"Living in a Nuclear Age"

TV tune in turn on!

FOR LEADERS/TEACHERS

"We live in an age that's nuclear
Just what this means to some is unclear
Understand the atom, that's common sense.
Protect yourself, that's Civil Defense."

"Living in a Nuclear Age" is a 4-H TV production for teens on the atom and its effect on our lives today. The program is unique in several ways and could easily be one of the most relevant and interesting you have ever conducted with young people.

"Living in a Nuclear Age" is built around a series of six highly informative yet entertaining TV shows. In addition, youths receive a supplemental guide of experiments and other activities that can be done at home or in a club or classroom situation (Each of your club or class members should have one.) This guide provides additional information and helps you correlate the shows into a meaningful, adventurous unit.

Before you start — even before the TV programs begin — look over both the Guide for Teens and this guide. You may want to assemble books, leaflets, or other materials — or get acquainted with your civil defense director and others in the community who might be helpful.

You and Your Youth

You will find teenagers learn by doing throughout this project. The experiments and demonstrations in the Guide for Teens help them discover almost every new concept for themselves. From the solid foundation that results you can build on more difficult or technical concepts (a few are suggested in this guide).

You don't need a science background, however, to conduct *"Living in a Nuclear Age"* as a club or group activity. All of the most pertinent information is contained in the TV shows, the Guide for Teens, and this guide.

Your best asset is an inquiring mind. Nuclear energy is in the news — in current and exciting research developments, in world-power politics, in questions of ecology. If you become interested enough to keep informed and learn more, your enthusiasm will spread to the youth with whom you work.

"Living in a Nuclear Age" has been developed especially for 7th and 8th graders. However, younger boys and girls (4th through 6th graders) will enjoy the TV programs, too, and should be able to do all the main activities in the guide. They may need more adult supervision, but should still find the project worthwhile and fun. You can easily gear the project to older youth by including more of the community-oriented activities (from "More Things To Do" sections) along with extra material in this guide.

DISCOVERING THE ATOM

Show Preview: Animated portions will describe parts of the atom, different kinds of atoms, fission, dangers of radiation exposure, and need for shielding. Civil defense protective measures such as shelters and radiation monitoring are introduced along with some of the beneficial uses of nuclear energy.

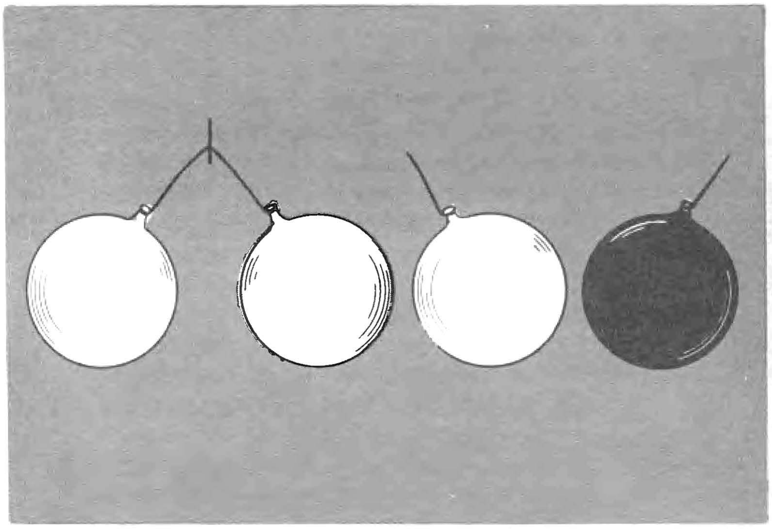
Guide for Teens: Through activities in the guide, teenagers have a chance to follow the development of our knowledge about the atom in several interesting ways.

Static Electricity

- Puffed cereals, smooth styrofoam balls, strips of nylon or pith balls can be substituted for the balloons. Members could challenge each other to identify the charge produced by objects they select.
- Teachers may want to discuss similarities between electrical and magnetic properties.

Making an Electroscope

- Dry conditions are important in the construction and operation of an electroscope. Placing the container in a warm oven before assembling and then assembling while warm will help insure the low humidity needed inside the container.
- Teachers may want to discuss conduction and induction.



Making an Atom Model

- Some members may want to make models that can be suspended as mobiles. Suggested materials: clay balls, ping pong balls, styrofoam, beads. Keep in mind that the nucleus is massive compared to tiny, light electrons orbiting at a distance.

Time Line

- To place into perspective and determine the various events related to the development of the nuclear age, place string across the top of a bulletin board at school or against the wall of your room. Attach strips of paper to the string to divide the string into equal parts representing decades or centuries. Then, attach additional strips of paper showing dates and events.

