Bonus Activity

# Nuclear Chain Reaction

**Observe fission reactions similar to those in a nuclear reactor.**

## Materials

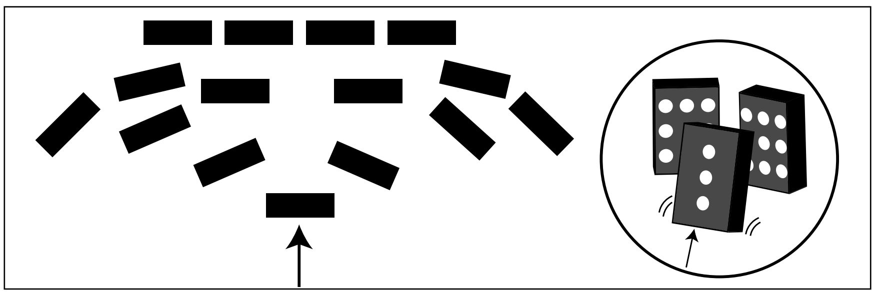
Dominoes

Ruler

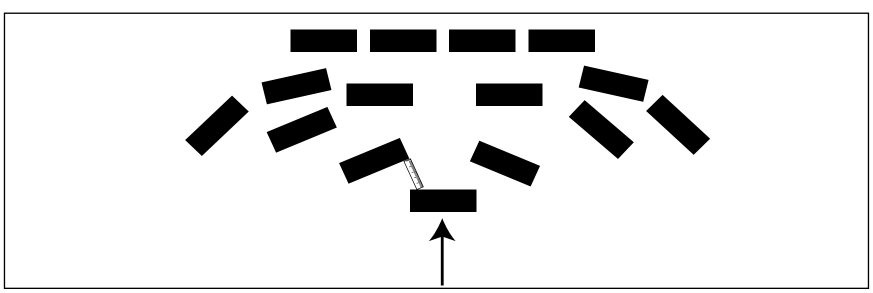
Steady flat table

## Instructions

1. Arrange the dominoes in a similar formation to the figure below.



2. Knock over the domino labeled with an arrow and observe what happens.
3. Build a straight line of dominoes and knock it down.
4. Rebuild the formation from step 1.
5. Place the ruler between the domino marked with an arrow and either of the dominoes it will directly knock over. Knock over the domino marked with the arrow and note any differences from the first trial.



6. Rebuild the formation and place the ruler in another location. Knock over the domino marked with the arrow and observe that happens. Repeat as desired.

## Discussion Questions

In the first formation, how many dominoes did each individual domino knock over?

How did the number of dominoes knocked over change at each step in the first formation?

How is the first formation different from a straight line of dominoes?

What happened when the ruler was placed between two dominoes?

Bonus Activity

FOR THE TEACHER

# Nuclear Chain Reaction

## Discussion

A nuclear chain reaction is a series of several nuclear reactions. To start the chain reaction a neutron must collide with a nucleus, or in this simulation a finger must strike a domino. Then the radioactive element involved in the reaction, such as Uranium-235, undergoes a process called fission. The Uranium-235 nucleus splits into two lighter nuclei such as strontium and xenon, and releases several neutrons and photons along the way. The neutrons strike more Uranium-235 atoms causing the fission process to start all over again. The repetitive nature of this process causes a nuclear chain reaction. The photons emitted in the process are light in the form of gamma rays, which are very dangerous to living things. The first domino formation simulates such a chain reaction. In this case each reaction triggers two more reactions. This contrasts with the straight line formation, in which only one reaction is triggered by each completed reaction.

Once fission occurs and begins a nuclear chain reaction, we sometimes need to control how many more fission reactions occur. If the number of released neutrons were not controlled, then the number of fission reactions would increase drastically (more and more dominoes would fall down, as seen in the first formation). One way to control the number of released neutrons is to use a control rod. In the experiment, the ruler acts as a control rod. Since the neutrons that are produced during the splitting of the nucleus are the reason that a fission reaction occurs, something is needed to prevent the neutrons from colliding with more Uranium-235 atoms. A control rod absorbs neutrons so more fission reactions will not take place. When the ruler is placed between two dominoes in the second formation, the ruler acts as the control rod by absorbing the released neutrons from the dominoes' fission reaction and therefore prohibits another nuclear reaction.

