the same.

Day One K-8 Grade Standard Alignment

K
7.9.1 Describe an object by its observable properties.
7.1.1 Recognize that many things are made of parts.

These standards will be met during the model building and discussion of atoms. Students will realize that all things are made of parts because all things are made of atoms and even atoms are made of parts.

1
7.1.1 Recognize that living [and non-lving] things have parts that work together.
7.1.3 Make diagrams and models to record and communicate observations and understanding.

These standards will be met during the model building and discussion of atoms. Students will realize that all things are made of parts because all things are made of atoms and even atoms are made of parts, empty space, electrons, neutrons, and protons, that all work together to form elements and structures.

2
7.1.1 Recognize that plants and animals [and other objects] are made up of smaller parts.
RI.2.3. Describe the connection between a series of historical events, scientific ideas and/or concepts

These standards will be met during the model building and discussion of atoms. Students will realize that all things are made of parts because all things are made of atoms and even atoms are made of parts, empty space, electrons, neutrons, and protons. We will discuss the history of the discovery of atoms and how each scientist built on the theories and ideas of the ones before him/her, even when they didn't agree, they were still building on the knowledge and experiments of prior scientists.

3
7.10.1 Identify various sources of energy.
RI.3.3. Describe the relationship between a series of historical events, scientific ideas or concepts, ex. in a text, using language that pertains to time, sequence, and cause/effect.

These standards will be met during the model building and discussion of atoms and the energy that they contain/release. We will discuss the history of the discovery of atoms and how each scientist built on the theories and ideas of the ones before him/her, even when they didn't agree, they were still building on the knowledge and experiments of prior scientists.

4
RI.4.3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
7.Inq.5 Recognize that people may interpret the same results in different ways.

These standards will be met as we discuss the history of the discovery of atoms and how each scientist built on the theories and ideas of the ones before him/her, even when they didn't agree, they were still building on the knowledge and experiments of prior scientists. We'll discuss how scientists looked at the same/similar/their own evidence and came up with different theories of how atoms are made up and relate this back to the measurement experiment we did in the last unit.

5
RI.5.3. Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.
7.Inq.5 Recognize that people may interpret the same results in different ways.

These standards will be met as we discuss the history of the discovery of atoms and how each scientist built on the theories and ideas of the ones before him/her, even when they didn't agree, they were still building on the knowledge and experiments of prior scientists. We'll discuss how scientists looked at the same/similar/their own evidence and came up with different theories of how atoms are made up and relate this back to the measurement experiment we did in the last unit.

6

RI.7.9. Analyze how two or more authors [scientists] writing about the same topic shape their presentations of key information by emphasizing different evidence or advancing different interpretations of facts and results.
7.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.

These standards will be met during the model building and discussion of atoms. We will discuss the history of the discovery of atoms and how each scientist built on the theories and ideas of the ones before him/her, even when they didn't agree, they were still building on the knowledge and experiments of prior scientists. We'll discuss how scientists looked at the same/similar/their own evidence and came up with different theories of how atoms are made up and relate this back to the measurement experiment we did in the last unit.
We'll demonstrate our understanding of atomic structure by building, labeling, and explaining our models.

7
7.9.1a Understand that all matter is made up of atoms.
7.9.1b Identify atoms as the fundamental particles that make up matter.

These standards will be met during the model building and discussion of atoms. Students will realize that all things are made of atoms.

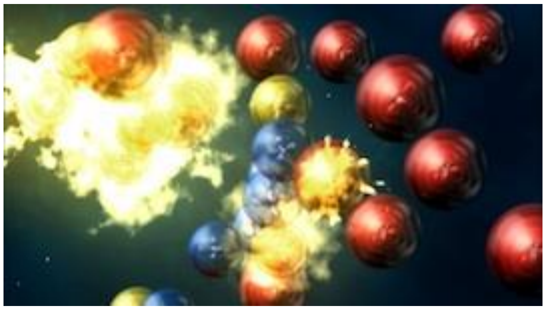
8
1.1.1.Compare and contrast historical models of the atom.
4.1.1 Explain and illustrate the arrangement of electrons surrounding an atom.
1.6.9 Identify the parts of an atom.
1.6.10 Describe the properties and location of subatomic particles.
1.3.8 Describe radioactive decay and analyze the half-life concept.

These standards will be met during the model building, radioactive decay experiments, and discussion of atoms, fission, fusion, etc..

unit two: day two

"Gone fission?"

To introduce this section/help with discussion have students watch the excellent short [2:45] video: http://www.pbslearningmedia.org/asset/nvhe_vid_fission/ Students will discover how scientists once



thought that uranium was the end of the periodic table and find out how the table has grown since atomic scientists created synthetic elements. Visit the Nuclear Museum in New Mexico to learn about the process of nuclear fission and to see a fun and memorable demonstration (using mousetraps & ping pong balls) of what happens inside a nuclear chain reaction in a bomb.

See a fun (and slo-mo) variation at: https://www.youtube.com/watch?v=vjqIJW_Qr3c An array of 138 mousetraps are set off in a chain reaction. Ping-pong balls help visualize both neutrons and the release of energy in a nuclear bomb. Shot in 600 fps and 1000 fps.