The names of people or things are as follows:

Democritus defines the atom
Discovery of the electron
Bomb dropped on Hiroshima
Einstein predicts E equals Mc^2
Rutherford discovers alpha, beta, and gamma radiation
Becquerel discovers natural radioactivity
The Curies discover radium
First atomic submarine
Discovery of the neutron
Roentgen discovers X-rays
First atomic reactor
Fermi produces the first artificially-made elements
First hydrogen (fusion) bomb tested
Bohr describes the structure of the atom
Carbon-14 dating discovered

When would you say our nuclear age began?

Rutherford's Experiment

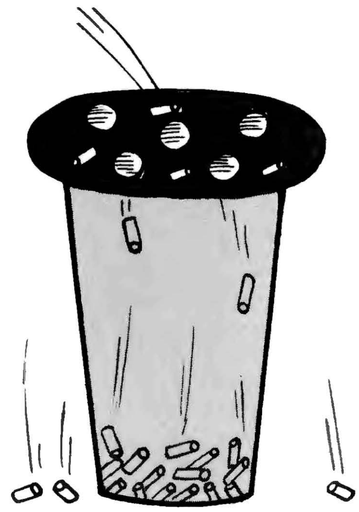
- In this activity, members use an indirect method to measure the area of holes — similar to Rutherford's method of measuring the nucleus. The experiment works very well with a large group; all members have a chance to participate.

PROCEDURE:

Cut a circle with a two-foot diameter from cardboard. Cut 5 equal-sized holes in the circle, spacing the holes as evenly as possible. The holes should be about 2 inches in diameter — estimate, don't measure at this time.

Place the cardboard over a box or bucket. Place a chair about 6 feet from the box. Cut soda straws into pieces about ¼ inch long. Sit in the chair and throw the soda straw pieces at the cardboard. If a piece of straw goes directly in one of the holes, count this as a "hit." If a piece of straw strikes the cardboard first before going into a hole or onto the floor, count it as a "miss." If a straw misses the cardboard don't count it at all. Continue throwing until there are at least 20 or 30 hits. The greater the number of hits and misses, the greater the chance for significant results. Be sure to record both hits and misses.

Calculate the total area of the holes by following the formula below. Divide by 5 to get the *experimental area* of one hole. Measure a hole with a ruler. From this information figure out the actual area and compare the figure with the experimental area.



Formula

$$\frac{\text{Area of holes}}{\text{Area of cardboard}} = \frac{\text{Hits}}{\text{Misses}}$$

This formula can also be written:

$$\text{Area of holes} = \frac{\text{Hits}}{\text{Hits} + \text{Misses}} \times \text{Area of cardboard}$$

The area of a circle is equal to the radius times the radius times "pi" (3.14). Using this formula the area of the cardboard would be 12 inches x 12 inches x 3.14 or 452.16 square inches. The area of the measured hole can be figured out from the radius in the same way.

- Some members may try to cancel hits in the numerator and denominator of the formula. This can't be done. You may also notice that some members feel a high number of hits is important and tend to call questionable tosses "hits."

• An experiment similar to Rutherford's is explained below:

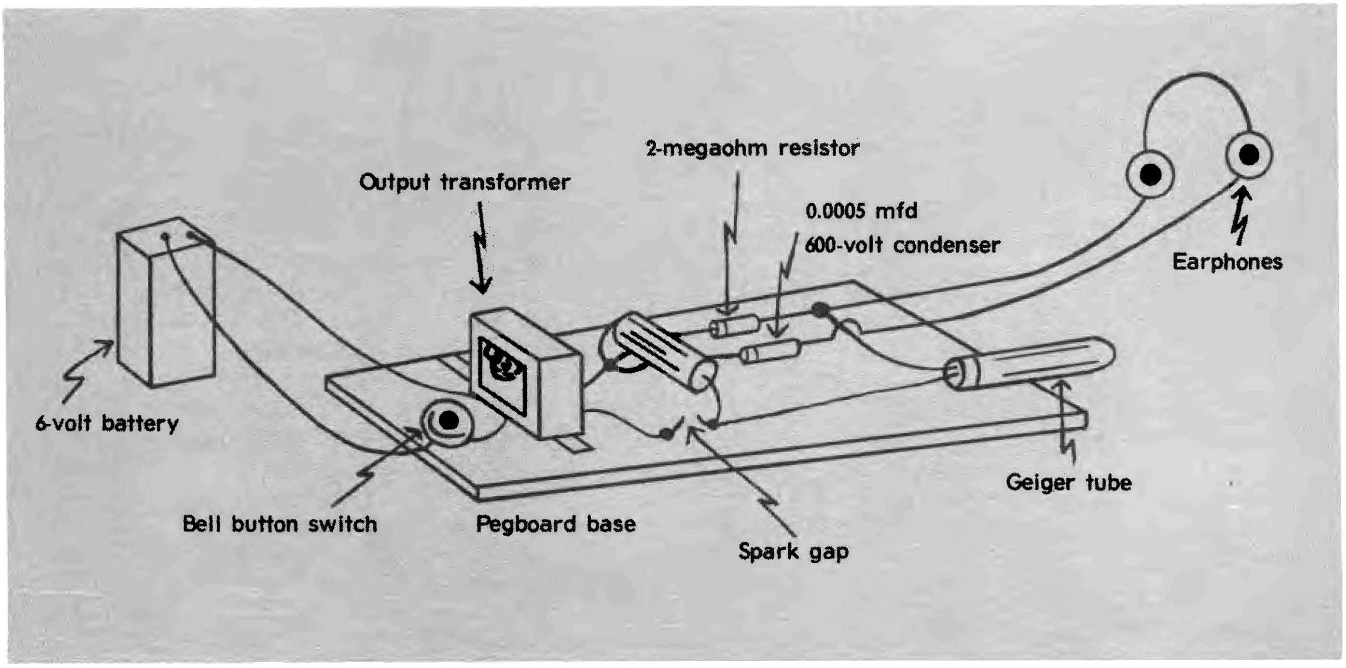
A small piece of very thin, gold foil is measured accurately. From certain rules of science this measurement can be used to tell the number of atoms in the foil. The foil is then placed in front of a fluorescent screen. A device is placed on the other side of the foil which produces a stream of protons. When the protons strike the screen, a small part of the screen glows. If a proton comes close to the nucleus the positive charge of the nucleus repels the positive proton. Most of the protons pass through the foil without being greatly affected by the nuclei. The screen shows a few protons are thrown off course by being repelled.

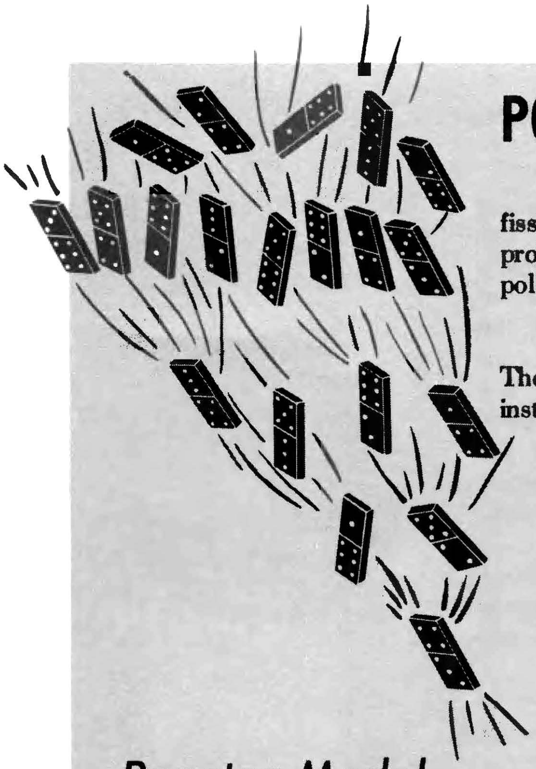
Can members explain which parts of their experiment correlate to the gold foil (cardboard), nuclei of atoms (holes), fluorescent screen (box), protons (straws) and device producing protons (members)?

Making a Geiger Counter

• How a Geiger counter works: The Geiger tube or probe acts as a special electrical switch. A high voltage (about 1000 volts) will try to flow through the switch by moving from the metal cylinder near the outside of the tube to the wire along the center of the tube (see diagram of tube). The special gas inside the tube will not ordinarily conduct electricity; the electrical circuit is open and nothing happens.

Radiation capable of penetrating the glass tube and metal cylinder causes some of the gas atoms along the path of the radiation to become charged (ionized). These atoms conduct electricity from the cylinder to the wire. A burst of electrical current flows through the counter. The Geiger counter may show this brief bit of electrical current on a meter (the meter scale tells the number of counters—bits of radiation—per minute or second), it may cause a light to flash, or it may cause a loud speaker or earphones to click.





POWER FROM THE ATOM

Show Preview: Animated portions will describe chain reaction and fissioning uranium-235. The tour of a nuclear power plant leads to a consideration of problems such as cost of nuclear power, availability of uranium-235, and thermal pollution. Nuclear power is compared to water power, oil, and coal.

