"Living in a Nuclear Age"

TV tune in turn on!

4-H FOR TEENS

We live in an age that's nuclear.
Just what that means to some is unclear.
Understand the atom, that's common sense.
Protect yourself, that's civil defense.
I'm Ion Fleming, your atomic sage.
And I'll be your guide through this nuclear age.

In this book, you'll find . . .

Welcome

Welcome to "Living in a Nuclear Age," a series of 6 half-hour television programs. The nuclear age is **your** age. Unlike any generation before you, you've lived your whole life in it. Here is your chance to find out about the nuclear age — and why it is one of the most exciting and challenging times of scientific change man has ever known.

As you watch each program of the 4-H TV series, "Living in a Nuclear Age," follow along in this manual. You'll find the experiments, puzzles, and other activities fun to do. They'll help you understand the atom better. Discoveries that will be making news and affecting your life in the future will be more meaningful.

Our knowledge of the atom has been a mixed blessing. It opened the door to amazing benefits. But at the same time it added a new threat and many challenges to our lives. In the years to come, will we wisely use the atom for good? Will we recognize its dangers and protect ourselves from them? These are questions you and your generation will have to answer. What you learn now about the atom can help you live more safely and securely in the years to come and enjoy life more in the nuclear age.

Secret Atom

To tell us the secret we've tried to persuade
Nature please tell us of what you are made.
Everyone knew that the atom was there
It had to be, it has to be, but where, just where.

If the atom's secrets you want to know,
Then come with me and we will go,
On trips and on journeys through inner space,
To find the atom's hiding place.

1

The Atoms Character
An atom hides within a crowd
He rarely shows his little face,
And when you come to sort him out
You see he's mostly empty space.

The nucleus weight is really large
Next to electrons of negative charge.
In the core each proton's heavy weight,
Is balanced in the core of a tiny electron mate.

Show 1 . . . . DISCOVERING THE ATOM

Show Preview

Animated portions 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.

STATIC ELECTRICITY . . . to describe the effects of static electricity on small pieces of paper.

Materials:

- **balloon at least 8 inches in diameter when inflated.**
- **wool or nylon, each piece approximately 2 inches square.**
- **tiny scraps of paper perhaps the size of a fingernail.**

More than 2,000 years ago, a Greek philosopher, Thales, discovered static electricity by rubbing a piece of amber on wool. He then noticed that the amber attracted bits of wood and straw. Neither Thales nor the other early Greeks, nor scientists for hundreds of years after that, could explain this mystifying property of rubbed amber. But, when the process was finally named, it was called "electricity" after the Greek word for amber, **elektron.**

You can repeat the experiences of Thales and others now.

Procedures

Inflate a balloon and rub it with a piece of wool or nylon. Now bring it near some tiny scraps of paper. Did the tiny scraps of paper move closer to, or away from the balloon?

CHARGING MATTER . . . to describe balloons or other objects in terms of their having similar or dissimilar kinds of electrical charges when rubbed with wool or nylon.

Materials:

- **two balloons.**
- **two lengths of string each about 6 feet long.**
- **hard rubber or plastic comb.**
- **rod or other object made of lucite (hard plastic) or glass at least ¼ inch in diameter and 6 inches long.**
- **wool and nylon, each piece 2 inches square.**
- **two chairs.**

A French scientist, Charles du Fay, believed he had discovered two kinds of electricity. He would have been credited with discovering two basic laws of matter had he identified these two kinds of electricity as "electrical charges" — both positive and negative. You can try an experiment similar to du Fay's.

Procedures

Tie a piece of string between two chairs and attach an inflated balloon to the string. Charge the balloon by rubbing it with wool. (Recharge the balloon after each test in this activity.)

Now charge a second balloon by rubbing it with the wool and slowly bring it towards the first. What happens to the balloons? Do they move toward one another or away from one another?

After charging the balloons by rubbing with wool, bring the objects in the list below (plus some of your own choosing) close to the first balloon and watch what happens.

Object	Reaction of Object to First Balloon
Wool used to charge balloon	
Comb rubbed with wool	
Comb rubbed with nylon	
Glass or lucite rubbed with wool	
Glass or lucite rubbed with silk	

Did you notice that some of the objects caused the balloon to behave in another way?

Why do you think they behaved differently, if they do?

SURPLUS ELECTRONS . . . to describe the action of running water when a balloon charged with surplus electrons is held close to it.

Materials:

- **balloon inflated to at least 8 inches in diameter.**
- **piece of wool at least 1 inch square.**
- **running water from a faucet.**

All matter is made up of positively and negatively charged particles. Positive particles called protons are found in the center or nucleus of an atom. Negative particles called **electrons** are moving at certain distances from the nucleus (energy levels).

When a balloon is rubbed with wool it picks up extra electrons from the wool. This gives it a negative charge. With this in mind, see if you can explain what happens in the following experiment.

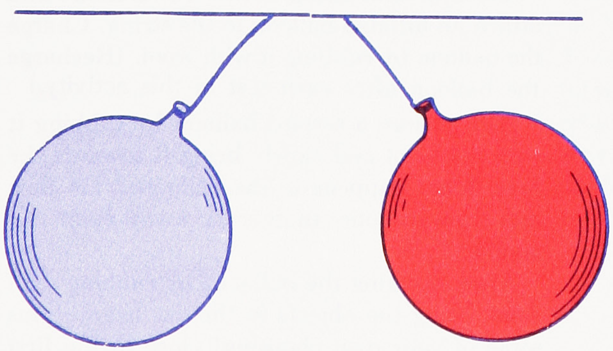
Procedures

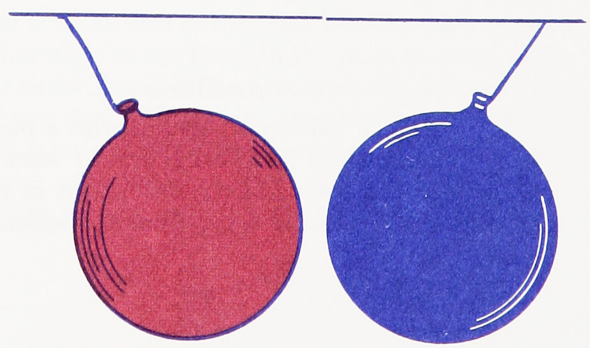
Rub an inflated balloon with wool. Place it near a small stream of water from a faucet.

What was the reaction or action of the water when the charged balloon was brought close to it?

Are you surprised by the result?

What do you conclude as a result of the action of the water?





MAKING AN ELECTROSCOPE . . . to make an electroscope and charge it with the static electricity from a balloon rubbed with wool.

Materials:

- **bottle with narrow mouth and base at least 3 inches in diameter such as a vinegar or syrup bottle.**
- **cork to fit the mouth of the bottle.**
- **strand of No. 14 copper wire about twice the length of the bottle.**
- **disc 1½ inches in diameter cut from a sheet of copper metal.**
- **solder and soldering equipment including a soldering iron, source of heat, and flux or rosin core solder.**
- **emery cloth at least 2 inches square.**
- **two pieces of foil from chewing gum wrappers or two pieces of household foil similar in size.**
- **nail slightly larger than the diameter of the wire.**
- **silicon (household) cement.**
- **punch, ice pick, or other tool to punch a hole through the cork.**
- **balloon used in previous activities.**
- **comb made of hard rubber or plastic.**
- **rod or other object made of lucite (hard plastic) or glass at least ¼ inch in diameter and 6 inches long.**
- **wool and silk, each piece 2 inches square.**

Procedures

Thoroughly wash the bottle. Remove all possible moisture by drying it in the oven (use the lowest setting so the bottle will not crack or break) or use a hair dryer or heat register.

Assemble the top as follows: Bend the wire in half (figure 1). Punch a hole through the cork and push the doubled-over end from the bottom of the cork up through the cork until the doubled-over end extends about 1 inch above the top of the cork. Bend the wire above the cork to form a right angle (figure 2).

Figure 1.

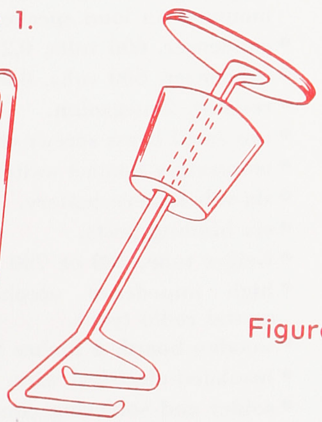


Figure 2.

Polish all surfaces and edges of the copper disc with emery cloth. Solder the disc to the bent-over wire. Use an emery cloth to smooth any sharp points in the solder connection. Bend the wire below the bottom of the cork so the ends of the wire (figure 2) are parallel and about ¼ inch apart. Wrap the foil around the nail one or two times. Now withdraw the nail and slip the foils onto the ends of the copper wire.

Place the cork in the bottle, adjusting the wire so the foil strips are an equal distance from the sides and top and bottom of the bottle (figure 3). Use silicon cement to seal the cork to the bottle and the wire to the cork.

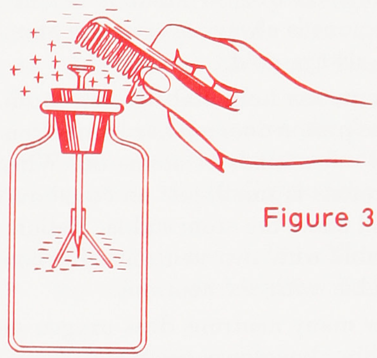


Figure 3.

Your electroscope is now ready to use. If you rub a balloon with wool and touch it to the copper disc, the charge from the balloon will be transferred directly to the electroscope. This is called charging your electroscope.

Can you predict what will happen? Try it and see.

What happens if you now touch the disc with your finger?

What happens when you remove your finger and then remove the object?

MAKING AN ATOM MODEL . . . to describe the number of protons, electrons and neutrons in atoms of various elements.

Materials:

- **poster board at least 11 inches by 14 inches and preferably 14 inches by 22 inches.**
- **three different colors of one of these items: cake decoration candies, bingo markers, or cross section pieces of soda straws.**
- **adhesive paste or cement.**

In 1932, Sir James Chadwick discovered a new particle inside the nucleus of an atom. It weighed about the same as a proton but did not have a charge. Since it was electrically neutral, he called it a **neutron.**

With this discovery, many scientists believed that everything inside an atom had been found. But they were mistaken. Many other kinds of particles have since been discovered within the atom — **positrons, neutrinos, mesons,** and **hyperons.** Nevertheless, the main parts of an atom still seem to be protons and neutrons, packed into the nucleus, and electrons vibrating around them.

Here are some facts you need to know to make an atom model:

- The number of protons in the nucleus determines what kind of an atom it is. An atom with eight protons is always oxygen. An atom with 79 protons is always gold.
- **Neutrons help stabilize an atom.** Hydrogen with one proton does not need a neutron for stability, but all other kinds of atoms do. When the number of protons is small, just an equal number of neutrons will make the atom stable. Helium (two protons) is stable with two neutrons. Carbon (six protons) is stable with six neutrons.

How many neutrons does oxygen need? (Figure out from the above paragraph.)