### Materials

**Dominoes**

**Ruler**

**Steady flat table**

## Suggested Resources

Nuclear Reaction:
http://en.wikipedia.org/wiki/Nuclear_reaction

Nuclear Chain Reaction:
http://en.wikipedia.org/wiki/Nuclear_chain_reaction

Uranium Fission:
http://hyperphysics.phy-astr.gsu.edu/hbase/nucene/u235chn.html

## Bibliography

Nuclear Chain Reaction:
http://www.energyquest.ca.gov/projects/nuclear.html

Bonus Activity

# Half-Life

**Experimentally determine the half-life of an M&M sample.**

### Materials

100 plain (not peanut) M&Ms

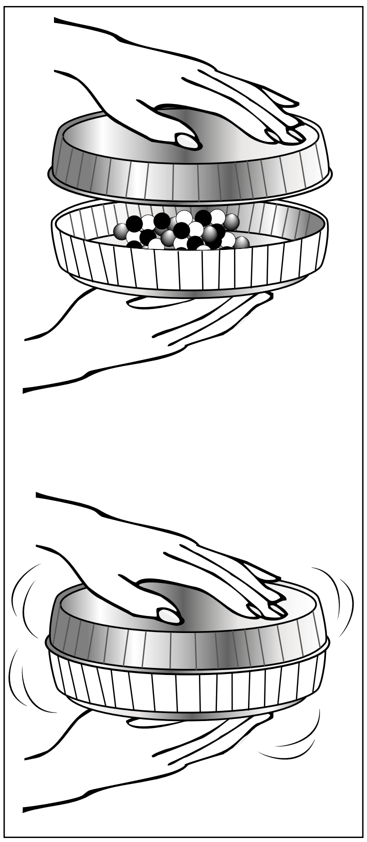
2 pie tins

Graph paper

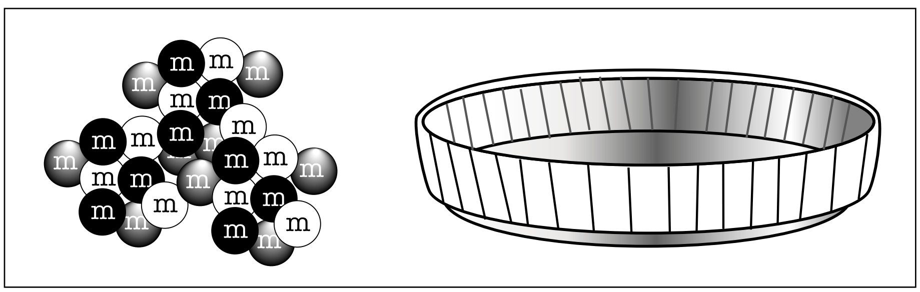
Pencil

### Instructions

1. Place the candies "M" side down in one tin.
2. Cover the filled tin with the empty tin and shake the tins gently. Make sure that the tins are shaken enough to bounce the candies around the improvised container.



3. Remove the top tin and take out all the "changed" ("M" side up) candies in the bottom tin.



4. Record the number of "changed" candies and "unchanged" (still "M" side down) candies in a chart similar to the one below. You may need to add space for more trials at the bottom of the chart.
5. Repeat steps 2, 3, and 4 until all the candies have flipped. Each time you record the number of "changed" candies write down the total number outside the tin, not just the ones removed in the last trial.
6. Graph the information from the chart on the graph paper. Draw a smooth curve through the data.

| Trial | Number of “changed” atoms | Number of “unchanged” atoms |
|---|---|---|
| 0 | 0 | 100 |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

## Discussion Questions

Can you see a pattern to the decay of the candies?  Describe it.

How many tosses does it take before half the candies have decayed?

During each shake, what were the odds that any one M&M would change?

Bonus Activity

FOR THE TEACHER

# Half-Life

## Discussion

The half life of something describes how long it takes for half of it to decay, or change. In this activity, the students measure the decay or change rate of M&M candies. Depending on how they shake the tins the students may find different decay rates. It is important that the students shake the tins in a consistent way for their data to make sense.

In science, decay rates are usually found for radioactive isotopes of different elements. For example, beryllium-11 (beryllium with 4 protons and 7 neutrons) decays into boron-11 (boron with 5 protons and 6 neutrons). We describe the rate at which this happens by measuring the isotope's half-life. The half-life is a measurement of how long it takes for half of a sample to decay. For beryllium-11 decaying into boron-11 the half-life is about 13.8 seconds, so after 13.8 seconds half of the beryllium-11 you started with will have decayed into boron-11. If you wait another 13.8 seconds, half of the remaining beryllium-11 will have decayed, leaving only 25% of the original sample in its original form.

This process will happen the same way regardless of the size of the sample, so it is a great way to find out how long a sample of a radioactive isotope has been sitting around. The half-life of a dangerous radioactive isotope can also be used to determine how long to wait before it is safe to expose humans or other living things to the sample. It is necessary to wait much longer to open a sample of radioactive material with a long half-life because the material decays into safer isotopes more slowly.

The students can find the half-life of the M&M candies by checking how many trials it takes for half of the candies to flip over. If they are consistent they should find that when they repeat the experiment with a different number of M&Ms the half life will be about the same.

### Materials

100 plain (not peanut) M&Ms

2 pie tins

Graph paper

Pencil

**A description of the use of the half-life of carbon-14 from** *Active Physics Predictions***:**

Geologists and archaeologists take advantage of the known half-lives of common nuclei to date materials that contain these nuclei. The nucleus used to develop radioactive dating was one type of carbon called carbon-14 because it has 6 protons and 8 neutrons, 14 particles total, in its nucleus.

The half-life of carbon-14 is 5730 years. Every half-life, the radioactivity of the carbon-14 atom decreases by half. Living things like plants or animals absorb carbon-14, which is produced in the atmosphere by cosmic radiation, and build it into their tissues along with other kinds of carbon. When they die, the carbon-14 in their tissues decays. By measuring the remaining radioactivity due to carbon-14 in a long-dead sample, archaeologists can determine how many half-lives the material has been dead.

## Tips

For a little variety you may wish to have some students work with sugar cubes that have been marked on one side with marker or food coloring. The students should start with the marked side down and only remove the cubes that have the colored side facing up at the end of each trial. Since the cubes have six sides instead of the two sides of the M&Ms, a smaller percentage of the cubes "decay" after each trial and the cubes show a longer half-life. This difference demonstrates that different isotopes have different half-lives based on their properties.

## Suggested Resources

Half-Life:
http://www.colorado.edu/physics/2000/isotopes/radioactive_decay3.html

## Bibliography

Eisenkraft, A., *Active Physics, Predictions*, American Association of Physics Teachers, 1995.

**Radioactive decay graph from http://home.earthlink.net/~bhoglund/radiation_Facts.html**

Below is a sample graph of radioactive decay. The students' graphs should show a similar shape, though the axes should be "Unchanged M&Ms instead of "Amount" and "trials" instead of "Time (in Years)."