Guide for Teens: Teenagers build a model reactor and demonstrate fission. They also have a chance to find out how people in a community feel about nuclear installations and to discuss the ecology of nuclear power.

Reactor Model

- Dimensions and materials can be varied as long as basic components are present. Removal and insertion of control rod dowels may present some problems. Soda straws could be glued to the inside of the model to guide the rods. Red cellophane could be used to line the model indicating heat.

- This model represents a very limited range of reactors. Models of other types may be more valuable — especially if a different type of reactor is in the area and available for tours. Some students may want to make a model of a breeder reactor, for example.

Controlling a Chain Reaction

- Students should understand that one domino block striking another is equivalent to the release of a neutron causing further fission. Move blocks farther apart so that some blocks will fall without hitting another. This can demonstrate what happens when the uranium is not *critical size,* which means not enough uranium for fissioning. Or the demonstration could represent the role of control rods.

- If you have a steady hand, try this for an effective demonstration of chain reaction: Obtain a large box and fit it with a transparent cover (clear plastic is fine). Place a group of mousetraps of the snap-spring type on the floor of the box after setting each trap. Now very carefully place one or more ping-pong balls on each trap. Move the cover into place and drop a single ping-pong ball on one edge of the cover.

Fast and Slow Neutrons

- Neutrons must be going slow enough to be "captured" by a uranium-235 nucleus. The extra neutron can "shake up" the nucleus enough to cause it to break apart.

- Faster neutrons can be used with uranium-238 nuclei—and this can lead to fission but through a different process. When the neutron is captured, a neutron in the uranium-238 nucleus changes into a proton and electron. The electron is thrown off leaving a new element, neptunium (93 protons, atomic weight 239). In a few days the neptunium changes in the same way becoming plutonium (94 protons, atomic weight 239). The plutonium is fissionable. Uranium-238 is used in a breeder reactor—called "breeder" because it breeds its own fuel, plutonium.

Community Survey

- Conducting a survey to learn community reactions to nuclear plants will have strong appeal for many young people as well as being potentially very useful. Present public concern for the environment coupled with fears due to a lack of nuclear knowledge could prevent the use of nuclear power in areas where the need is vital.

- The opinions expressed in the survey could reveal a broad range of concerns, all good topics for further study and discussion. Some members may become so interested that they'll want to do individual research to find out facts pertaining to fears, and solutions being suggested for problem areas.

- For a different approach to an environmental discussion, introduce a pollution problem—then try to find a solution through the use of nuclear energy. For example: auto exhaust could be eliminated by using electricity — electricity supplied by a reactor.

RADIOISOTOPES

Show Preview: Animated portions will introduce radioisotopes and radioactive decay (half-life). You also will observe some of the amazing ways radioisotopes are being used as "tracers," "daters," and sources of power.

Guide for Teens: Teenagers take a close look at the Periodic Table and learn about atomic families and atomic "twins" (isotopes). They watch a radioactive substance decay and demonstrate how radioisotopes can be used as tracers. (Note: Half-life experiments are included in the final section, "Bombarding Things.")

Meet Some Atomic Families

- Teenagers may wonder why atomic weights are not whole numbers. See if anyone recognizes the reason: that the atomic weight is an average of isotope weights. Point out that isotopes are identified by atomic weight, for example: carbon-12, carbon-14. Do all members understand that the atomic number is the number of protons?

- Rounding off atomic weights may be difficult for some young people. Review how to do it.

- Use the newer elements to point out how research going on right now is expanding our knowledge. The discovery of Element 104, announced by the Russians in 1964 and named Khurkatovium, is being questioned by other scientists, mainly because they have not been able to duplicate and thus confirm the Russian experiments. In the meantime, scientists at the University of California, Berkeley, where all of the other artificial elements have been produced, have developed isotopes of 104, using their own methods.

Watch the Show!

- Be sure that the scintillations are viewed in a dark room *after* adequate time to allow the eye to adjust to dim light. Proper magnification is a must. Ten power or more is needed.

- The sparks observed are the result of electrons losing energy as each moves to a position closer to the nucleus of an atom.

- A more permanent spinthariscope can be made by mounting the lens on one of two pieces of cardboard tubing which telescope together. The luminous material can be mounted on glass at the opposite end of the larger tube. Painting the inside with flat black paint will improve the viewing. Inexpensive lenses are available through Army Surplus or Edmund Scientific Company.