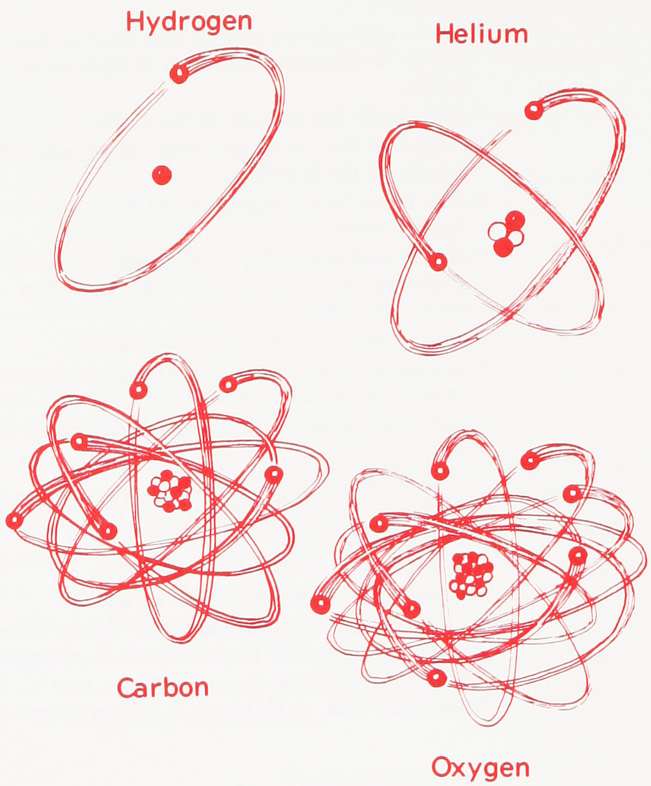
An equal number of protons and neutrons won't do for heavier atoms. They need increasing numbers of extra neutrons. For example, the most common form of uranium (92 protons) has 146 neutrons — or 54 extra neutrons!

Using the above information, make models of hydrogen, helium, carbon, and oxygen atoms. Try an uranium atom model, too. (Remember the number of electrons in orbit will be the same as the number of protons.)

Procedures

Arrange and paste the atoms on poster board, using such things as cake decoration candies, sugar crystals, bingo markers, or cross section pieces of soda straws for the protons and neutrons. Use two colors to show the difference between protons and neutrons in the nucleus. Choose another color and kind of marker for the electron. Be sure to label the atoms and parts.

This won't show what atoms look like, nor will they show the proper size or space relationships of an atom's parts. But by showing the number of protons, neutrons, and electrons in specific atoms, your models can be a big help later when you do experiments with fission and radiation.

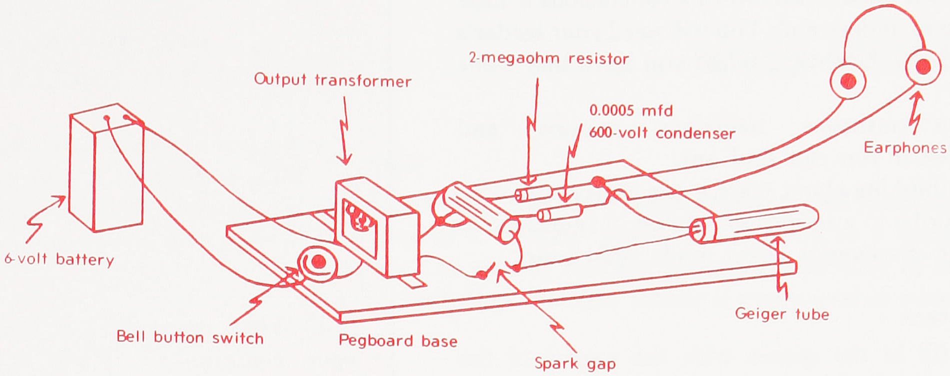


Fissions Conditions — Riff
When the old atom fissions,
There are some risky conditions
Particles fly with speed and shielding is the immediate need!
If too many hit you, you're bound to get ill,
And massive amounts can actually-----------!

MAKING A GEIGER COUNTER . . . to construct a simple Geiger Counter.

Materials:

- **output transformer such as those usually mounted on loud speakers.**
- **condenser, 600 volts, 0.25 mfd.**
- **condenser, 600 volts, 0.000 mfd.**
- **resistor, 2-megaohm.**
- **two small brass screws sharpened to a point.**
- **momentary contact switch.**
- **six-volt lantern battery.**
- **six binding posts.**
- **Geiger tube, 300 or 700 volt.**
- **high impedence earphones (inexpensive, crystal radio type).**
- **wooden board, 4 inches by 6 inches.**
- **insulated electrical wire.**
- **solder and soldering equipment.**



Procedures

Assemble the instrument as shown in figure.

The transformer should be hooked up in reverse of the normal operation. Current from the battery is sent into the low voltage winding which was originally connected to the voice coil of the speaker. The secondary, which has many turns of wire and relatively high voltage, is the winding from the amplifier.

If the Geiger tube has three terminals asymmetrically arranged, wire from spark gap to single terminal, and from resistor to double terminals.

The gap distance is not critical but should be about 2mm.

The storage condenser is a 0.25 mfd, 600-volt condenser. Once charged, this condenser may operate the counter for several minutes, thus permitting the battery to be disconnected and the counter to be carried about. If you find that with a 700-volt Geiger tube, it takes too long to charge the condenser, substitute a 0.1 mfd, 1,000-volt condenser for the 0.25 mfd, 600-volt one.

History's Mystery

So the tiny atom, strong and so stable,
To split it everybody tried, but no one was able,
Then a very bright lad said, "Energy equals M C square,"
And so from then on we knew that energy was there.
Yeah, but where?
Find the unfindable, Split the unsplitable,
Find the unsplitable.
At last the answer we came upon, upon.
To split the atom, use neutrons, use neutrons!

Operation:

Sharply press and release the momentary contact switch 15 or 20 times. This sufficiently charges the condenser to operate the Geiger tube for several minutes. Pressing and releasing at 15-second intervals should maintain the voltage.

If the counter fails to operate, reverse the battery connection since, depending on the direction of winding of the transformer, the polarity on the Geiger tube may be reversed.

The counter will give a background of 20 to 25 counts per minute and will respond to relatively low levels of radiation.

CAUTION: Always discharge condenser with insulated handle screwdrivers after use. High voltage stored in condenser may come as quite a shock.

Principle:

Note figure. Each time the momentary contact switch (s) closes and opens the circuit of the primary of the step-up transformer (t), a high voltage is induced in the secondary. The voltage is sufficiently high to jump the gap (s.g.) and charge condenser. Repeated opening and closing of the switch builds up the voltage on Cl. This voltage appears across the terminals of the Geiger tube (G). Each time, as the Geiger tube is ionized by radiation, current flows from Cl, through resistance R. When current flows, the voltage drop appearing across R drops the voltage at the Geiger tube so that the discharge is given ahead and the tube is ready for the next ionizing radiation. The voltage drop across R at each pulse operates the head phones (P) through a small capacitor (C2).

More Things To Do

Some of the most exciting discoveries of all time have happened in this century. One of them was around 1911 when Ernest Rutherford discovered that the atom is mostly space with a small massive center or nucleus. If you are a member of a club or class doing this "Living in a Nuclear Age" project, you might want to try an interesting experiment from your leader's or teacher's guide. It should make Rutherford's conclusions a little easier for you to understand. You will need your leader's or teacher's help, however, unless you have had some algebra.

What are positrons, neutrinos, mesons, and hyperons? See if you can find out.

If you are thinking about science as a career, you may want to subscribe to a science newsletter or magazine to keep up with discoveries being made right now.

Famous Names

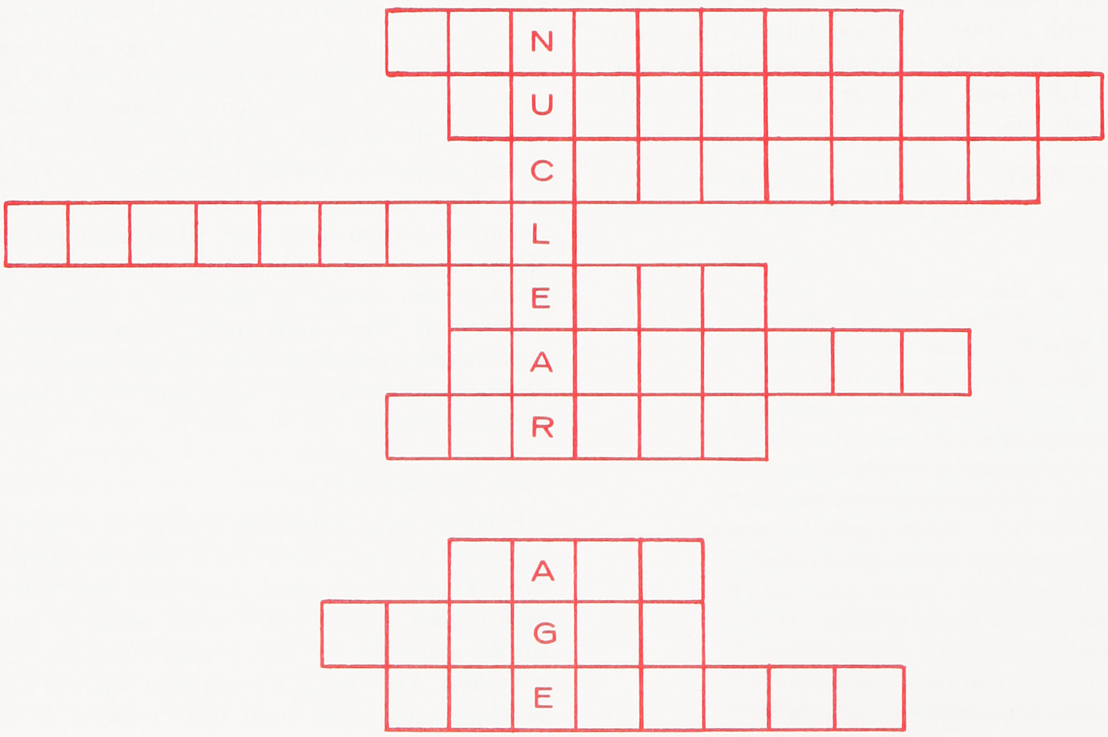
Can you fill in the spaces with the names of the famous scientists described below? Arranged as shown, their names spell out the age they all helped create. Answers are on page 29.

1. Predicted E equals mc^2.
2. Discovered the atom has a nucleus.
3. Discovered neutrons.
4. Discovered natural radioactivity.
5. Built the first nuclear reactor.
6. Developed the cyclotron.
7. Discovered radium.
8. Discovered nuclear fission.
9. Developed a "counter" to detect radiation.
10. Discovered x-rays.

HOW DO YOU LIVE IN THE NUCLEAR AGE?

Nuclear energy is here to stay. Man must learn to harness it and put it to use to benefit man. What problems are created by this new energy source?

1. What are sources of low level radiation in your community? What special checks and controls are made to protect individuals from excess exposure?
2. Do nuclear power plants offer sufficient potential economic advantages to justify further development? Or should research efforts be channeled to other untapped power sources?
3. Do projects such as Gas Buggy result in a quicker than normal consumption of finite energy sources? Should finite sources of energy be used up quickly?
4. Does anyone dare to leave a shelter for even a short period of time during the first two weeks after a nuclear attack?



2

Show 2 . . . . POWER FROM THE ATOM

Show Preview

Animated portions 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.

A few decades ago harnessing the tremendous energy inside the atom was only a dream. Today it is a reality. Nuclear power plants can be found throughout the United States and the world.