Then: [900 Mousetraps Unleashed with Science Bob on Jimmy Kimmel Live] This demonstration utilized 900 mousetraps that were set-up for a chain reaction. It took 4 people 7 hours to set up the traps! As far as we know there has not been a similar reaction at this scale. The demonstration visualizes how nuclear fission, Newton's Laws, and potential and kinetic energy work. http://www.youtube.com/watch?v=XIvHd76EdQ4

Nuclear bombs involve the forces, strong and weak, that hold the nucleus of an atom together, especially atoms with unstable nuclei. There are two basic ways that nuclear energy can be released from an atom. In **nuclear fission**, scientists split the nucleus of an atom into two smaller fragments with a neutron.

Nuclear fusion -- the process by which the sun produces energy -- involves bringing together two smaller atoms to form a larger one. In either process, fission or fusion, large amounts of heat energy and radiation are given off.

Around this time (the 1930s), scientists began using particle accelerators to bombard the nuclei of atoms in the hopes of splitting atoms and creating energy. Initially, they achieved very little success -- early particle accelerators shot out protons and alpha particles, both positively charged. Even at high speeds, these particles were easily repelled by the positively charged nuclei (remember opposites attract and same charges repel), and figures such as Rutherford, Albert Einstein and Niels Bohr felt that harnessing atomic power was close to impossible.

This changed when Italian physicist Enrico Fermi thought to use neutrons for bombardment in 1934. Since neutrons have no charge, they can hit an atom's nucleus without being repelled. He successfully bombarded several elements and created new, radioactive ones in the process. What Fermi had done, without recognizing it, was discover the process of nuclear fission. Two German scientists, Otto Hahn and Fritz Strassmann, were the first to officially acknowledge this process in 1938 when they successfully split uranium atoms into two or more parts by bombarding it with neutrons, which produced a radioactive barium isotope. They concluded that the low-speed neutrons caused the uranium nucleus to fission, or break apart, into two smaller pieces.

To demonstrate the concept of nuclear fission and its resulting burst of energy to younger students.

Materials:

- notebook
- one long balloon
- one pair of scissors

1. The teacher will blow up the balloon and tie it closed. (Leave a small amount of room for expansion.) Explain that this balloon represents an atom of uranium.
2. Twist the balloon in the center to make two separate air chambers. Hold it with two hands, pinching off both chambers with the fingers.
3. Have a student cut the balloon between the two chambers (the scissors are the neutron), making two separate balloons. Explain that this is fission, the splitting of one atom into two atoms of smaller size.
4. Let both the pieces go. As they fly away explain that this is like the energy released during fission.

5. Retrieve both pieces. Ask if these pieces are useful anymore (no, they are not). Explain that these pieces are now like nuclear waste.

Questions for discussion:

What is nuclear fission?

In the demonstration seen in the video, what do the mousetraps and ping-pong balls represent?

Describe how a fission chain reaction can be self-sustaining.

Stop, Drop, and Split? An Oil-Drop Model of a Splitting Atom

THINGS YOU NEED:

- A small water glass.
- Five or six ounces of rubbing alcohol.
- An ounce or so of cooking oil.
- Some water.
- A teaspoon and a butter knife.
- A paper towel.

Many scientists have suggested that a splitting atom behaves somewhat like a drop of liquid when it breaks up into droplets. This experiment demonstrates the point.

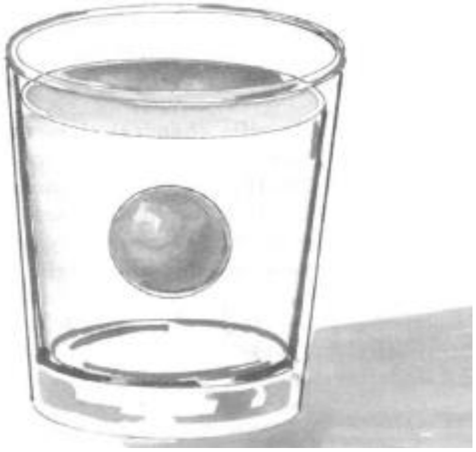
Fill the water glass about half full with rubbing alcohol, then add enough water to fill the glass two-thirds full.

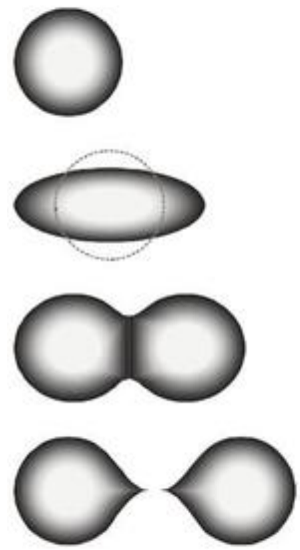
Stir the alcohol-water mixture with the teaspoon.

Next, wipe the teaspoon dry and fill it with cooking oil.

Now comes the tricky part: Have students carefully bring the spoon close to the surface of the alcohol-water mixture in the glass, then gently tip the spoon over. If they've done the job right, a single blob of oil will slide into the glass.

If the blob of oil is floating on the surface, carefully add a bit more alcohol to the mixture (use your teaspoon): if the blob has sunk to the bottom of the glass, spoon in some more water. The idea is to change the blob of oil into an oil drop that hovers somewhere in the middle of the glass, as shown in the drawing.