- Teachers of some classes might want to discuss physical processes producing light—also possible application of the scintillations to measure the strength of a radioactive source or to produce light for commercial uses such as luminous switches or dials.

- Caution members to wash their hands after working with radium dials and similar substances. The paint isn't dangerous to the touch but can be harmful if ingested. Members will learn later that alpha particles given off by the radium can damage internal cells if any of the substance gets in the mouth.

Isotope Models

You may wish to construct models to describe the differences among isotopes of the same element.

Use white styrofoam balls for protons and colored ones for neutrons. Hold protons and neutrons together with toothpicks. Mount each nucleus on a stick or wire. Insert in a styrofoam or wood base and label with the name of the element or isotope.

Model 1 representing hydrogen (H-1, atomic weight 1) has one neutron only.

Model 2 representing deuterium (H-2, atomic weight 2) has one proton and one neutron.

Model 3 representing tritium (H-3, atomic weight 3) has one proton and two neutrons.

Each of these three models shows the nucleus of the same element. Because these atoms are the same in everything except mass (number of neutrons) they are called isotopes, after the Greek word meaning "twins."

RADIATION AND LIVING THINGS

Show Preview: Animated portions explain the amount of background radiation which our bodies can tolerate and point out that radiation is damaging to living cells. Illustrations show radiation as useful in treating cancer and eliminating insect pests, as well as detrimental in its effects on chromosomes, chickens, and irradiated seeds.

Guide for Teens: Teenagers experiment with film to detect natural radiation. They learn about three kinds of radiation and make a cloud chamber to observe radiation paths. They also have a chance to plant irradiated seeds.

Radiation in the Air

- X-ray film, if obtainable, is better than the ordinary roll film suggested because of its sensitivity. It requires darkroom developing. Purchasing any of the film for a group may be less expensive than individual purchases.
- Point out that the Polaroid film should be rolled in one direction only for developing. Different sizes and speeds may be used. Slower film speed will require a longer developing time. Polaroid color film has been used, but requires special handling due to the lack of individual film packs.
- Members who have darkrooms may be willing to develop film for the group.

Three Kinds of Radiation

- Did all members figure out that carbon-14 stabilizes by giving off a beta particle to become nitrogen-14?
- The nuclear process of changing from one element to another element of nearly the same size is called *transmutation.* Changing by giving off alpha or beta particles is a form of transmutation. Converting a neutron into a proton and electron during neutron bombardment is also transmutation (example: uranium-238 changing to neptunium-239 and then plutonium-239).

Making a Cloud Chamber

- The majority of tracks observed will be alpha tracks.
- If the cloud chamber does not seem to be working, reasons may be:

(a) Glass is too thick to create the cold temperature needed at the base of the chamber. Screw on the top and turn the jar over, using the metal top as the base. Or just allowing the jar to sit on the ice longer may help.

(b) Water vapor may be preventing cloud formation. Dry the chamber with paper toweling, add fresh alcohol and try again.

(c) The radioactive substance may be too near or too far from the bottom. Attach a thread to the substance so its position can be adjusted.

(d) Air currents may be preventing proper operation. Seal the top with vaseline.

(e) Members may be viewing from the wrong place. Have them look directly down from above, with the light entering from the side.

(f) If all else fails, a new radioactive source may be needed.

- Teachers may want to discuss condensation nuclei and how emission trails are produced.

Obtaining Radioactive Materials

If efforts to obtain radioactive materials for the cloud chamber and other devices and experiments fail, several commercial substances are available. Most useful of these are the radioactive materials available for the Introductory Physical Science program and the Earth Science Curriculum Project. Science teachers should be able to supply catalogues with listings for these programs. Each substance can be checked with a commercial Geiger counter and a lead sheet for emission of beta particles and gamma rays and with a cloud chamber for emission of alpha. Your local civil defense director may also be able to help you obtain and check radioactive substances.

SOCIETY AND THINGS NUCLEAR

Show Preview: The show describes how civil defense preparedness can help limit damages in nuclear and other emergencies. The program shows home and public fallout shelters, and tells the story of precautions taken in the building of nuclear power plants and in the disposal of radioactive wastes.

Guide for Teens: Teenagers learn about fallout and how distance and shielding can give valuable protection. They have a chance to evaluate public shelters in their own communities as well as discover, through a survey, public attitudes on shelters. As a group they have an interesting opportunity to learn how they might react to a community emergency through role-playing.