Try to visit a nuclear power plant (your leader, teacher, or civil defense director in your city or county may be able to tell you the nearest location of one). If a tour isn't possible, write to the plant asking for information.

Nuclear Power

Well if you don't want nuclear power,
Power to do the chore, Try water power,
It's been done before
Water flows from up to down, forever seeking lower ground.
Watch the water as it flows, watch it turn the dynamos.
Lakes and streams and rushing rivers, they like atoms are energy givers.
Lakes and streams and rushing rivers,
Powerful turbines are energy givers.

Well if you don't want nuclear power, power to do the chore,
And water power leaves rivers no more,
Try burning things, try burning things, it's been done before.
Try burning things, try burning things, it's been done before.

And when the end is here in sight and we cry for still more steam,
Will mankind's hopeful future be just a dream.
Will mankind's hopeful future just be a dream.

REACTOR MODEL . . . to construct a model of a nuclear reactor.

Materials:

- **six pieces 1/8-inch pegboard, each about 6 inches by 8 inches.**
- **Styrofoam about 12 inches by 16 inches and 1/2 inch thick.**
- **ten 1-foot pieces of 1/8-inch dowel rod.**
- **four wood blocks, each 1 inch by 1 inch by 6 inches.**
- **sixteen screws to attach the pegboard to the small wood blocks.**
- **screwdriver.**
- **three different colors of paint, small 1/2 pint of each.**
- **paintbrush, perhaps 1/4 inch, to paint representation of blocks on the pegboard.**
- **two flashlight batteries.**
- **two flat, springy strips of copper or brass. (These should curve from the ends to the center where there is no pressure on them. Obtain from sources suggested by your parents or school science teacher.)**
- **flashlight bulb.**
- **construction paper, 8 1/2 inches by 11 inches.**
- **electrical No. 14 copper wire about 2 feet long.**
- **solder and soldering equipment.**

Whether or not you visit a nuclear power plant, it would be fun to make a model reactor. These instructions will help you build a model to represent the first working reactor. It was constructed under a football stadium at the University of Chicago in 1942! The reactor was a mass of graphite blocks, uranium, concrete, and lead. In all, it weighed 1,400 tons. The uranium alone, which was used as fuel, weighed 52 tons.

In this kind of a reactor, layers of graphite blocks (pegboard of your model) are used as a **moderator** to slow down neutrons. Rods of cadmium or boron are inserted to control the **fission** process. The concrete and lead (Styrofoam of your model) are used as a shield to prevent dangerous radiation from leaking.

Procedures

Make a box with pegboard, using small wood blocks to brace the corners. Use screws to fasten the pegboard to the wood blocks. Paint the pegboard with drawings which represent small blocks piled together. The lines representing the blocks may be patterned after the drawing.

Cut and assemble the Styrofoam around the pegboard so that it gives the impression of a cut-away view (see figure). Use glue to fasten the Styrofoam together.

Paint four of the dowel rods one color to represent fuel rods. Paint three of the dowel rods a second color to represent control rods. Paint two of the dowel rods a third color to represent materials inserted into the reactor for irradiation.

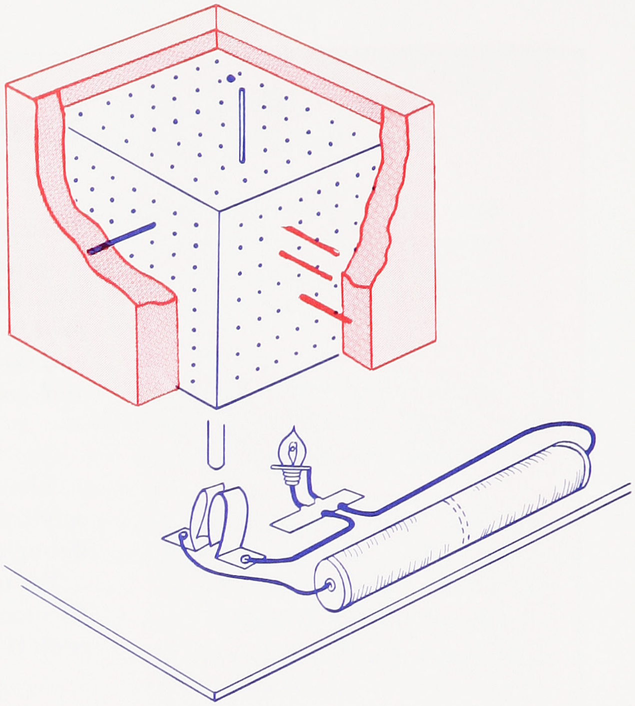
Insert the fuel rods in one side of the model. Insert the control rods at the top. Insert the rods to be irradiated on the remaining "cut-away" side.

You can easily add some action to your model by assembling a light circuit under a control rod. Attach the circuit to the bottom piece of pegboard.

Assemble the circuit as shown in the figure. Hold the batteries in place with a tube of construction paper taped around the two batteries. Solder the wire connections to the batteries, flashlight bulb, and the strips of copper or brass as indicated in the drawing. Fasten the flashlight bulb and strips of copper or brass to the inside base of the reactor model with small screws or electrical tape.

Be sure the metal strips are located directly under one of the control rods. When you lower the rod, it should separate the two metal pieces. When you pull up the rod, the metal pieces will make contact and your reactor will light up.

You might wish to compare your model reactor with the picture of the model reactor shown at the top of the next column.

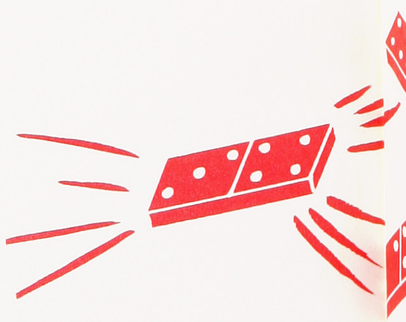


SIMULATING FISSION . . . to simulate some of the processes which occur in atomic fission.

Materials:

- **nine marbles of one color and fifteen of a second color.**
- **aluminum pan similar to the kind used for frozen pot pies.**
- **strand of thread about ten feet long.**
- **heavy nail or metal rod of similar size 4 inches long.**
- **mat or pad to lay under the nail to protect a table top.**
- **scissors.**

If a heavy atom like uranium-235 is hit with a neutron, an amazing thing happens. The atom will actually split into lighter atoms (figure 7). The process is called **fission**. At the same time, a tremendous amount of energy is given off. And, as in the experiment which follows, extra neutrons "roll away" to hit other uranium-235 atoms and start a **chain reaction.**



Procedures

Use epoxy cement to glue together four marbles of one color. These will be your proton marbles. Glue together five marbles of a second color. These will be the neutron marbles. Then glue together a second group of five proton colored marbles and a group of six neutron colored marbles.

Glue together the four proton marbles and the five neutron marbles. Glue together the five proton marbles and the six neutron marbles.

Place the two groups of marbles, plus two extra neutron marbles, in a small aluminum pie pan.

Using a thread or string, hang the pie pan over a table. Lay the heavy nail or rod on the table, under the pan. Make sure the nail is directly under, and on the dividing line, between the two groups of marbles. (Use a mat or pad under the nail to protect the table.)

Now drop a neutron marble into the pie pan, at the same time cutting or lowering the thread so the pan falls on the nail. If adjusted properly, the two groups of marbles will separate with the extra neutrons rolling away.

Your pie pan of marbles represents an atom with a massive nucleus that has extra neutrons but still isn't very stable. Call it uranium-235 (uranium that has 92 protons and 143 neutrons).

Can you figure out why all the neutrons aren't used up by the new, lighter atoms?

CONTROLLING A CHAIN REACTION . . .

to simulate the action of free neutrons striking atoms.

Materials:

- ten to twenty-five dominoes.

Arrange a row of dominoes on end and in a single line about ½ inch apart with the face of one domino ½ inch from the back or face of the adjacent domino. Consider these dominoes as uranium-235 atoms. Push the first domino in line to represent the first neutron striking the first atom. When one atom "splits" (falls over), a part of it (a neutron) strikes another atom. This process is repeated down the line.

Now set up the dominoes as shown in the figure. Notice that each block will fall and touch two more blocks. This could represent a fissioning atom releasing two neutrons. Try to time the rate at which these blocks fall. Compare this to the time required for the same number of dominoes in a single line.

If you had billions of dominoes (representing billions of atoms) would it take very long for all of the blocks to fall over, if they were set up in a pattern such as the dominoes in the second arrangement? Can you think of ways of slowing down or controlling such a chain reaction?

Scientists slow down the chain reaction in a reactor by using control rods of cadmium or boron. These elements absorb neutrons very easily and in this way stop them from hitting uranium-235 atoms. If enough cadmium or boron is present no fission can take place.

FAST AND SLOW NEUTRONS . . . to simulate the different reactions which occur when "slow" neutrons strike an atom compared with a "fast" neutron striking an atom.

Materials:

- nine marbles of one color and eleven of a second color.
- paper at least 8½ inches by 11 inches or a plastic ruler.
- shallow pie pan with a sloping rim about 1 inch high.

Slow neutrons work better than fast neutrons in splitting atoms. Why? This experiment may help you understand the reasons.

Procedures

Place nine marbles of one color (representing protons) and ten marbles of another color (representing neutrons) in a shallow pan. With a trough made of paper or by using the groove in a plastic ruler, roll a neutron colored marble into the pan. Try rolling the marble with the back end of the trough at different heights. What happens if the marble is going too fast?

REACTION

The scrambled words below all spell parts or products of a nuclear reactor. Can you figure them out? Answers are on page 30.

REDAMORTO _ _ _ _ _ _ _ _ _ _

NACOTOL _ _ _ _ _ _ _

LUFE _ _ _ _

TOCLORN _ _ _ _ _ _ _

SROTUNNE _ _ _ _ _ _ _ _

ATHE _ _ _ _

WORPE _ _ _ _ _

Nuclear Power Reprise

Oh we need something better that won't let us down —
Won't poison the sky or spoil the ground,
So maybe it is just as you say —
Nuclear power can save the day.

There are tricky problems it's true,
When we try ideas that are brand spanking new.
We must not upset nature's balance,
But make best use of all of our talents.

Cool It, Babe

Oh these reactors have a hot water flow,
So there are two things we really gotta know —
How to cool it, how to cool it, cool it, babe, and
How to use it, how to use it, use it, babe.
Either cool it or use it, cool it or use it,
That's the only way to go.

Oh there are those who say that water could cool,
If we just let it stand in a pool
Well, how to cool it, how to cool it, cool it, babe, and
How to use it, how to use it, use it, babe.
Either cool it or use it, cool it or use it,
That's the only way to go.

So others say that the water should be higher,
So they will cool it in a tower,
Well, how to cool it, how to cool it, cool it, babe, and
How to use it, how to use it, use it, babe.
Either cool it or use it, cool it or use it,
That's the only way to go.

HOW DO YOU LIVE IN THE NUCLEAR AGE?

Nuclear energy is here to stay. Man must learn to harness it and put it to use to benefit man. What problems are created by this new energy source?

1. Should nuclear power plants as well as other industrial plants be required to make economical and safe use of all residues?
2. What is the comparative efficiency of fossil fuel vs. nuclear fuel power plants?
3. What are the advantages of nuclear power plants being operated by government? By private utilities?
4. Does the government subsidize present day nuclear power plants? Should the manufacturing of nuclear fuel remain under governmental control? Should it provide subsidies for development of alternative power sources?
5. What are the pollutants and effects of pollutants from fossil fuel power plants? Nuclear energy power plants?