Note how perfectly spherical the drop is. The forces that hold the oil drop together are comparable to the forces that hold an atom together.

Now take the butter knife and carefully prod the drop apart. At first, the drop will bulge (observe the different shapes the oil drop takes on before it splits into two or more drops.) Then, it will tear apart into two perfectly round oil drops. The oil-drop 'atom' will have split into two smaller atoms.

Note that the drop wouldn't split until it was critically deformed by the knife. Atoms behave in much the same way: They resist splitting until some action critically deforms them.

Day Two K-8 Grade Standard Alignment

K

- 7.9.1 Describe an object by its observable properties.
- 7.Inq.1 Use senses and simple tools to make observations.

These standards will be met and reinforced while watching video clips and during the discussion of atoms and during the experiments. Students will be asked to describe the balloon and oil models of the atom and how they act/react during the experiment process.

1

- 7.Inq.2 Ask questions, make logical predictions, and plan investigations, and represent data.
- 7.Inq.3 Communicate understanding of simple data using age-appropriate vocabulary.

These standards will be met and reinforced while watching the videos, during the discussion of atoms and during the experiments. Students will be asked to predict what they think will happen with the mousetraps in the video as well as during the experiments and then will explain what they learned from them afterwards and put into their own words how splitting an atom and chain reactions work.

2

- 7.Inq.2 Ask questions, make logical predictions, and plan investigations, and represent data.
- 7.Inq.3 Communicate understanding of simple data using age-appropriate vocabulary.

These standards will be met and reinforced while watching the videos, during the discussion of atoms and during the experiments. Students will be asked to predict what they think will happen with the mousetraps in the video as well as during the experiments and then will explain what they learned from them afterwards and put into their own words how splitting an atom and chain reactions work.

3

- 7.10.1 Use an illustration (ex. picture, graphic, video) to identify various sources of energy.
- 7.10.1 Investigate phenomena that produce energy, ex. heat.

These standards will be met and reinforced while watching the videos, during the discussion of atoms and during the experiments. Students will be asked to predict what they think will happen with the mousetraps in the video as well as during the experiments and then will explain what they learned from them afterwards and put into their own words how splitting an atom and chain reactions work to transfer/transform/release energy.

4

- 7.10.1 Identify different forms of energy, such as potential, kinetic, heat, light, and chemical
- 7.10.1 Distinguish among different forms of energy such as heat, radiant, potential, kinetic, and/or chemical.

These standards will be met and reinforced while watching the videos, during the discussion of atoms and during the experiments as students see the potential energy stored within the mousetraps and the kinetic energy of the moving ping pong balls and relate it to the stored energy of the atoms and the kinetic energy of the chain reactions and release of energy through fission demonstrations with the oil and balloons.

5

- 7.10.1 Differentiate between potential and kinetic energy.
- 7.10.2 Use data from an investigation to determine the method by which energy, ex. heat, is transferred.

These standards will be met and reinforced while watching the videos, during the discussion of atoms and during the experiments as students see the potential energy stored within the mousetraps and the kinetic energy of the moving ping pong balls and relate it to the stored energy of the atoms and the kinetic energy of the chain reactions and release of energy through fission demonstrations with the oil and balloons.

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 while watching the videos, during the discussion of atoms and during the experiments as students see the potential energy stored within the mousetraps and the kinetic energy of the moving ping pong balls and relate it to the stored *energy of the atoms and the kinetic energy of the chain reactions and release of energy through fission demonstrations with the oil and balloons.*

7

- 7.9.1a Understand that all matter is made up of atoms.
- 7.9.1b Identify atoms as the fundamental particles that make up matter.

These standards will be met and reinforced while watching the videos, during the discussion of atoms and during the experiments.

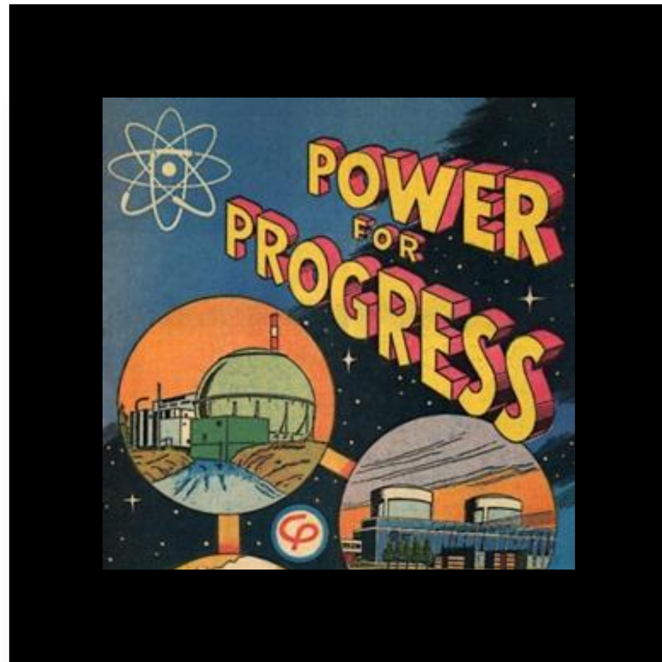
8

- 1.6.10 Describe the properties and location of subatomic particles.
- 1.3.9 Compare and contrast nuclear fission and fusion.