Fallout—The Greatest Threat

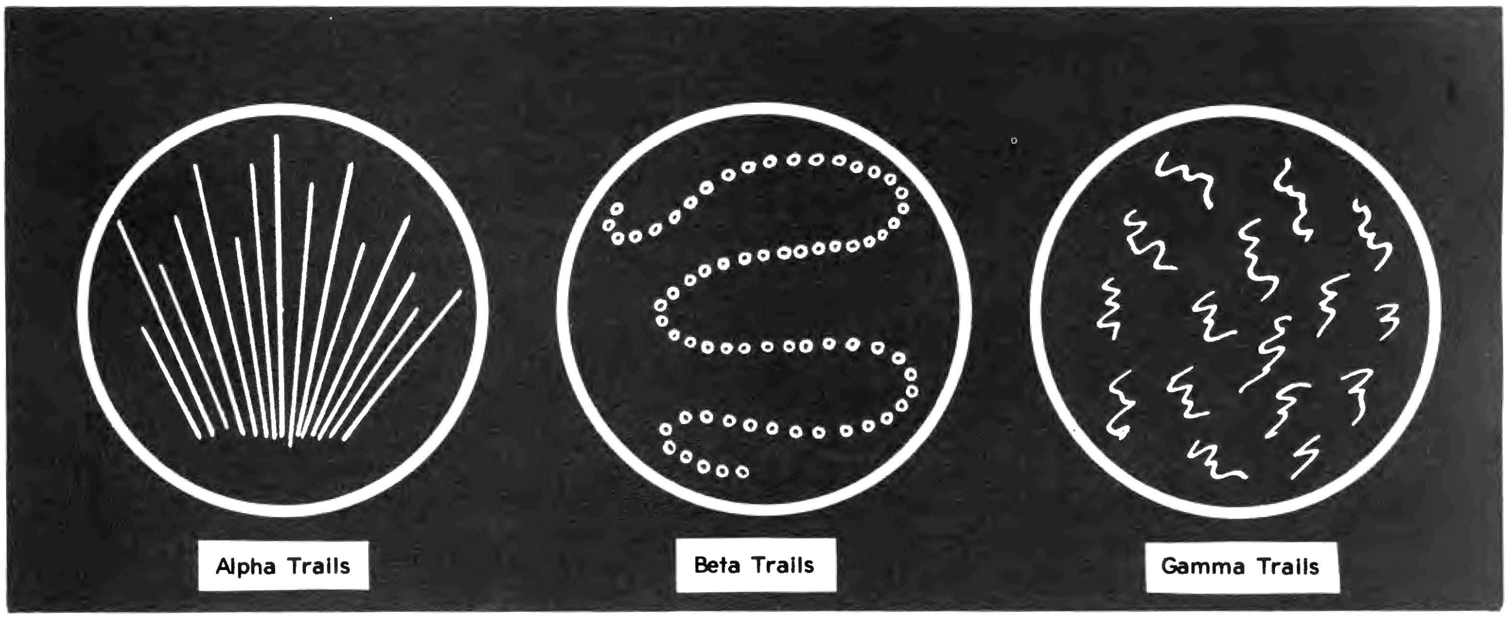
- Point out that radiation from fallout will be in alpha, beta and gamma forms. Except for the possibility of eating or drinking materials contaminated by fallout, there is little danger from alpha radiation. Beta radiation can damage the skin and other tissues. If fallout contaminates food, beta particles could destroy internal tissues. Gamma rays create the greatest dangers. However, if gamma rays pass through a substance, the substance does not become radioactive.

- Possible discussion questions: What could you do to prevent skin damage from direct contact with—or internal damage from eating or drinking—contaminated foods? Are sealed foods and liquids safe to consume after they have been exposed to radiation? If you have been exposed to radiation and you wash off the radioactive materials, are you a danger to others?

Distance Can Help

- Your local civil defense director may be able to help with these experiments. If there is no civil defense director in your locality, ask your county Extension agent for others who may be able to assist. (For example: the Soil Conservation Service conservationist might have a Geiger counter and could explain his role in radiation monitoring.)

- Your civil defense director or possibly your county Extension agent would know if this has been done in or near your locality.



Shelters

- If you would like supplemental booklets or other materials for members on fallout, stocking emergency supplies, home shelter plans, medical self-help and related topics, your county Extension agent can get them for you.

- Ask teenagers to explain their choice of location for home shelters. The location should be the best protected part of the house and also an area that can be reinforced. Underground shelters away from the house should also be considered.

- Locating public shelters in the community and visiting some of them could be an interesting activity for a group.

- Perhaps you can also visit a well-constructed home fallout shelter. It may be serving a double purpose such as a workshop or recreation room. Ask teenagers to suggest ways in which fallout shelters could meet current family needs and add to the livability of a house.