3

Show 3 . . . . RADIOISOTOPES

Show Preview

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

Do you want to know how old an ancient skull might be? How much a wheel on a machine has worn down? Where the leak in a pipeline is located? Call on a radioisotope to do the job! In the words of the song, "Living in a Nuclear Age," radioisotopes can "go everywhere . . . anywhere's their thoroughfare . . . anywhere whatso'er."

Nuclear reactors have made it possible to produce radioisotopes of almost every element. Scientists are finding amazing ways to use them in medicine, biochemistry, physics, engineering, industry, archeology, agriculture, and many other fields.

Used wisely, radioisotopes hold the promise of benefits that can't even be imagined yet. But used unwisely, they can kill.

Isotope Walk

Radioisotopes can see what's inside you
And nothing inside you can hide you,
Don't try to hide, they'll be inside.

Radioisotopes can go anywhere,
Anywhere that they may care,
Anywhere's their thoroughfare,
Anywhere's their thoroughfare,
Anywhere whatso'er.

Radioisotopes can be fine keys,
They can solve riddles and mysteries
Hardly a puzzle,
That they can't rustle.

MEET SOME ATOMIC FAMILIES . . . to be aware of the basis for the arrangement of the elements in the periodic table.

PERIODIC TABLE OF THE ELEMENTS

ATOMIC NUMBER	ATOMIC WEIGHT
SYMBOL	
NAME	

Explanation:

Symbol
- BLUE — solid
- LT. BLUE — synthetically prepared
- RED — gas
- OUTLINED — liquid

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	O
1	1 1.00797 H Hydrogen																	2 4.0026 He Helium
2	3 6.939 Li Lithium	4 9.0122 Be Beryllium											5 10.811 B Boron	6 12.01115 C Carbon	7 14.0067 N Nitrogen	8 15.9994 O Oxygen	9 18.9984 F Fluorine	10 20.183 Ne Neon
3	11 22.9898 Na Sodium	12 24.312 Mg Magnesium											13 26.9815 Al Aluminum	14 28.086 Si Silicon	15 30.9738 P Phosphorus	16 32.064 S Sulfur	17 35.453 Cl Chlorine	18 39.948 Ar Argon
4	19 39.102 K Potassium	20 40.08 Ca Calcium	21 44.956 Sc Scandium	22 47.90 Ti Titanium	23 50.942 V Vanadium	24 51.996 Cr Chromium	25 54.938 Mn Manganese	26 55.847 Fe Iron	27 58.933 Co Cobalt	28 58.71 Ni Nickel	29 63.54 Cu Copper	30 65.37 Zn Zinc	31 69.72 Ga Gallium	32 72.59 Ge Germanium	33 74.922 As Arsenic	34 78.96 Se Selenium	35 79.909 Br Bromine	36 83.80 Kr Krypton
5	37 85.47 Rb Rubidium	38 87.62 Sr Strontium	39 88.905 Y Yttrium	40 91.22 Zr Zirconium	41 92.906 Nb Niobium	42 95.94 Mo Molybdenum	43 (98) Tc Technetium	44 101.07 Ru Ruthenium	45 102.905 Rh Rhodium	46 106.4 Pd Palladium	47 107.870 Ag Silver	48 112.40 Cd Cadmium	49 114.82 In Indium	50 118.69 Sn Tin	51 121.75 Sb Antimony	52 127.60 Te Tellurium	53 126.904 I Iodine	54 131.30 Xe Xenon
6	55 132.905 Cs Cesium	56 137.34 Ba Barium	57 138.91 La★ Lanthanum	72 178.49 Hf Hafnium	73 180.948 Ta Tantalum	74 183.85 W Wolfram	75 186.2 Re Rhenium	76 190.2 Os Osmium	77 192.2 Ir Iridium	78 195.09 Pt Platinum	79 196.967 Au Gold	80 200.59 Hg Mercury	81 204.37 Tl Thallium	82 207.19 Pb Lead	83 208.980 Bi Bismuth	84 (210) Po Polonium	85 (210) At Astatine	86 (222) Rn Radon
7	87 (223) Fr Francium	88 (226) Ra Radium	89 (227) Ac★★ Actinium															

★ 6	58 140.12 Ce Cerium	59 140.907 Pr Praseodymium	60 144.24 Nd Neodymium	61 (147) Pm Promethium	62 150.35 Sm Samarium	63 151.96 Eu Europium	64 157.25 Gd Gadolinium	65 158.924 Tb Terbium	66 162.50 Dy Dysprosium	67 164.930 Ho Holmium	68 167.26 Er Erbium	69 168.934 Tm Thulium	70 173.04 Yb Ytterbium	71 174.97 Lu Lutetium
★★ 7	90 232.038 Th Thorium	91 (231) Pa Protactinium	92 238.03 U Uranium	93 (237) Np Neptunium	94 (242) Pu Plutonium	95 (243) Am Americium	96 (245) Cm Curium	97 (249) Bk Berkelium	98 (251) Cf Californium	99 (254) Es Einsteinium	100 (255) Fm Fermium	101 (256) Md Mendelevium	102 (254) No Nobelium	103 (257) Lw Lawrencium

Procedures

Take a good look at the periodic table, page 13. Every kind of atom or element known to man is listed here. Some are solid *(Blue)*, some liquid (outlined), some gas. A surprising number are man-made *(Lt. Blue)*.

The first element to be made by man was technetium (43), discovered in 1939 and named from a Greek word meaning "artificial." Can you figure out how the elements after uranium (92) were named? Think of the **ium** as meaning "named after."

All of the man-made elements have been produced at a famous university in the United States. Can you tell which one? Two of the names of elements are a clue.

Elements in the periodic table are arranged by families. Scientists know, for example, that helium and the five elements under it will all be alike in certain ways. (Each is a gas that does not combine chemically with other elements.)

The two newest elements, 104 and 105 (discovered in 1970) are the start of a new "atomic" family with chemical and physical properties different from any elements known before. Scientists expect to discover seven more members of the family in years to come.

A surprising amount of information is packed into each square of the periodic table. Take the uranium square, for example. The large letter (U) is a **symbol** — a kind of shorthand scientists use in referring to an element. The number in the upper left is the **atomic number.** Can you figure out what it represents? (Refer back to your atom models.)

The remaining number is the **atomic weight.** Most of the atomic weights in the periodic table have decimal fractions. To understand them better, round them off to the nearest whole number — 238.03 becomes 238; 92.906 becomes 93. Atomic weights are simply the number of protons and number of neutrons added together. (Electrons, remember, weigh almost nothing.)

If an element has 82 protons and an atomic weight of 207, how many neutrons does it have?

What is the element?

If an element has 20 protons and 20 neutrons, what is its atomic weight?

What is the element?

WATCH THE SHOW! . . . to see the particles given off by radioactive materials.

Materials:

- **old watch or clock dial with luminous paint on it. (Newer models which use substances that merely store light will not work.)**
- **magnifying glass with ten power or more strength.**
- **cardboard tube approximately 10 inches long and 1½ or more inches in diameter.**
- **black paint.**
- **paintbrush.**
- **knife or scissors.**

It's easy to watch radioactive atoms break down with a magnifying glass (10 power or more) and an old luminous watch or clock dial.

Procedures

Move into a dark room and allow your eyes to adjust to the dark (5 to 10 minutes). When you can easily see the dial of the clock or watch,

Using the periodic table, see if you can fill out the following chart:

Element	Symbol	Atomic Number	Atomic Weight (rounded off)	No. of Protons	No. of Electrons	No. of Neutrons
Helium						
Carbon						
Cobalt						
Radium						
Plutonium						

use the magnifying glass to examine the glowing surface. You should be able to see many small flashes called **scintillations.** The light flashes you see are given off whenever a particle thrown out by the unstable radium strikes another chemical in the paint.

You may wish to construct a **spinthariscope.** First paint the inside of a cardboard tube black. Then mount the luminous dial at one end of the cardboard tube with masking tape. You will have to experiment to determine how long the tube should be to get a sharp image through the magnifying glass. Start with as long a tube as possible (up to 1½ feet) and reduce the length of the tube by stages until you secure a sharp image.

Rays and particles given off by radioisotopes in the process of becoming more stable can be detected by Geiger counters and other devices also. This makes radioisotopes very valuable as tracers.

SIMULATION OF RADIOISOTOPES . . . to describe the action of radioisotopes by observing the effect of colored water on a porous product.

Materials:

- **stick of celery.**
- **small amount of vegetable dye.**
- **pan or jar of water.**

Procedures

Place a stalk of celery in colored water. Observe for a day or two. What happens?

If radioisotopes were used in place of the dye in the water, what could you tell by keeping track of the radiations?

What are some ways radioisotopes are being used as tracers? List them.

Carbon Dating

As long as something's alive —
Carbon fourteen thrives inside
But when that thing decides to die,
Carbon fourteen says bye bye.

But shed no tears
It takes him years
But shed no tears
It takes him years and years and years.

The steady decaying, while he's waiting
Gives us radioactive dating
Old or new or in the middle
Fourteen C can solve the riddle.

MORE THINGS TO DO

- See if you can find out how radioisotopes are being used in a nearby hospital or medical lab. Perhaps a doctor could talk to your class or club on how radioisotopes are used to diagnose and treat disease.
- Atomic energy is often in the news. Make a scrapbook of newspaper stories and magazine articles on atoms including isotopes and how they are being used today.

Find the Element

Can you find the names of at least 50 elements in this puzzle? The names may be written forward, backward, up, down, or diagonally. Circle each element as you find it. Have fun! (Answer on page 30).

```
C N C U R I U M A R G O N A B I T C Z P
A O D H A H N I U M O P O S E R I D I L
R N M U I R O H T S L M R M U I N A R U
B E A S D F F D Q W D S I C C D H E C T
O X Y G E N E N I R O U L F N I S L O O
N O C I L I S C R U T H E N I U M O N N
O I M U I M O R H C M Y T I Z M A E I I
T I T A N I U M R T S U L P H U R N U U
P D G R O P K E S E N A G N A M Y I M M
Y C H L O R I N E M U I M D A C P O B N
R W E B B G B A R I U M N E G O R D Y H
K S O R O N E O S B Y R L L M P O I B M
F E I M I R O N O B E L I U M P S N P U
M H E L I U M N D M U I S E C E N E O N
U W E R V T M R I U E N I M O R B L H I
I G S E L E N I U M R M A G N E S I U M
C C I N E S R A M O P A M E R C U R Y U
L I T H I U M S A M U I F S T M I O N L
A T R E N I C K E L S Y N O M I T N A A
C O B A L T M U I D N I V A N A D I U M
```

HOW DO YOU LIVE IN THE NUCLEAR AGE?

Nuclear energy is here to stay. Man must learn to harness it and put it to use to benefit man. What problems are created by this new energy source?

1. Do the results of carbon dating tend to cast doubts upon the validity of religious history?
2. Radioactivity provides at least the possibility of genetic alteration. What are your feelings about altering by design the physical, mental, and personality characteristics of man and animals?

4

Show 4 . . . . 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 effect on chromosomes, chickens, and irradiated seeds.

Radiation is nothing new. Primitive man was exposed to it just as we are today.

Natural radiation is all around us. Where does it come from? Some radiation occurs naturally on earth, thrown off by such elements as radium and uranium. Most of it, however, is showered down on us from outer space. (Our sun is actually a huge nuclear reactor — probably one of many in the universe.) This cosmic radiation is so strong that on a bright sunny day you can get a sunburn even though the sun is millions of miles away and our atmosphere acts as a shield to protect us.

