sck cen Academy

Lesson activity

Fission chips
Demonstration of nuclear fission

Credits: The Society for Radiological Protection (https://www.srp-uk.org)

Checklist for the teacher

Target audience
Third-grade science/STEM pupils

Format of activity
interactive class activity as part of a lesson or summary

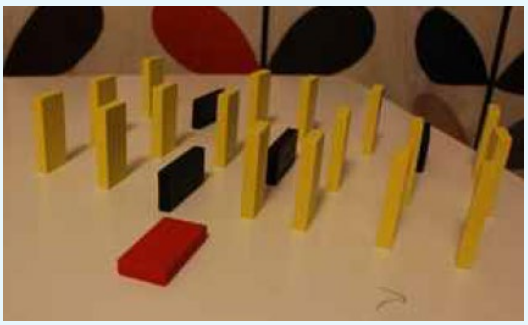
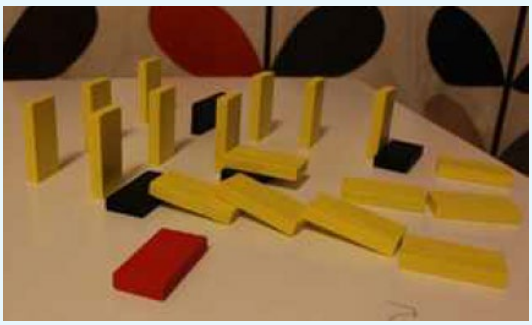
Duration
1 hour

Learning objectives
After completing this learning activity, the pupil will be able to:
- understand that a nuclear fission reaction can be maintained (chain reaction)
- describe how control rods can be used to avoid an uncontrolled reaction in nuclear fission
- understand the probability of a fission reaction that can be increased by the process of enrichment

Required equipment and space
- 36 dominoes per group
- 2 wooden cubes per group

The dominoes are used to illustrate the fission reaction in a nuclear reactor.

Time	Teacher action	Pupil action
0 mins	Introduces the topic of nuclear energy: explain (briefly) how nuclear energy can be converted to electrical energy and what the dominoes represent (uranium atoms). Divide the class into groups. Tell the pupils that each domino represents a nucleus of U-235, which can undergo nuclear fission when it absorbs an extra neutron. When nuclear fission takes place, it will release a neutron. Explain that toppling 1 domino represents nuclear fission with the release of neutrons. Next, explain the concept of a chain reaction.	Divide into groups and take a set of dominoes (one per group). Place the dominoes in a straight line and knock over the first one. Note the observation. Then make a triangle arrangement, knock over the first domino and note the observation.
15 mins	Give each group some more dominoes and tell the pupils to make a triangle arrangement. Ask the pupils what will happen if more rows are set up in the triangle, and what problems will result. 	Make a new triangle arrangement, knock over the first domino and note the observation. 
25 mins	Introduce the concept of control rods. Give each group two wooden cubes, with each cube representing a control rod. 	
30 mins	Explain that a typical sample of uranium contains two isotopes – U-235 and U-238. Clarify that most atoms in uranium consist of the isotope U-238, but that U-235 is the fissile isotope, whereby the proportion of U-235 atoms can be increased by the process of enrichment. Explain how enrichment is performed in practice by a centrifuge; explain what a centrifuge is and how U-238 and U-235 are separated based on their difference in mass. Clarify to the pupils that the dominoes must be positioned so that they are closer together than the length of a domino, but farther apart than the width of a domino to observe the desired effect.	Make the triangle arrangement again, like the previous arrangement, but this time replace two dominoes with the 'control rods'. Knock over the first domino and note the observation.

45 mins	 Instruct the pupils that every other domino should be rotated so that they are alternately positioned horizontally and vertically.	 Reposition the dominoes such that they alternate between horizontal and vertical. Knock over the first domino and note the observation.
55 mins	General questions via PowerPoint	

The science

- The heat energy from nuclear fission is used to generate steam under high pressure. The pressure from the steam is used to turn a turbine, which in turn drives an alternator to produce electricity.
- Uranium is the material typically used. The most common isotope is U-238, but it is U-235 that is fissile.
- When a U-235 atom undergoes nuclear fission, it releases a neutron that is absorbed by a neighbouring identical atom. This again causes nuclear fission, where again neutrons are released that can be absorbed by the next atom and so on. This is also known as a chain reaction.
- The proportion of U-235 (compared to U-238) in a sample is increased by a process called enrichment.
- The chain reaction may possibly spread further than what is needed (or desired), i.e. an uncontrolled reaction. This may lead to a 'runaway' effect and nuclear 'meltdown', potentially triggering chemical explosions as in the Fukushima disaster.
  However, this problem can be avoided by using control rods, known as such because they control the reaction and can prevent such events.