- Teenagers may want to compare their lists of shelter provisions with those of others in the group.

- Some communities have conducted studies of basements and have suggested to homeowners ways in which radiation protection can be improved. Your civil defense director or possibly your county Extension agent would know if this has been done in or near your locality.

Community Action

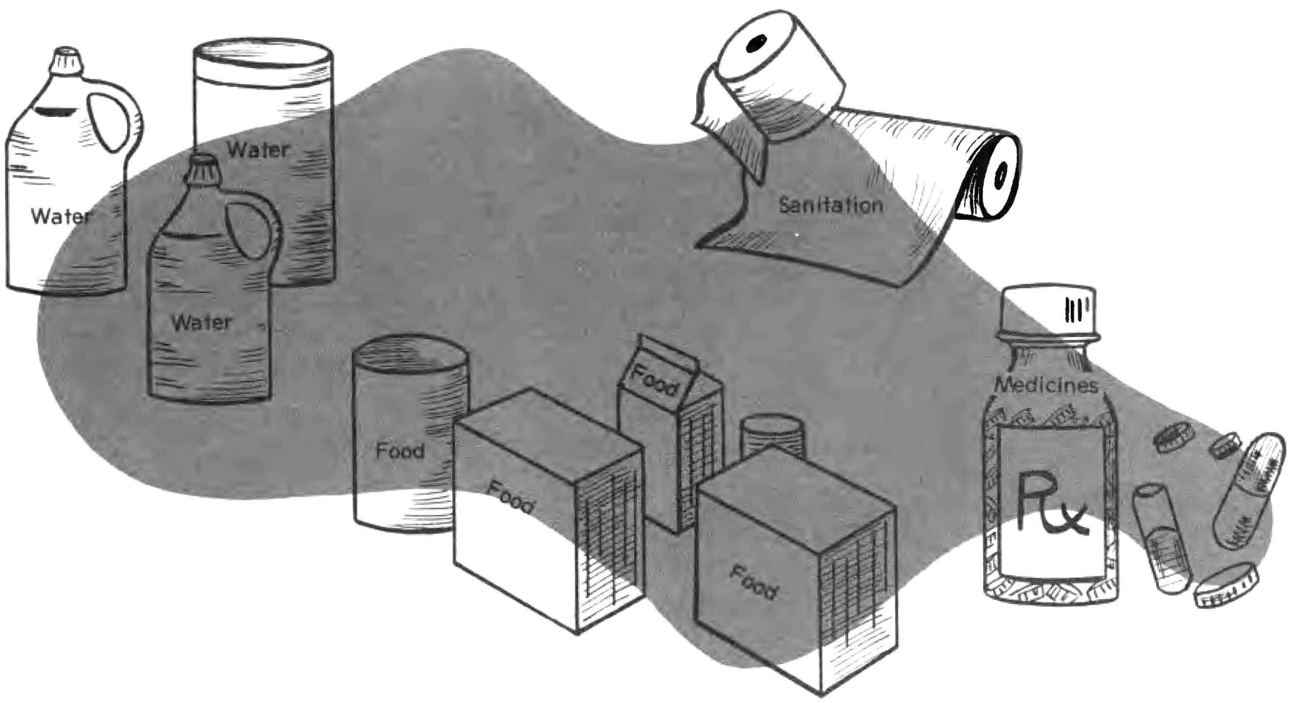
- Could your community cope with disaster? A community that is well prepared to meet an emergency such as a tornado, earthquake, large-scale fire, or flood has the organization ready to meet a nuclear emergency, too. Members of older groups especially may want to find out if the community has a written disaster plan, who would be in charge, and what the roles of various agencies might be. If there is no community emergency plan, your members may want to urge the adoption of one.

Role-Playing

- The Community Response Game is an excellent simulation of real emergency situations. The game works best with older youths and adults as some maturity is needed in the decision-making. Players will become quite involved and should have several hours available, if necessary, to finish the game. The game could be introduced in one session and played in another.

- The shelter-living role-playing can also be a dramatic and revealing simulation of how people react in various ways to an emergency.

Absolute Necessities in a Shelter



BOMBARDING THINGS

Show Preview: Animated portions identify alpha and beta particles and gamma rays, providing a good review for what viewers already know. The show pictures atomic rays and particles being used in thickness gauging, radiography, food preservation, and the identifying of unknown substances (neutron activation analysis).