As anyone who has had a sunburn can tell, radiation affects living things. Radiation disrupts body cells as it passes through living tissue. Our bodies can tolerate background radiation and other small amounts of radiation quite well. But as the "dose" or the length of exposure increases, the damage can be enough to cause sickness or death.

Natural Radiation

Natural radiation, we get it from the earth, the stars, the sun.
Background radiation, it's been here since time began.
Most gets caught in the atmosphere, but some finds its way right down here.
Some bounces off, some goes right through,
It won't turn you pink and it won't turn you blue.

Natural radiation, you get it while on vacation
Background radiation, you get it in moderation.
It fell on the ape-man and ancient Chinese,
They didn't even know there was a cosmic breeze.
So radiant energy doesn't scare me.
Not by a long shot, no sir-ee.
It fell on the Greeks, and they didn't mind,
It's falling on me and I feel fine.
So the idea of radiation doesn't scare me, not a chance, no, not me.

Natural radiation, you get it while on vacation.
Background radiation, you get it in moderation.
Natural radiation, Natural radiation, Natural radiation, Natural radiation.

RADIATION IN THE AIR? . . . to detect with photographic film the presence of radioactive materials in your home.

Materials:

- **several 6-inch lengths of ordinary roll film wrapped in black paper or several sections of Polaroid film (preferably 3,000 speed type 57).**
- **one 6-inch square of used furnace filter. (Do not remove the dust.)**
- **one ink roller, rolling pin, or hard straight edge at least 4 inches long, (if Polaroid film packs are used).**
- **access to a color television set.**
- **three pieces of aluminum foil, half the size of the film.**

Are there radioactive particles in the air of your house?

Procedures

Cut out a 6-inch square of used furnace filter. Don't remove any dust — the more dust the better. Lay the section of furnace filter over a piece of film wrapped in black paper. Leave the furnace filter laying over the piece of wrapped film or piece of Polaroid film for 24 to 48 hours.

Develop the film. To develop the Polaroid film, place an ink roller, rolling pin, or hard straight edge at the point marked on the back. With one motion, push to the other end. Wait 10 seconds or as long as the instructions indicate. Open the pack and strip off the developed plate. "Fix" with the sponge that comes with the film.

If radioactive particles are present in the furnace filter, they will penetrate the film pack or wrapper, leaving dark spots on the negative or white spots on the film.

In recent years, quite a few news articles have been written about the radiation dangers of certain color television sets. To check your television set for radiation, tape the wrapped film or Polaroid film on various parts of the set. Be careful to avoid those places where heat from the set could cause the film to catch fire.

If the film shows exposed areas after it has been left on the television set for 24 to 48 hours, repeat the experiment using two or three layers of aluminum foil over half the film. If the film under the foil is exposed, be sure to suggest to your parents that they have the television set checked for excessive radiation (X-rays).

TESTING FOR RADIOACTIVITY . . . to use an electroscope to check the radioactivity of materials.

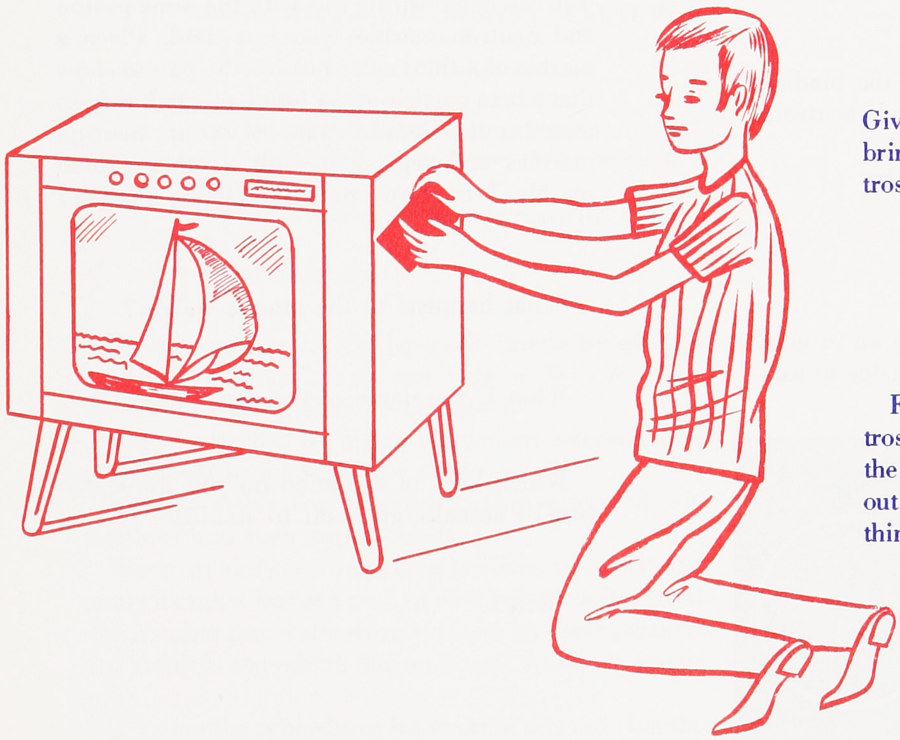
Materials:

- **piece of wool and silk at least 2 inches by 2 inches.**
- **electroscope. (You can use the one you made earlier.)**
- **radium-dial watch or some other radioactive material.**
- **balloon.**

Marie Curie was a student of Becquerel's and wondered whether other substances might be radioactive, also. With her husband, Pierre, she carefully broke down and analyzed the ore from which uranium is obtained. After months of hard work the Curies discovered two new elements, **polonium** (which Marie named after her native country, Poland) and **radium.** The Curies used an electroscope to check radioactivity. You can do the same.

Procedures

Bring a radium-dial watch or some other radioactive material near an electroscope charged with an inflated balloon rubbed with wool. What happens? Does the electroscope discharge at the same rate as or faster than when left alone?



Give the electroscope a positive charge and bring the radioactive material near the electroscope. Check the rate of discharge again.

From what you know about ions and electroscopes, can you figure out anything about the particles the radioactive material is tossing out? Do they carry a charge? Why do you think so?

THREE KINDS OF RADIATION . . . to be aware of the differences in the emissions of three different kinds of radioactivity.

Materials:

- **seven marbles of one color.**
- **eight marbles of a second color.**
- **one marble of a third color.**
- **shallow pan with slanted edge.**

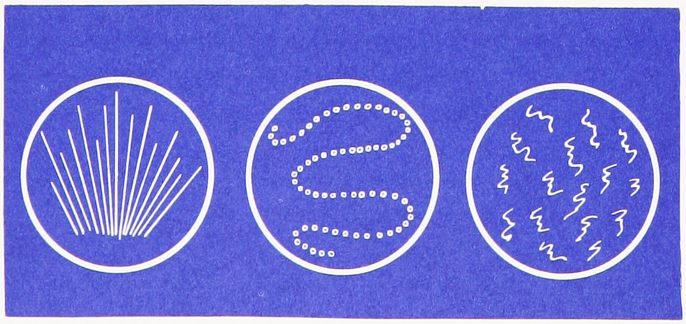
Scientists now know that an atom in the process of breaking down can give off three kinds of radiation — alpha particles, beta particles, and gamma rays.

Alpha particles consist of two protons and two neutrons, identical to a helium nucleus. The scintillations you watched with a magnifying glass or spinthariscope as a part of the activities in the last show were **alpha particles** in action. An alpha particle carries a positive charge. Why?

Beta particles are electrons. The beta particle or electron is not from the atom's outer orbit. It comes instead from the nucleus! A neutron breaks down into a proton and an electron. The electron or beta particle is tossed out along with some of the binding force (gamma rays) that kept the neutron together. What charge must beta particles have?

Gamma rays are pure energy, some of the binding force that keeps an atom's protons and neutrons together.

All of these kinds of radiation ionize the air around them. This allows the charge on an electroscope to leak off faster than it ordinarily would.



Alpha Trails Beta Trails Gamma Trails

Procedure

To demonstrate alpha particles, place 6 proton marbles in a shallow pan. Place 8 neutron marbles in the same pan. This happens to represent the radioactive form of a common element. What is the element?

What is the atomic weight of this isotope?

Remove enough protons and neutrons to represent an alpha particle. What element is left?

What is the atomic number?

What is the atomic weight?

When radiation is given off, one element actually changes into another element of nearly the same size. This process is called **radioactive decay.**

A different kind of radioactive decay takes place when an atom gives off a beta particle. You can demonstrate this with the same proton and neutron marbles you just used. Place a marble of a third color outside the pan to show that a beta particle and a bit of energy has been tossed out. Remove one of your neutron marbles and replace it with another proton marble. What happens to the atomic number?

What happens to the atomic weight?

What is the name of the new element?

Which kind of radiation do you think carbon-14 actually gives off to stabilize?

Why?

MAKING A CLOUD CHAMBER . . . to construct a cloud chamber and use it to see emissions from radioactive material.

Materials:

- **small, wide-mouth jar such as a quart canning jar or large salad dressing jar.**
- **black cloth or paper cut to fit the bottom of the jar.**
- **one-half inch strip of wool or blotter long enough to fit around the inside of the jar.**
- **rubber cement.**
- **methyl alcohol. CAUTION: methyl alcohol or "wood" alcohol is poisonous. DO NOT INHALE THE FUMES. You can also use shaving lotion with a high alcohol content or spirit duplicator fluids containing methyl alcohol.**
- **four-inch square block of dry ice. (CAUTION: Do not touch with bare hands.)**
- **cotton pad at least 4 inches square.**
- **cake pan.**
- **radium painted dial or some other radioactive substance which can be placed in the jar on its side.**
- **sheet of glass large enough to cover the top of the jar.**
- **strong flashlight.**

Would you like to see the tracks made by different kinds of radiation? You can with a **Wilson cloud chamber** (named after its inventor).

This device has been one of modern science's most useful tools in studying the atom.

The air inside the chamber is first saturated with moisture and then supercooled.

When an alpha particle, beta particle, or gamma ray comes along, it leaves a path of charged particles. Inside the chamber tiny water droplets form on these particles. The result is something like a jet trail, but on a smaller scale.

Here are the procedures for making a cloud chamber which you can use to see for yourself.

Procedures

Lay a piece of black cloth or black paper flat on the bottom of a jar. Cement the strip of wool or blotter to the jar, just under the inside rim. Place the jar on top of a 4-inch square block of dry ice. (Caution: Don't touch dry ice with bare skin!) Place the dry ice on a cotton pad in a cake pan.

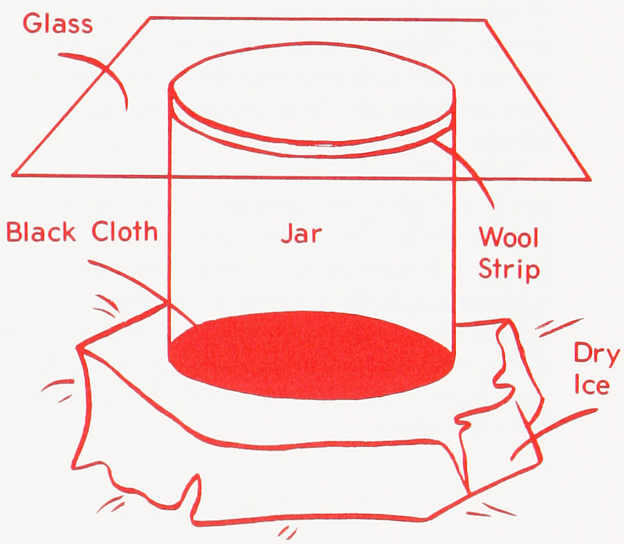
Saturate the cloth with alcohol at the bottom of the jar and the ring of wool at the top.