These standards will be met and reinforced while watching the videos, during the discussion of atoms and during the experiments. We will compare what we have learned through videos and discussion to what happens with atoms and neutrons at subatomic levels and whether or not students think the experiments are good models for what we've learned.

unit two, day three

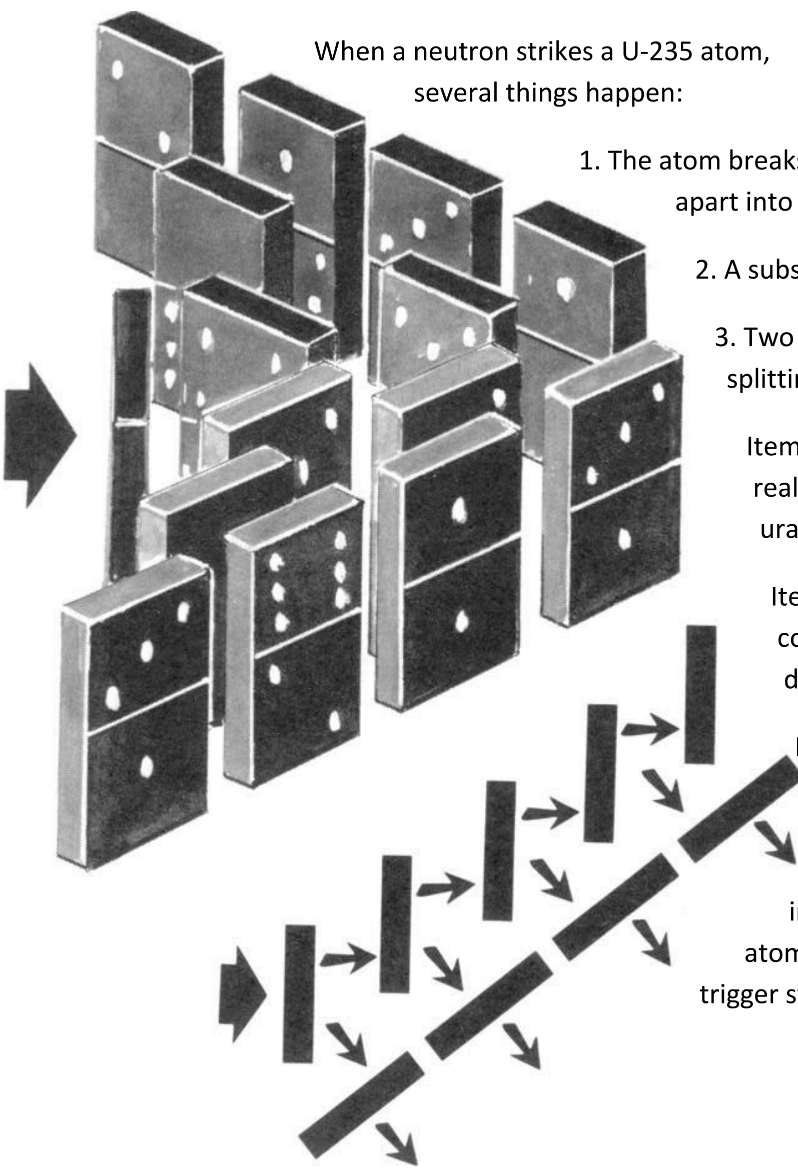
A Domino Model of a Chain Reaction



THINGS YOU NEED: Sets of Dominos.

Back in the beginning we talked about atoms that decay spontaneously into smaller atoms. Inside a nuclear power plant, though, atoms are made to split. And this splitting occurs more or less on schedule, rather than by accident.

The type of uranium called U-235 is ideally suited for such action. U-235 atoms are easily split by bombarding them with neutrons. In effect, the neutrons act like bullets that trigger the splitting of the uranium atoms.



When a neutron strikes a U-235 atom, several things happen:

1. The atom breaks apart into the smaller atoms of barium and krypton.
2. A substantial amount of energy is released.
3. Two or more neutrons are hurled away by the splitting atom.

Item 1 is not too important, because we aren't really concerned with the by-products of the split uranium atom.

Item 2 is very important. This energy will be converted into electricity (we'll see how in a different experiment).

Item 3 is absolutely vital. For these emitted neutrons make it possible to produce a steady stream of nuclear energy. Why? When one U-235 atom splits, the neutrons it releases bang into other U-235 atoms and cause other U-235 atoms to split. The additional neutrons released trigger still other U-235 atoms. And on and on it goes.

This kind of process is called a chain reaction.

Imagine a chunk of U-235 in which a chain reaction has begun. If the reaction takes place quickly enough, an enormous amount of energy is released.

Domino Effect!

Materials:

- Dominos
- Ruler
- Flat surface that won't shake
- Students divided into small groups

Students can demonstrate this type of rapid-fire chain reaction by setting up your dominos as shown in the first domino drawing. **Challenge teams to set up as large of a reaction as they can, but they must remember to double each layer, 1, 2, 4, 8, 16, etc. How large can they set it up?**

Challenge! Build the largest domino reactor that has multiple paths for the reaction to follow using dominoes.

