

8. What are some of the advantages and disadvantages of generating electricity at nuclear power plants?
9. How widespread is the use of nuclear energy?
10. What happened at the Chernobyl nuclear power plant in 1989?
11. What did Marie Curie contribute to our understanding of nuclear energy?
12. What is radioactivity?
13. What is a half-life?
14. How do different scientists make use of the knowledge of a substance's half-life?
15. What helpful applications of nuclear energy have been developed?

Follow-up Discussion

Research indicates that students will retain their previous misconceptions about a topic, in preference to new information, until they actively recognize and correct their own errors. Therefore, it is important to have your students re-examine the facts/beliefs they put on their "Everything We Think We Know About..." list. It might also be helpful to review the list by marking each entry with a "+" or "-" to show which facts were correct and which were incorrect.

Thought-provoking discussions provide a good way to assess the overall depth of student understanding. The following are some suggested discussion topics.

- Discuss the fact that all energy sources have advantages as well as disadvantages. Ask students to explain why nuclear energy is used even though there are risks associated with its use.
- Have students explain their views on nuclear weapons and power.
- Carbon-14 has a half-life of 5,730 years, while phosphorous-32 has a half-life of 15 days. Discuss why archaeologists are able to use carbon dating to determine the age of fossils, while doctors are able to use radioactive phosphorous to treat sick people.

Follow-up Activities

- Have students research the life of scientists who contributed to our understanding of the atom. After each student has completed and presented a report on their chosen scientist, display them in chronological order on a classroom time line. Examples include Marie and Pierre Curie, John Dalton, Albert Einstein, Ernest Rutherford, Neils Bohr, and Antoine Lavoisier.
- As a class, watch the movie "Hiroshima: City of Peace." The movie was a joint production by Japanese and American film companies. The events leading up to the bombing at Hiroshima are examined from both sides in this film.
- Hold a series of informed classroom debates. Suggested topics:
 - * Do the dangers of nuclear energy outweigh the benefits?
 - * Should we ban all nuclear weapons?

Suggested Internet Resources

Periodically, Internet Resources are updated on our web site at www.LibraryVideo.com

- www.kapili.com/physics4kids/modern/radioactive.html
This excellent Physics 4 Kids site explains the science behind radioactivity.
- www.atomicmuseum.com/tour/index.cfm
This site from the National Atomic Museum provides readily accessible educational materials and information reflecting the Atomic Age.

Suggested Print Resources

- Clark, John. *Matter and Energy*. Oxford University Press, London, England; 1994.
- Fox, Karen. *The Chain Reaction: Pioneers of Nuclear Science (Lives in Science)*. Franklin Watts, Danbury, CT; 1998.
- Roxbee Cox, Phil & Max Parsonage. *Atoms and Molecules*. Usborne Publishing, Tulsa, OK; 1992.

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Nuclear Energy

Grades 5-8

Students in grade 5-8 classrooms possess a wide range of background knowledge. Student response to this video program is sure to be varied, so the teachers at these grades need all the help they can get! This guide has been designed to help the 5-8 science teacher by providing a brief synopsis of the program, previewing and follow-up questions, activities, vocabulary and additional resources.

Before Viewing: Extensive research tells how important it is for the teacher to discover what the students know — or think they know — about a topic, before actually starting a new unit. Therefore, after prompting discussion with the pre-viewing questions, lead your class to create an "Everything We Think We Know About..." list. You may also wish to preview key vocabulary words, and have students raise additional questions they hope will be answered.

After Viewing: Have your students share video excerpts that fascinated or surprised them, then challenge your students to prove or disprove the accuracy of the facts they put on their "Everything We Think We Know About..." list. Discuss what else they learned and use the followup questions and activities to inspire further discussion. Encourage students to research the topic further with the Internet and reading resources provided.



Program Summary

Atoms are the tiny building blocks of matter. How can something as small as an atom unleash enormous quantities of energy? The nucleus of the atom, which contains most of its mass, is held together by a tremendous nuclear force. This powerful nuclear energy can be released when the nucleus, composed of positively charged protons and neutrally charged neutrons, is forced to split in a process called fission, or when the nucleus is forced to combine with other nuclei in a process called fusion.

Fusion releases nuclear energy by forcing small nuclei to combine or fuse together to create larger nuclei, a process that requires extreme levels of heat and pressure. The fusion reactions constantly taking place on the sun and other stars produce heat and light. The most common fuel of fusion is hydrogen. It takes only half of a liter of this fuel to produce the same amount of energy as 6,000 tons of coal! If the process of fusion could be perfected on Earth, it could provide enough energy for thousands of generations to come. However, because the temperature required for fusion to take place is 100 million degrees or more, any attempt by scientists to duplicate fusion on Earth has taken more energy to create than the energy that it can produce.

Fission is the process of releasing nuclear energy by splitting the nucleus of a large atom, releasing small particles as well as a great deal of energy. In the 1930s, physicists Lise Meitner and Otto Hahn bombarded uranium atoms with neutrons. The result was the release of energy and atoms that were lighter than uranium. Their research led to an understanding of the chain reaction that occurs during fission and helped launch the modern nuclear age, leading to the creation of the atomic bomb as well as the development of power plants to produce electricity.