Place a radium-painted dial or some other radioactive substance on one side and face toward the center of the jar. Cover the jar with a sheet of glass. Turn out the lights and shine a strong flashlight beam through the side of the jar. At first you will see a light mist of alcohol drops near the bottom. Eventually you should see white streaks (alcohol cloud) which seem to come from the radioactive material.

Are all the streaks about the same size and length?

Do they all seem to come from the radioactive material?

Do they resemble any of the illustrated tracks?



Creatures Hurrah

Let's hear it, hey, for the creatures.
They are mankind's greatest teachers,
Who've told us all that they possibly can
About how radiation might affect man.
They taught us that too much too quick,
Can make you oh so sad and sicker.
They taught us that too much too quick
Will kick away your ticker in a flicker.

There are simple diagnoses for radiation overdoses
But a little bit overtime, doesn't have to be a crime.
Radiation will tap the tender oft,
So don't let the rays hit you on the soft.
It's the soft, not hard, that starts to quiver,
A tooth is tougher than a liver.
And even too much doesn't mean the end,
What you got and how you got it, it will depend
On just how fast your body will mend,
So even too much doesn't mean the end.

RADIATION AND LIVING THINGS . . . to examine the effects of radiation on plant seeds.

Materials:

- **irradiated seeds. (Ask your science teacher or county Extension agent where to obtain these seeds if they are not available locally.)**
- **normal seeds of the same variety as the irradiated seeds.**
- **two pots of soil or access to a small area of ground in your yard or garden.**

Alpha particles, beta particles, and gamma rays invade and disrupt living cells. This can be very harmful to man. Gamma rays can penetrate right through a person's body, destroying cells in its path. Alpha and beta particles do their greatest damage if taken internally.

Being able to kill cells with radiation can be useful if you're a doctor, for example, trying to get rid of unwanted cells. See what you can find out about radiation treatment for cancer. Also find out how the surrounding healthy tissue is protected.

Radiation is especially dangerous to developing forms of life such as human embryos or seeds. Unexpected changes or **mutations** can result. You may wish to try this experiment.

Procedures

Plant some irradiated seeds in one pot or part of a garden and some normal seeds for control in another pot or part of a garden.

Water the seeds. Be sure they have enough sunlight to develop. See what grows from your irradiated seeds and what grows from the normal seeds.

MORE THINGS TO DO

- Persons who work around radioactive materials often carry dosimeters. Your civil defense director may be able to show you one. Find out how they work and how they resemble an electroscope.
- X-rays and gamma rays are not the same, but they both affect living cells. Find out what you can about X-rays. Why are they called X-rays? Ask your dentist to explain his X-ray equipment including any shielding materials used. Perhaps you can visit an X-ray lab.
- Radiation — Here's a game you can play by yourself or in a group. Start with the word, "radiation," and then try to think of another word (associated with the atom) that starts with the last letter of the word just used. For example:

  Radiation
  Nucleus
  Shelter
  Roentgen

Got the idea? Go! See who can get the longest list.

HOW DO YOU LIVE IN THE NUCLEAR AGE?

Nuclear energy is here to stay. Man must learn to harness it and put it to use to benefit man. What problems are created by this new energy source?

1. Has the level of radiation gone up since 1945? Where can present-day readings be obtained or information about past readings?

2. No healthy animal or plant is ever helped by radiation. How should decisions be made as to when X-rays should be used in the human body?

3. What mutations have been discovered and what is their significance? Their economic impact? What would they mean to man? Who has the right to bring about mutations in plants, animals, or humans?

4. What are the arguments for and against the sterilizing of insects for disease control?

Show 5 . . . . SOCIETY AND THINGS NUCLEAR

Show Preview

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

World War II was just starting when Otto Hahn and Lise Meitner sent messages to fellow scientists that the atom had been split. So it happened that the first use of nuclear energy was in the form of two bombs, far more destructive than any used before. One was dropped by our country on the Japanese city of Hiroshima, August 6, 1945. We dropped another three days later over Nagasaki. Both cities were practically leveled.

This was our introduction to the nuclear age and it was a frightening one. We saw the bad side first. However, we learned an important lesson: to live securely in the nuclear age and to enjoy its benefits we must understand its dangers and guard against them. Nuclear accidents — even nuclear warfare — are possibilities with which we must live. To survive, we need to be able to protect ourselves, our families and our communities. That protection is called civil defense.

FALLOUT — THE GREATEST THREAT

. . . to be aware of the distribution of fallout materials downwind from a nuclear bomb explosion.

Materials:

- **map of the United States.**
- **baking soda.**
- **information as to the direction upper winds are blowing (500 millibar map).**

When a nuclear bomb explodes at or near ground level, it forms an enormous fireball. The heat and energy are so intense that everything for miles around is pulverized. All of this pulverized dirt and debris is swept up into a huge mushroom-shaped cloud. There it becomes radioactive.

When the cloud cools, this great amount of radioactive dust comes back to earth as fallout. Some drops on the blast area, but the rest is carried along by the winds to fall as a shower of deadly radiation on other places.

Fallout has been called the greatest threat to the greatest number of people. Millions of people could be saved if protected from its radiations.

You can demonstrate how fallout can affect a very large area. Here's how.

Procedures

Find out from your local weather station, newspaper, or radio weather report which direction the upper winds are blowing. Northwesterly winds, for example, blow from the northwest. You might want to try the experiment on different days. Each time you do the experiment, use whatever direction the wind is coming from that day.

Imagine that a nuclear explosion has taken place over your community. Locate the area of your community on the map of the United States and hold a pinch of baking soda between two fingers directly over it. Now, rub your fingers together to release "fallout," at the same time moving your hand in the direction of the wind.

How large an area did your hand pass over before the baking soda was all gone?

How did the amount of fallout change as you moved downwind?

DISTANCE CAN HELP . . . to understand that distance from a radioactive source reduces the effect of radioactivity.

Materials:

- electroscope.
- balloon.
- wool or nylon, each piece at least 2 inches square.
- radioactive source such as a radioactive watch or clock dial.

Procedures

Charge the electroscope with the inflated balloon after it has been rubbed with the wool or nylon. Place a radioactive material very close to the electroscope and notice how long it takes for the foil leaves of the electroscope to come together.

Now recharge the electroscope and repeat the experiment several times, moving the radioactive material farther away each time.

What happens?

What do you conclude?

Would you say that distance can offer protection from a radiation source?

SHIELDING IS IMPORTANT . . . to be aware that some substances provide more shielding than other substances against radioactive emissions.

Materials:

- electroscope or Geiger Counter.
- assistance of your civil defense director or someone who has access to radioactive materials which can be used in educational programs for youth under 18 years of age.
- paper, 8½ inches by 11 inches.
- wood at least 4 inches by 6 inches in size and approximately 1 inch thick.
- copper bottomed pan or sheet of lead.

During and after fallout, being underground (away from the fallout at ground level) can help cut down on the amount of radiation a person receives. Moving to the inner parts of large buildings, away from windows and doors, can lessen the radiation dose, too.

The ground and the structure of the house or building act as shields from the radiation. You can use the procedures in this activity to demonstrate the effect of shielding.

Alpha particles are slow and heavy and can be stopped by a piece of paper or outer skin. Beta particles are much smaller and faster and can penetrate several layers of clothing or a ½-inch thickness of wood. Gamma rays are highly penetrating and destructive. It takes several inches of lead or a foot of concrete to stop them.

Procedures

Ask your local civil defense director or someone else who has access to radioactive materials which can be used in educational programs for youth under 18 years of age to help you with this project.

Observe what happens when various radioactive materials are brought near a charged electroscope or Gieger counter. Next observe what happens when the electroscope or Geiger counter and the radioactive source are separated by materials of different densities. Try such things as a piece of paper, wood, copper bottomed pan, or sheet of lead.

What do you conclude?

Main Title

In today's game of life you just gotta know
Just get it together, think, plan, then go
Atomic age and baseballs the same,
To win you learn to play the same game.
With knowledge and judgment,
No one gets hurt, provided that we stay alert.

Some folks believe the atoms all bad
Yes, one use, real use, is sad, but it need not be
Just you read history. We used to be afraid of electricity
Yes we used to be afraid of electricity.

FINDING PUBLIC SHELTER . . . to determine the location and components of a public shelter.

Materials:

- **paper and pen or pencil.**
- **information about the location of the nearest public fallout shelter.**
- **access to the nearest public fallout shelter.**

Survey your community or area for public fallout shelters. Perhaps you can visit one with your civil defense director. Draw a map of how to reach the nearest public shelter from your home.

What kinds of provisions are included in a public shelter?

Does your school have a shelter area? If so, you and other members of your club or class might want to study the space and supplies provided and make suggestions for any needed improvements. If your school does not have a public shelter area, is there a good place in the building for one? If not, draw a map showing the way from your school to the nearest public shelter.

INSIDE A SHELTER . . . to determine the materials which would be required for living two weeks in a fallout shelter.

Materials:

- **pencil and paper.**

Nothing can destroy radiation — except its own rate of decay. Once an atom has given off rays and particles and becomes stable, it is no longer radioactive. This is important to remember for protection.

Some radioisotopes decay in seconds — others take thousands of years. On an average, however, the largest amount of radioactive fallout will have decayed within two weeks after an attack. This means that being able to stay in a fallout shelter for a long enough period of time could make the difference between life and death.

How well could your family live for two weeks in a shelter area? Would there be enough food and water? Would there be first aid supplies? Would there be bedding and clothing? Would there be sanitation supplies? Would there be games or other activities to keep you busy?

Procedure

Look at the suggestions below. Then discuss with your family what would be needed for a two week stay in the shelter and make up a list of shelter provisions needed.

Shelter Suggestions

Water — Plan ½ gallon a day as a bare minimum for each member of the family for eating and food preparation. Juices and other liquids can help meet this need.

Food — Choose foods that keep well, need only a little preparation, and meet all your body needs. They should also be foods your family likes! Examples: canned meats, fruits, and vegetables; cheese, meals-in-a-can such as stew; crackers, cookies, and canned breads; jams, jellies, and peanut butter; instant foods such as juice powders, dehydrated milk, powdered coffee and bouillon; salt and other seasonings and sugar.

Clothing and Bedding — Be sure to consider a variety of weather conditions. It may be cold and there may not be heat, though heat and humidity will be a larger problem most of the year in the United States. Consider possible temperature extremes for your area.

Medical and First Aid Supplies — A good first aid kit isn't enough. First aid supplies should include special medicine and dietary foods needed. Could wounds or illness be treated over a period of time? Does anyone need special medicine?

Personal Care and Sanitation — This includes soaps, combs, toothbrushes, and other good grooming aids. You'll also need pails, plastic bags, and other items for disposing of wastes and garbage. Should you consider some protection against germs?

Utensils and Tools — What will you eat on and with? How will you repair equipment?

Shelter Life Items — Electricity and other services we take for granted may not be available. You'll need a battery-powered radio (plus extra batteries) and some light source such as a flashlight. Shelter life can be boring. Do you want books, games, instruments, hobbies, record player, and records?