Did your "reactor" work in using all the "fuel"? Why?
When you tip the leading domino over, as if shooting a neutron bullet into uranium, it tips two other dominos over (releases two new neutrons). In turn, the two falling dominos tip over four more. And the continues on and on, getting bigger and bigger with each split until the uncontrolled chain reaction goes to completion. But in a nuclear power plant, a runaway chain reaction that is, an atomic bomb explosion is nearly impossible.

Nuclear power plants (not invented in the 1940's) control the reaction. Here's how it's done:

The heart of a nuclear power plant is a nuclear reactor. Without getting bogged down in details, a reactor contains bundles of nuclear fuel (U-235) separated by materials that absorb neutrons, called control rods.

To see this have students set up a few rows of dominoes. Now, line up your dominoes again, push over the front one, and hold a ruler in between some of the rows as they begin to fall. This is your control rod, which limits the extent of the reaction.

Thus when a U-235 atom splits, all but one of the neutrons are absorbed before they can reach other U-235 atoms. The single remaining neutron is available to split another U-235 atom. If you insert the control rod between the uranium atoms, the amount of neutrons available to cause more splits is reduced. In our example the ruler served as a control rod. Putting it between two dominos breaks the chain reaction similar to what happens in a nuclear reactor.

The result is a steady release of energy over a long period of time . . . a chain reaction that lasts years instead of a single catastrophic fraction of a second. We can model this slow-moving kind of chain reaction by setting up our dominos as shown in the second part of the domino drawing. This type of chain reaction wastes some of the neutrons produced. Some dominos fall without hitting other dominos.

Have students play the Flash game Nuclear Power Plant Simulator to help solidify their understanding of how a nuclear power plant works. http://esa21.kennesaw.edu/activities/nukeenergy/nuke.htm

Shut the Box!

Dominoes are a descendent of dice, and dice can be played in any number of interesting and challenging games. One of the oldest (and most fun) comes from france and is commonly called Shut the Box. Shut-the-Box is a very simple yet entertaining board game with many legends behind it. Some say that the pirates used to play the game at sea.

You can buy the Shut the Box game boxes in stores but there are fun ways that mimic and serve the same purpose.... for free.

It is a super easy game to set up for your kids to play and once your kids get hooked on this classic strategy game, you'll .... have a hard time getting them to stop! This game can help reinforce addition, multiplication and mental math skills. It's incredibly easy to play, but just like in science and atoms, choose carefully, one wrong choice can start a chain reaction, or stop you in your tracks! This fun game can even challenge adults!

Number of Players: 2 or more

Materials: 2 dice, Shut the Box number cards/sheet, nine or 12 counters (printable ones are included) to cover the numbers per student

Goal: To achieve the lowest score

Skill: Addition for the 9 box game, Multiplication and Addition for the 12 box version of the game

How to Play:

1. Players roll the dice to decide who goes first (highest score)

2. Player 1 rolls the dice and adds them together. The player places counters on any boxes which add up to that total. They choose one combination of their choice.

For example: rolling a 5 and 3 (5 +3 = 8)

Player one can cover any one of the following combinations:

8

7+1

6+2

5+3

1+2+5

1+3+4

Usually a player will try to cover the higher numbers (7, 8, 9) first.

3. Player One then throws both dice again and tries to flip or cover any remaining numbers with the new total. The combination **must** add up to the total on the dice.

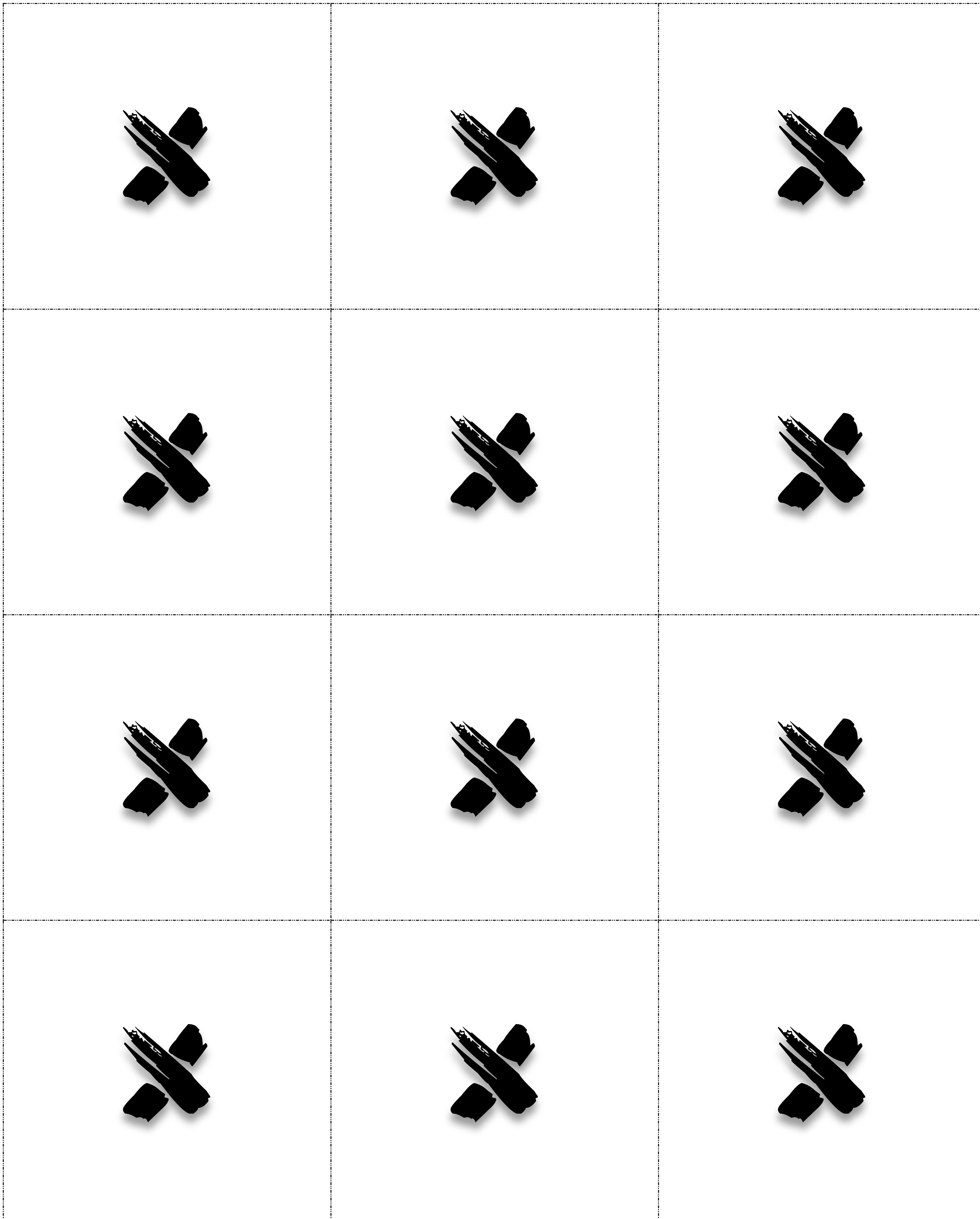
4. Player One continues until they cover any boxes using combinations which add to the total thrown. At this point, Player One finishes their turn with a score equal to the total of the uncovered boxes. Numbers 1, 4, and 3 are left then the player total would be 8 points for the round. If she has covered every number (a score of zero), she has "Shut the Box".