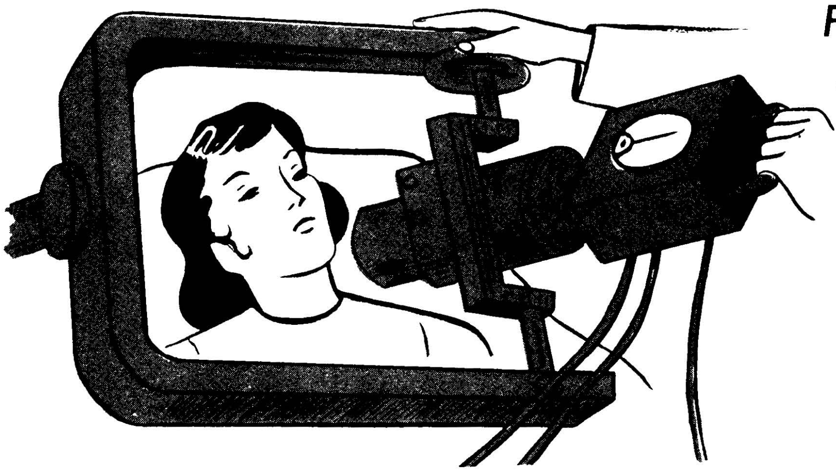
Guide for Teens: Teenagers conduct experiments that help them understand industrial uses for beta particles. They learn about "half-life" and solve problems with this knowledge. They also build a model to demonstrate fusion — the nuclear reaction which scientists believe will produce our power for the future.

Beta Particles at Work

- Members may want to find out if, how and where atomic particles and radioactive substances are being used in their community.

For example:

a) Hospital and medical labs (diagnosing and treating disease)
b) Manufacturing plants (thickness gauging and product testing)
c) State police (crime detection, civil defense training)
d) Laboratories in universities and elsewhere (research)
e) City water departments and large oil companies (to detect pipeline leaks or determine flow)
f) Highway construction companies or state highway departments (measuring density and moisture in soils for road building)



Understanding Half-Life

- Violent shaking won't give the pennies a chance to flip.

- Some teenagers may need help with graphing.

- From the data assembled you can help members recognize certain important relationships:

a) Radiation decreases by one-half the previous amount during each half-life.
b) A given quantity of radioactive material will emit a greater amount of radiation in a given period of time if the half-life is short.
c) Radioactive isotopes with a short half-life are more dangerous (for a given quantity and time) than isotopes with a long half-life. Members should be able to understand a little better from this how time (staying sheltered long enough) can be a form of protection during fallout.

Fusion: Power of the Future

- Fusion is also called a *thermonuclear* reaction— thermo coming from the Greek word meaning heat.

- Students should be able to relate the use of extra cement and the change in weight to the formula $E=mc^2$. It isn't necessary to consider many more values of the formula than the change of mass to energy.

FOR MORE INFORMATION

Check your school and public libraries for books and magazines on nuclear energy and current developments. Science teachers may have access to many more publications. Civil defense directors can supply informational materials on fallout, shelter and other protective measures as well as a list of films on emergency preparedness available through the Office of Civil Defense. County Extension agents can order for you a wide variety of government and university publications concerning radiation protection for home and farm. Or write to any of the following:

U.S. Atomic Energy Commission, P.O. Box 62, Oak Ridge, Tennessee 37830

"Understanding the Atom" series
"World of the Atom" series

Complete sets of each of these series are available to school and public librarians, and to teachers for group use by making requests on school or library letterheads. Individuals may obtain 1 to 3 copies of titles in the series free.

State and Local Civil Defense offices, or OCD, The Pentagon, Washington, D.C. 20310

Civil Defense (OCD MP-54)
Civil Defense Motion Picture Catalog (OCD MP-6)
In Time of Emergency: A Citizen's Handbook on Nuclear Attack and Natural Disaster No. H-14

Your County Extension Office

Family Food Stockpile for Survival, Home and Garden Bulletin 77

- If seeds for the irradiated seed experiment are not available locally, try the following sources:

Carolina Biological Supply Company, Burlington, North Carolina 27215
General Biological Supply House, 8200 S. Hoyne Avenue, Chicago, Illinois 60620
Carolina Biological Supply Company, Powell Laboratories Division, P.O. Box 7, Gladstone, Oregon 97027
Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, New York 14603

- The following references provide further information for the irradiated seed experiment:
  - *Experiments with Radiation on Seeds, Number 1,* also
  - *Experiments with Radiation on Seeds, Number 2,* U.S. Atomic Energy Commission, Division of Technical Information Extension, Education Materials Section, P.O. Box 62, Oak Ridge, Tennessee 37830.
  - *The American Biology Teacher,* Journal of the National Association of Biology Teachers, Volume 27, Number 6, August 1965.

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