Your List of Shelter Provisions

Shelter Shelter

If you ever hurry to a shelter,
Don't let your brain run you helter, skelter,
Think, then do, yeah, that's the best way,
For you and your friends to come out o.k.
Know what to do and what you will need
Then you will be able to take the lead.
Yeah, why don't you be the expert in your shelter in time of alert.

Interruption Song

Some low level radioactive trash,
May just decay in almost a flash.
So there's really no reason for a big scare,
We might even release it in the air.
But watch out, some of this nuclear garbage stays hot.
Let it loose? Oh, no we simply cannot.
So we seal it up so there will be no release
Then underground in concrete it can decay in peace.

COMMUNITY ACTION . . . to be aware of city, town, or county emergency plans.

Materials:

- **copy of the town or city emergency plan.**
- **visit with the county civil defense director.**

Civil defense today means being prepared to meet community disaster — any kind of disaster. It is people helping people in a time of emergency.

Procedures

Check with your local civil defense agency to see if there is a local emergency plan for the public. If so, obtain a copy, read it, and determine what would happen if there was an emergency in your community. If your club or class is doing this project, invite a member of the city council or county commissioners to tell you what planning has been done for emergencies.

What happens in your community if a tornado or an earthquake strikes?

What happens if your area is flooded — or fire roars through a whole part of town?

In time of disaster, who would be in charge? What would be the role of the Mayor, the Civil Defense Director, Red Cross workers, policemen, firemen, and public works personnel?

More Things To Do

- If you are a member of an older group (preferably high school) play the "Community Response" game. This game simulates some of the problems individuals face when a community is hit by disaster. Each player is given a role in the true-to-life situation. The game can be obtained through your county Extension agent.
- How do people feel about shelters? Take a community survey. Is there a difference between what people **think** is true and the actual facts? Talk over results of the survey with your local civil defense director.
- Make a public shelter sign to display in your club or classroom.
- What is the difference between an "alert" or "attention" warning and an "attack" warning? Perhaps you can get a tape recording of the sounds from your civil defense director.
- If you are a member of a group doing this project, simulate a nuclear disaster situation. Your clubroom or classroom can be the shelter area.

  What would those of you in the shelter do?

  What rules would you make?

  What leadership would you choose?

  What committees might you form?

  How, in general, would you organize and meet the problems of shelter living?

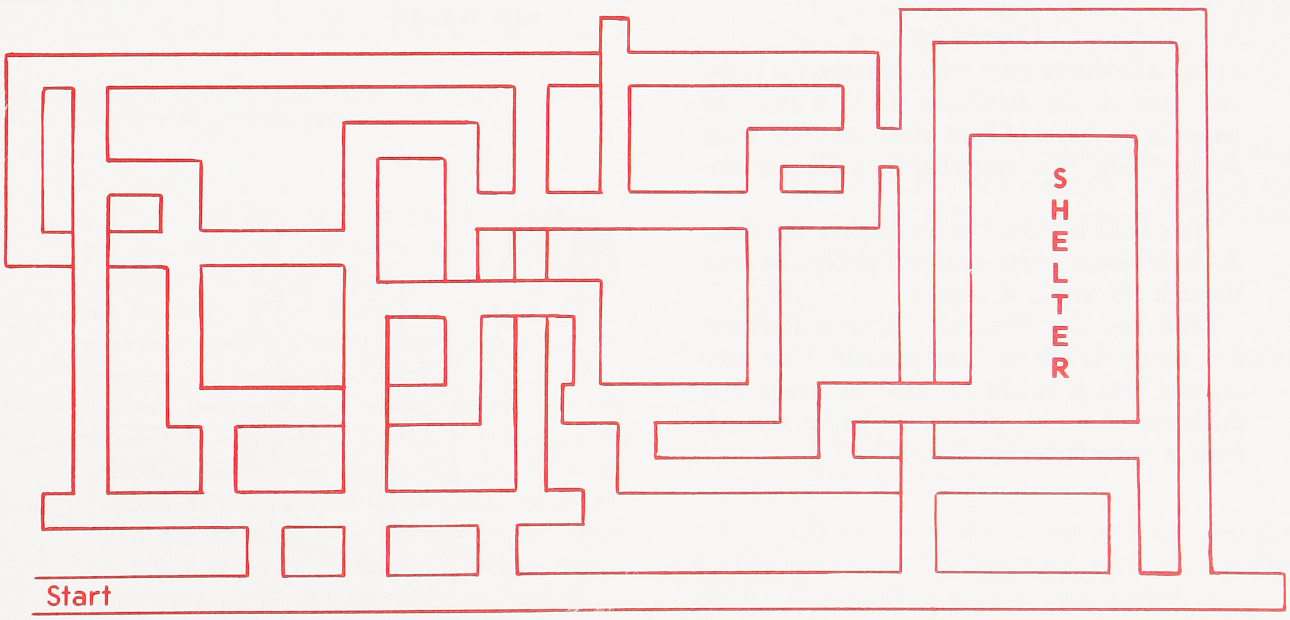
HOW DO YOU LIVE IN THE NUCLEAR AGE?

Nuclear energy is here to stay. Man must learn to harness it and put it to use to benefit man. What problems are created by this new energy source?

1. We know we can save lives through shelters. What are the probabilities of nuclear attack?
2. What can an individual do to implement protective measures of all citizens from radioactive fallout? Should this be a governmental, community, or group effort? What is being done in your community to provide and stock fallout shelter?
3. Would a nuclear bomb ban or civil defense efforts be best for mankind? Can it be an either / or question?
4. With knowledge and judgment . . . no one gets hurt. Is this really true? Is there a possibility that our technology is moving ahead of our judgment (social actions)?
5. Does shelter construction affect these probabilities? Is it urgent and feasible to increase the number of privately built shelters? Consider economic as well as social issues.

Can You Find Your Way to the Public Shelter?

There are at least three ways you can reach the public shelter. Can you find them all?



Show 6 . . . . BOMBARDING THINGS

Show Preview

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

In mankind's long history, no period of time has produced such fantastic scientific advances as the nuclear age. Since 1939 when fission was discovered, man has . . .

. . . used the power within an atom to light cities and run submarines.

. . . bombarded unknown substances with neutrons to solve crimes.

. . . gauged thicknesses by how far a beta particle could penetrate

. . . taken pictures with gamma rays.

. . . used radiation to locate and fight disease, and much more.

Yet scientists predict this is only a sampling of discoveries to come. On college campuses and in other laboratories all over the world, scientists are probing the atom for more secrets . . . more benefits . . . more power. And they expect to find them. The nuclear age has only begun.

BETA PARTICLES AT WORK . . . to understand how radioisotopes are used in industry for gauging or other uses.

Materials:

- **flashlight.**
- **six sheets of paper 8½ inches by 11 inches.**
- **transparent glass bottle or jar.**
- **milk or colored liquid which would fill the glass bottle or jar.**

Procedures

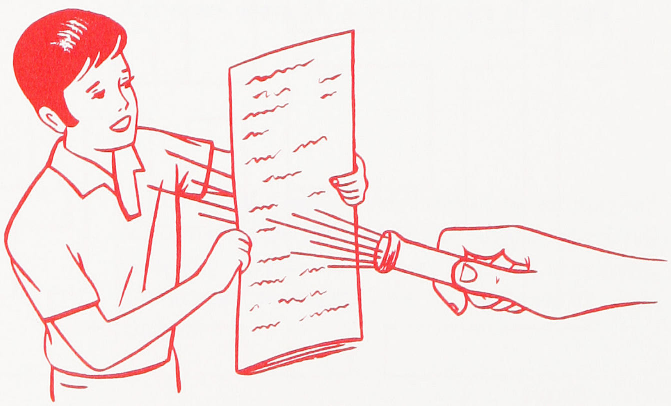
Lay a flashlight on a table. Darken the room and turn on the flashlight. Hold a sheet of paper in the beam of light about one foot from the flashlight. How much light goes through the paper?

Now hold a second sheet behind the first. Add additional sheets until no light can be seen through the stack of papers.

Let's say the flashlight is a radioactive isotope giving off a beta particle. Can you explain how it might be used to gauge the thickness of metal, plastic, or paper coming from a manufacturing plant?

Another demonstration you can try is this: Place a transparent glass bottle or jar on the table. Shine a flashlight through it. Hold a sheet of paper on the side of the bottle opposite the flashlight. Have someone fill the bottle with milk or a colored liquid while you observe the light coming through the paper.

By watching the light can you tell the height of the liquid in the bottle? Can you describe how radiation might be used to operate an automatic shut-off valve for a tank being filled with liquid?



UNDERSTANDING HALF-LIFE . . . to understand the principle underlying half-life.

Materials:
- **one hundred pennies.**
- **box with a lid.**
- **pencil.**

Radioactive atoms **decay** or change into more stable atoms at a steady rate. Every kind of radioisotope has its own rate of decay or **half-life.** This can be useful if you want to find out what an unknown substance is. Simply bombard it with neutrons to make it radioactive and then measure the half-life.

Procedures

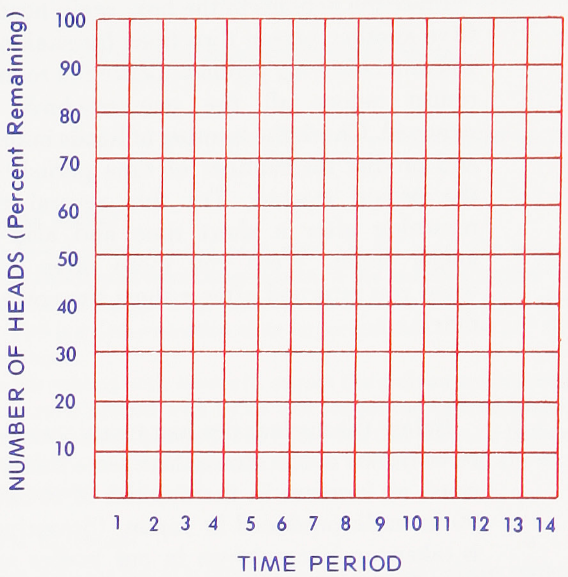
What is half-life? Here's an interesting way to find out. Place 100 pennies, all "heads" up, in a box with a lid. (Time Period 0). The heads represent unstable (radioactive) atoms. Shake the box sufficiently so that each penny has a chance to flip several times. Remove the lid and take out all the pennies showing "tails." Count the number of pennies left in the box and write it down on the Time Period Table (in the Trial 1, Time Period 1 square).

No. of heads	TIME PERIOD (Period of Shaking)								
	0	1	2	3	4	5	6	7	8
Trial 1									
Trial 2									
Trial 3									

Note: If this table doesn't have enough time periods, draw another table with the number of periods you need.

Close the box and shake the remaining pennies. Remove the "tails" and count those remaining in the box. Write down the number in Trial 1, Time Period 2 square. Keep shaking, counting and recording until no pennies are left in the box.

Using the graph in the next column, plot the number of heads that were left in each time period. This is easy to do. If you have 45 "heads" left after the first shaking, put a dot where the 45 (number of "heads") and 1 (time period) lines cross each other. Draw a line connecting all of the points on the graph.



Repeat the experiment two more times, starting each time with 100 pennies in the box. Keep track of the number of heads on the Time Period Table. Mark these numbers on the graph and then connect the dots, using a different colored line for each trial. You should have a graph with three colored lines. The lines should be somewhat similar. Try to draw a line of a fourth color that is an average of the other three lines.