5. All the counters are then removed. Play continues in a clockwise direction until every player has had a turn. The player with the lowest score wins that round.

The game can be played for any number of rounds or for a certain time limit. The overall winner is the player with the lowest total score over all the rounds.

Variations: The 9 box game is used for addition. The 12 box game can be used for multiplication and addition. If you rolled a 5 and 4, 5x4=20. A player could place a counter on the 12 and 8 which equals 20.

1	2	3
4	5	6
7	8	9
10	11	12



Day 3 Standards Alignment K-8

K

- 7.Inq.2 Ask questions, make logical predictions, plan investigations, and represent data.
- 7.T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their uses.

These standards will be met and reinforced as students participate in the dominos experiment. They will be challenged to find ways to set up as large of a 'chain reaction' as possible and use up all the fuel. Then they will be challenged to find ways to effectively control it using 'control rods.' We will discuss how/why U-235 is ideally suited for such action and what characteristics make it ideal for use in nuclear reactors as opposed to other materials.

1

- 7.Inq.2 Ask questions, make logical predictions, plan investigations, and represent data.
- 7.T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their uses.

These standards will be met and reinforced as students participate in the dominos experiment. They will be challenged to find ways to set up as large of a 'chain reaction' as possible and use up all the fuel. Then they will be challenged to find ways to effectively control it using 'control rods.' We will discuss how/why U-235 is ideally suited for such action and what characteristics make it ideal for use in nuclear reactors as opposed to other materials.

2

- 7.Inq.2a Ask questions, make logical predictions, plan investigations, and represent data.
- 7.T/E.1 Recognize that both natural materials and human-made tools have specific characteristics that determine their uses.

These standards will be met and reinforced as students participate in the dominos experiment. They will be challenged to find ways to set up as large of a 'chain reaction' as possible and use up all the fuel. Then they will be challenged to find ways to effectively control it using 'control rods.' We will discuss how/why U-235 is ideally suited for such action and what characteristics make it ideal for use in nuclear reactors as opposed to other materials.

3

- 7.7.2 Describe how rocks and minerals and other materials can be classified according to their physical characteristics.
- 7.10.1 Identify various sources of energy.

These standards will be met and reinforced as students participate in the discussion and experiments. They will be asked to identify sources of energy at the beginning of the discussion and we will see if they mention nuclear energy. We will talk about how/why U-235 is ideally suited for such action and what characteristics make it ideal for use in nuclear reactors as opposed to other materials and how scientists classify the different fissionable and radioactive materials, ex. how easily they can be induced to split.

4

- 7.Inq.4 Analyze and communicate findings from multiple investigations of similar phenomena to reach a conclusion.
- 7.T/E.3 Determine criteria to evaluate the effectiveness of a solution to a specified problem.

These standards will be met and reinforced as students participate in the dominos experiment and discussion. They will test their designs multiple times until they come up with a configuration of dominoes that uses all the 'fuel' and will see if they can find a size limit where it is no longer effective or possible to use all the fuel. [The goal/criteria of the challenge is to create the largest configuration/chain reaction of dominoes possible that still uses all the fuel with the resources available.] Then they will be challenged to control their reaction with the control rods and see if they think that rulers make effective control rods. We will see if they all come up with the same solution, if the materials demand the same solution, or if unique configurations are possible/practical.