In order to use fission for the generation of electricity, the nuclear chain-reaction must be controlled. In nuclear reactors, special control rods absorb many of the free-flying neutrons, preventing them from splitting other nuclei, thus controlling the reaction. The energy produced is enough to vaporize water into steam, which drives massive turbines that spin and generate electricity. There are currently over 400 nuclear power plants in the world, producing a large amount of the world's electricity. There are a number of advantages to using nuclear energy to generate electricity. When we do not use coal, oil or gas as fuel, we are not consuming the dwindling fossil fuel supply, and there is no air pollution produced as a result of using nuclear energy. A disadvantage is the great danger involved in the event of a nuclear accident, as there was in 1986 at the Chernobyl plant in the Ukraine. The release of nuclear radiation into the atmosphere from that accident was the equivalent of 1,000 atomic bombs.

Pioneers in the study of radiation, Madame Marie Curie and her husband Pierre discovered that some chemical elements have naturally unstable nuclei, which constantly break down, giving off radiation. They called these elements "radioactive." Radioactive substances have nuclei that continually decay until they break down into stable elements. The time it takes for half of a sample of a radioactive element to break down is called its half-life. A half-life can take anywhere from a fraction of a second to billions of years, but every element has a characteristic half-life. Archaeologists use this principle in the carbon-14 dating process to determine the age of fossils. Marie Curie's daughter, Irene Curie, and her husband, Frederic Joliot, discovered how to create an artificially unstable nucleus. This technology is used today in nuclear medicine to stop the growth of cancer cells and to find blockages in blood vessels.

Vocabulary

The following words are included for teacher reference or for use with students. They are listed in the order in which they appear in the video.

atom — The tiny particle that makes up everything around us. These particles are constantly moving. Atoms are composed of a nucleus (with protons and neutrons) and orbiting electrons.

matter — Any substance that takes up space. Matter is made of small particles called atoms, and can be in the form of a solid, liquid, gas or plasma.

energy — The ability to make things happen or to do work. Energy may exist in potential, kinetic, thermal, electrical, chemical, nuclear or other various forms.

work — The energy it takes to move or change something.

nuclear energy — The energy created when atoms are broken apart or forced together. The force that holds atoms together is so strong that breaking atoms apart or forcing them together creates the most powerful form of energy we know.

nucleus (plural: nuclei) — The core of the atom, where most of its mass and all of its positive charge is concentrated. With the exception of the hydrogen atom, a nucleus consists of protons and neutrons.

electrons — The negatively charged particles that orbit the nucleus of every atom. Electrons surround the atom's positively charged nucleus and determine the atom's chemical properties.

protons — One of the basic particles that makes up an atom. The proton is found in the nucleus and has a positive electrical charge equivalent to the negative charge of an electron and a mass similar to that of a neutron.

neutrons — One of the basic particles that makes up an atom. A neutron and a proton have about the same weight, but the neutron has no electrical charge.

fission — The splitting of a heavy atomic nucleus into smaller pieces, accompanied by the release of a large amount of energy.

fusion — The process of combining two small nuclei at a great temperature and pressure. This process is responsible for the energy of the sun and stars.

Lise Meitner — (1878 - 1968 CE) A German physicist who played a major role in developing nuclear fission with her colleague Otto Hahn.

nuclear chain reaction — The process that occurs when nuclei are split by fission, releasing energy and neutron particles, and the freed neutrons shoot off in all directions, splitting surrounding nuclei and releasing more energy.

nuclear reactor — A device in which a fission chain reaction can be initiated, maintained and controlled. Its essential components are fuel rods, shielding, control rods and coolant.

control rods — The neutron-absorbing rods inserted into a nuclear reactor to absorb the free neutrons released by fission; thereby controlling the release of nuclear energy and preventing an uncontrolled chain reaction.

uranium — A radioactive metal that is used as fuel in nuclear fission reactors.

nuclear radiation, radioactivity — The energy and particles released from a disintegrating atomic nucleus.

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radioactive decay — The change of a radioactive nucleus of one element into a different, more stable element by the spontaneous emission of energy and nuclear particles.

half-life — The time in which half the atoms of a particular radioactive substance disintegrate into a stable element. The half-life is a characteristic property of each radioactive element and can vary from seconds to billions of years.

Marie Curie — (1867-1934 CE) A scientist who won two Nobel prizes for her studies of radioactivity. She discovered that some elements have naturally unstable nuclei that break down and release radiation.

Hiroshima — One of the Japanese cities on which the atomic bomb was dropped on August 6, 1945, by the United States, to end World War II. 75,000 people died immediately from the explosion and at least another 70,000 died from radiation sickness.

Chernobyl — The location of the worst nuclear power plant accident in history, occurring in the city of Chernobyl in the Ukraine on April 26, 1986, resulting in a radiation release equal to 1,000 Hiroshima bombs.

radioactive dating — A technique for estimating the age of an object by measuring the amounts of various radioisotopes in it. Carbon-14 dating is important in archeology.

Pre-viewing Discussion

Before students generate their list of "Everything We Think We Know About..." for this topic, stimulate and focus their thinking by raising these questions so that their list will better reflect the key ideas in this show:

- What makes up matter?
- How do we obtain energy from matter?
- Why does the sun shine?

After the class has completed their "Everything We Think We Know About..." list, ask them what other questions they have that they hope will be answered during this program. Have students listen closely to learn if everything on their class list is accurate and to hear if any of their own questions are answered.

Focus Questions

1. What are matter, energy and work? How are they related?
2. Describe the parts of an atom.
3. What is nuclear energy?
4. What is fusion? Why do you think fusion happens naturally on the sun and other stars, but not on Earth?
5. If fusion could provide Earth with clean energy for thousands of generations, why don't we start using it now?
6. What did Lise Meitner and Otto Hahn discover in 1939? Why do you suppose that their research helped launch the modern nuclear age?
7. Describe a nuclear chain reaction. How is it controlled in a nuclear power plant?

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