5

- 7.Inq.4 Analyze and communicate findings from multiple investigations of similar phenomena to reach a conclusion.
- 7.T/E.3 Determine criteria to evaluate the effectiveness of a solution to a specified problem.

These standards will be met and reinforced as students participate in the dominos experiment and discussion. They will test their designs multiple times until they come up with a configuration of dominoes that uses all the 'fuel' and will see if they can find a size limit where it is no longer effective or possible to use all the fuel. [The goal/criteria of the challenge is to create the largest configuration/chain reaction of dominoes possible that still uses all the fuel with the resources available.] Then they will be challenged to control their reaction with the control rods and see if they think that rulers make effective control rods. We will see if they all come up with the same solution, if the materials demand the same solution, or if unique configurations are possible/practical.

6

- 7.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.
- 7.T/E.3 Determine criteria to evaluate the effectiveness of a solution to a specified problem.

These standards will be met and reinforced as students participate in the dominos experiment and discussion. Students will be challenged to demonstrate their understanding of the concept of the chain reaction in a nuclear reactor using dominoes. They will be given the parameters of the challenge and then will have to come up with a configuration of dominoes that uses all the 'fuel' and test it. They will see if they can find a size limit where it is no longer effective or possible to use all the fuel. [The goal/criteria of the challenge is to create the largest configuration/chain reaction of dominoes possible that still uses all the fuel with the resources available.] Then they will be challenged to control their reaction with the control rods and see if they think that rulers make effective control rods. We will see if they all come up with the same solution, if the materials demand the same solution, or if unique configurations are possible/practical.

7

- 7.T/E.3 Determine criteria to evaluate the effectiveness of a solution to a specified problem.
- 7.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.

These standards will be met and reinforced as students participate in the dominos experiment and discussion. Students will be challenged to demonstrate their understanding of the concept of the chain reaction in a nuclear reactor using dominoes. They will be given the parameters of the challenge and then will have to come up with a configuration of dominoes that uses all the 'fuel' and test it. They will see if they can find a size limit where it is no longer effective or possible to use all the fuel. [The goal/criteria of the challenge is to create the largest configuration/chain reaction of dominoes possible that still uses all the fuel with the resources available.] Then they will be challenged to control their reaction with the control rods and see if they think that rulers make effective control rods. We will see if they all come up with the same solution, if the materials demand the same solution, or if unique configurations are possible/practical.

8

- 7.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.
- 7.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

These standards will be met and reinforced as students participate in the dominos experiment and discussion. Students will be challenged to demonstrate their understanding of the concept of the chain reaction in a nuclear reactor using dominoes. They will be given the parameters of the challenge and then will have to come up with a configuration of dominoes that uses all the 'fuel' and test it. They will see if they can find a size limit where it is no longer effective or possible to use all the fuel. [The goal/criteria of the challenge is to create the largest configuration/chain reaction of dominoes possible that still uses all the fuel with the resources available.] They will have to explain what happened with the dominoes/in a real reactor and why.
Then they will be challenged to control their reaction with the control rods and see if they think that rulers make effective control rods. We will see if they all come up with the same solution, if the materials demand the same solution, or if unique configurations are possible/practical. They will once again have to explain what happened with the dominoes/in a real reactor and why.

unit two: day four

A World Changing Reaction

Otto Hahn and Fritz Strassmann’s work sparked intense activity in research labs all over the world. At about the same time, other scientists discovered that the fission process resulted in even more neutrons being produced. This led Bohr and Wheeler to ask a momentous question: Could the free neutrons created in fission start a chain reaction that would release an enormous amount of energy? If so, it might be possible to build a weapon of unimagined power.

And it was.

News about nuclear fission traveled quickly from Europe to America, and by 1939, many leading physics labs in the United States, including Ernest Lawrence's at the Berkeley campus of the University of California, were testing the possibilities of generating power with uranium.

Although this was an exciting time for physics, it was also a tense and uncertain one. World War II was well under way by now, as Hitler had risen to power in Nazi Germany and invaded Poland on Sept. 1, 1939. Many feared the Germans were fast at work on a nuclear weapon, one they would undoubtedly use against their enemies during wartime. Prominent physicists such as Leo Szilard, Edward Teller and Eugene Wigner, all Europeans who fled to America to avoid the war, felt it necessary to warn the U.S. government about the dangers of Germany developing nuclear arms first.

Albert Einstein and Szilard were concerned enough to write a letter to U.S. President Franklin D. Roosevelt, describing the German threat and the possibility of constructing powerful weapons with uranium. After some discussion, Roosevelt decided it was necessary to begin research on nuclear power, and he set up the Advisory Committee on Uranium, with Lyman J. Briggs as its head.

The next two years were fraught with uncertainty, because no one was sure how much uranium was needed, how much bomb construction would cost or how much time the U.S. had to complete a functional weapon.

> Today, nuclear science plays a vital role in the lives of Americans…and the world. Consider these facts:
>
> • 18 million nuclear medicine procedures are performed per year among 305 million people in the United States (http://www.world-nuclear.org)
>
> • 104 operating nuclear reactors in the US employ an average of 700 people to operate them in the 31 states that have nuclear power generating plants (http://www.nei.org)
>
> • 20 percent of our nation’s electricity is generated by nuclear power (http://www.nei.org)
>
> • 436 nuclear power plants are operating in 30 countries, supplying 14 percent of the world’s electricity. Fifty-three new nuclear plants are under construction in 14 countries. (http://www.nei.org)

The Fission Game

This activity is meant to demonstrate that a nuclear reaction is constantly producing energy and to help students understand how a large atomic nucleus can be split into two smaller particles, which produce energy for nuclear power.

Nuclear fission is the process in which the nucleus of a uranium atom splits into smaller atoms (called fission products), producing 2 or 3 free neutrons and releasing a very very large amount of energy. Fission is the process by which energy is produced today in a nuclear reactor.

Materials:

- Balloons (2 per student) to serve as neutrons

Procedure:

1. Each student gets two balloons (neutrons) to hold. Students should stand together in a closely packed group.
2. The reaction starts with a balloon (source neutron) being thrown into the group by the teacher or a volunteer.
3. When hit with a balloon that is in the air, the students will demonstrate “fission” by throwing their two balloons into the air.
4. Add “control rods” (a person who grabs balloons out of the air, making them unavailable to cause fission) one at a time. Discuss how adding control rods affects the chain reaction. More control rods = slower reaction. Keep increasing the number of rods until the reaction proceeds very slowly or not at all.

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/

Nuclear Clams: Stop the Leak!

Materials:

Balloon, Frisbee or ball type device is needed.

Start by defining the boundaries of the playing field. One person volunteers to be the (broken and leaking) nuclear reactor and activates himself/herself with the balloon. The rest of the group members are clams and signify so by being as happy as possible. The object of the game is for the nuclear reactor to contaminate all the clams (turning them into sinister oysters) by tagging them with the balloon.

Once contaminated, the clams become frozen in place. As the reactor chases and tags the clams, it would appear that doomsday is just around the corner, at least for the hapless clams who are getting zapped one after another. There is hope, however, a frozen clam (aka sinister oyster) can be defrosted back into a happy clam if two mobile clams manage to link hands around him/her in a clamshell-like alliance and shout, “clam free!” Better yet, if seven clams can manage to link up in a circle and count to ten, then the leaking nuclear reactor is fixed!

Now, it’s time to clean up any contaminants on the clams!

Fast Fission!

Materials:

- String
- Balloons

Blow up two balloons (atoms) for each of the student‘s cientists’ and tie one to each of their ankles. Let the mayhem begin as the mad scientist quickly walk around the room trying to fissure (burst) each others atoms but at the same time trying to preserve their own. The scientists who manages to preserve the last atom is the winner.

Day 4 Standards Alignment K-8

K

- 7.Inq.1 Use senses and simple tools to make observations.
- 7.Inq.2 Communicate interest in simple phenomena and plan for simple investigations.

These standards will be met and reinforced through the discussion and experiments and games as students participate and are guided to making the connections between the activity and the scientific concepts they demonstrate/relate to.

1

- 7.Inq.1 Use senses and simple tools to make observations.
- 7.Inq.2 Communicate interest in simple phenomena and plan for simple investigations.

These standards will be met and reinforced through the discussion and experiments and games as students participate and are guided to making the connections between the activity and the scientific concepts they demonstrate/relate to.

2

- 7.Inq.1 Use senses and simple tools to make observations.
- 7.Inq.2 Communicate interest in simple phenomena and plan for simple investigations.

These standards will be met and reinforced through the discussion and experiments and games as students participate and are guided to making the connections between the activity and the scientific concepts they demonstrate/relate to.

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 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.

4

- 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 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.

5

- 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 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 energy (ex. possible new 'clean' form of endless energy, find 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

- 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 energy (ex. possible new 'clean' form of endless energy, find 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.

8

- 7.T/E.3b Explore how the unintended consequences of new technologies can impact society.
- 7.T/E.3c Distinguish between the intended benefits and the unintended consequences of a new technology.

These standards will be met and reinforced through the discussion as we discuss and compare the intended consequences of nuclear energy (ex. possible new 'clean' form of endless energy, find 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.

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
- International
- Social norms
- Absolute
- Variation
- Neutron
- Proton
- Electron
- Exothermic
- Atom

- Family
- Tension

Wings of the Crane Unit Two Sample Supply List

Day One:

- Cotton Candy (4 colors if possible)
- Rice Krispie treats or popcorn balls
- Peanuts, m&ms, sunflower seeds or other appropriate item
- Sprinkles (option)
- Pennies (1 per student)
- Balloons (1 per student)
- Data Analysis sheet for each student (included)
- 128 un-popped popcorn kernels, M&M's (aka 'candium'), Skittles, coins or poker chips with stickers on one side may also be used. Note: M&M's move the pace of the game quicker than popcorn kernels.

Day Two:

- Access to links
- Notebooks/paper
- Long balloons
- Scissors
- Small clear water glass(es)
- rubbing alcohol
- (small amount) cooking oil.
- water
- A teaspoon and a butter knife.
- paper towels

Day Three:

- Access to links
- Dominoes
- Rulers
- Dice
- Shut the Box number cards/sheet,
- Nine or 12 counters (printable ones are included) to cover the numbers per student

Day Four:

- Balloons
- String