Now think of the number of heads as "percents." Suppose each time period represents two years. What percent would still be in the box after eight years? ________

Two years? ________ Four years? ________

Suppose each time period repesents five days. How many days will it take to have 50% left? ________ 25% ________ 12½% __

Instead of saying "time period", use the term "half-life." Half-life is simply the time it takes for one-half (50%) of a number of radioactive atoms to decay.

PREDICTING WITH HALF-LIFE . . . to understand the predictive value of the principle of half-life.

Materials:
- **one hundred pennies.**
- **box with a lid.**

You can't predict exactly when a certain penny will flip but you can predict how many pennies from a large group will remain in a given time period.

Procedures

Place the pennies in the box, again heads up. Give another person directions for shaking the box and removing pennies. Leave the room and return before all the pennies have been removed. Check the number of heads in the box and predict the number of time periods since the person started. Try this several times, returning after a short time and also after longer times. Were you more often correct when you returned after a short time or a long time?

Before the nuclear test ban treaty was signed, certain tests in the atmosphere were believed to cause an increase in the amount of strontium-90 in milk produced in Japan. (Strontium-90 is taken up like calcium in our bodies and is stored in our bones.) Strontium-90 is radioactive and has a half-life of 28 years. Let the time periods of your graph be 28 years each and answer these questions.

If the maximum strontium-90 level was reached in 1960, what percent of this will be left after 28 years? _________ After 56 years? _________ After 84 years? _________. How old will you be when the strontium-90 has been reduced to 12.5% of the maximum?

FUSION: POWER OF THE FUTURE? . . .

to understand what happens to atoms when fusioned.

Materials:

- **eight marbles of one color.**
- **eight marbles of a second color.**
- **epoxy cement.**
- **scales.**

In the years after developing the atom (or fission) bomb, scientists produced a far more terrible weapon, the H- (or hydrogen) bomb, using **fusion.** In fission, heavy atoms are split apart. In fusion, light atoms are brought together, at the same time giving off enormously larger amounts of energy than happens in fission.

Fusion, however, requires millions of degrees of heat. An atomic bomb was used as the trigger for the H-bomb. Its fission provided the heat.

Procedures

You can make a fusion display using epoxy cement and colored marbles. First glue together 1 proton marble and 1 neutron marble. What element does this represent?

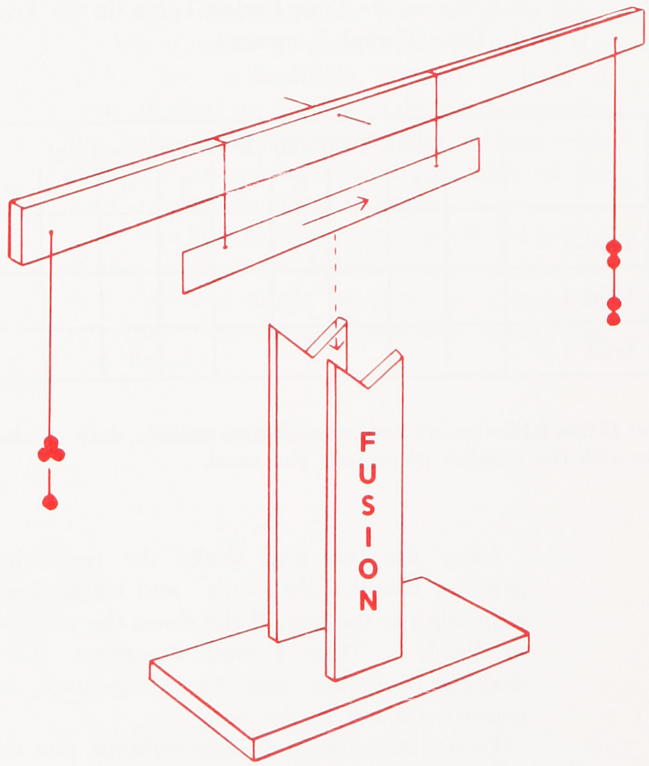
Which isotope?

What is its atomic weight?

Prepare a second marble atom containing 3 protons and 3 neutrons. What is the name and atomic weight of this atom?

Now prepare 2 marble atoms of helium, each containing 2 protons and 2 neutrons.

If you prepare these models carefully (and add a little extra cement to the lithium or hydrogen atom) the first 2 models should be slightly heavier than the 2 helium atoms. Assemble your model as shown in the figure.



Irradiation Waltz

We're radioisotopes, they say we're misfits
Just because we throw off our bits.
So please don't call me a second rater,
'Cause of particles gamma and beta.
Want to shield yourself, you'll do some good,
For gamma some concrete, for beta, some wood.
Alpha will stop at a piece of paper,
Anyone can halt them, alpha and beta.
Gammas aren't poison, they go right on through.
But many are the jobs they can do.
Easing disease and preserving potatoes.
They are my friends, those gammas and betas.
Atoms have pieces and they'll do a trick,
Give up heat and figure how thick.
Sub-atomic particles, they're big operators.
Sub-atomic alphas, gammas, and betas.

Neutron Analysis

An element's atoms are almost the same
When neutrons strike then they play the same game.
They send out gammas of identical strength,
And half will decay in a time of known length.

Neutron activation analysis,
Neutron activation analysis,
Oh the things that we might miss,
Without the revealing neutron kiss.

Analysis of atoms can happen when,
A neutron strikes his silent atom friend.
Then the atom awakes from his stable slumber
And answers out loud with name, rank, and number.

Neutron activation analysis,
Neutron activation analysis,
Oh the things that we might miss,
Without the revealing neutron kiss.

HOW DO YOU LIVE IN THE NUCLEAR AGE?

Nuclear energy is here to stay. Man must learn to harness it and put it to use to benefit man. What problems are created by this new energy source?

1. What are the bases for decisions in the use of nuclear energy?
2. What career fields will be opened or expanded as a result of life in the nuclear age? Which ones will be closed or reduced?
3. What will nuclear power replace?
4. Does the potential of long-time storage of food through irradiation provide the possibility of reducing world-wide hunger? How?

ANSWERS AND DISCUSSION

Show 1 — Discovering the Atom

Static Electricity

The tiny scraps of paper should have been attracted to the balloon.

Charging Matter

The first balloon rubbed with wool should repel the second balloon rubbed with wool because both of the balloons carried the same electrical charge. This causes them to move away from each other. This is a demonstration of an important rule of matter: like charges repel.

A comb rubbed with wool will attract the balloon rubbed with wool. A comb rubbed with nylon will attract the balloon rubbed with wool. Glass or lucite rubbed with wool will attract a balloon rubbed with wool. Glass or lucite rubbed with nylon will attract a balloon rubbed with wool.

Surplus Electrons

Water from the faucet is repelled by the inflated balloon rubbed with wool. This suggests that the running water is negatively charged also, and, therefore, is repelled from the negative charge on the inflated balloon.

Making an Electroscope

Charging the electroscope with the balloon rubbed with wool will cause the leaves of foil to be attracted towards one another. Nothing happens when you touch the disc with your finger. When your finger and the object are removed, the leaves should move apart.

Making an Atom Model

Oxygen needs eight neutrons, the same number as the number of protons and electrons, because the number of protons is relatively small. You should have one electron and one proton in your hydrogen model. Helium should have two protons, two neutrons, and two electrons.

Answers to the Crossword Puzzle

Reading across from the top down:

Einstein
Rutherford
Chadwick
Becquerel
Fermi
Lawrence
Curies
Hahn
Geiger
Roentgen

Show 2 — Power From the Atom

Light elements have a lower ratio of neutrons to protons than the heavy elements. Thus, when a heavy element is split, the two lighter elements do not require the same total number of neutrons.

Chain reactions can be controlled by placing material into the reactor to absorb or slow down the neutrons. Dominoes could be removed in certain places or a block could be placed between a row of dominoes, thus stopping or slowing down the reaction.

If the marble goes too fast, it may bounce out of the pan before disturbing the marbles in the pan. If it goes more slowly, it is not as likely to bounce out of or off the pan. In other words, if the neutron approaches atoms at too fast a rate, the neutron is likely to not be "captured" by the atom. Therefore, it will not disturb the neutrons and protons in the atom as much as will a slower moving neutron.

Scrambled Words Reaction

moderator
coolant
fuel
control
neutrons
heat
power

Show 3 — Radioisotopes

Meet Some Atomic Families

The elements after uranium were named after various individuals or places.

All of the man-made elements have been produced at the University of California in the United States.

A Closer Look

Atomic number represents the number of protons in the nucleus of the atom.

The element with 82 protons and an atomic weight of 207 has 125 neutrons. The element is lead. The element with 20 protons and 20 neutrons has an atomic weight of 40. It is calcium.

The chart on page 14 is completed below.

Simulation of Radioisotopes

The vegetable dye moves into the stalk of celery.

If radiation emissions were counted, you could tell when the material is picked up by the stalk, how fast it travels, where it stops, and if it leaves the plant.

Use of radioisotopes as tracers:

Industry — Locate leaks or blocks in pipelines, check wear on engines, check effectiveness of seal.

Medicine — Diagnose and treat diseases such as brain tumors and thyroid conditions.

Agriculture — Determine effect of fertilizers; when and how to apply fertilizers. Assist in identifying high milk and egg producers. Measure utilization of feed nutrients.

Answers to Find the Element

```
C N C U R I U M A R G O N A B I T C Z P
A O D H A H N I U M O P O S E R I D I L
R N M U I R O H T S L M R M U I N A R U
B E A S D F F D Q W D S I C C D H E C T
O X Y G E N E N I R O U L F N I S L O O
N O C I L I S C R U T H E N I U M O N N
O I M U I M O R H C M Y T I Z M A E I I
T I T A N I U M R T S U L P H U R N U U
P D G R O P K E S E N A G N A M Y I M M
Y C H L O R I N E M U I M D A C P O B N
R W E B B G B A R I U M N E G O R D Y H
K S O R O N E O S B Y R L L M P O I B M
F E I M I R O N O B E L I U M P S N P U
M H E L I U M N D M U I S E C E N E O N
U W E R V T M R I U E N I M O R B L H I
I G S E L E N I U M R M A G N E S I U M
C C I N E S R A M O P A M E R C U R Y U
L I T H I U M S A M U I F S T M I O N L
A T R E N I C K E L S Y N O M I T N A A
C O B A L T M U I D N I V A N A D I U M
```

Show 4 — Radiation and Living Things

Testing for Radioactivity

A radium-dial watch or some other radioactive material brought near a positively or negatively charged electroscope will cause the electroscope to discharge faster than when it was left alone.

Three Kinds of Radiation

Alpha particles carry a positive charge because they are composed of two protons and two neutrons each. Protons carry a plus charge and neutrons are neutral. The alpha particle is a helium nucleus with the electrons stripped from orbit.

Beta particles are negative because they are the electrons stripped from a nucleus. They also come from the breakdown of a neutron into a proton and an electron.

Six protons and eight neutrons represent the element carbon-14. The atomic weight of this isotope is 14.

Removing two protons and two neutrons (representing an alpha particle) leaves four protons and six neutrons. This element is an isotope of beryllium with an atomic weight of 9+.

When carbon-14 emits a beta particle (an electron resulting from a breakdown of a neutron into a proton and an electron) a new element called nitrogen-14 with an atomic number of 7 and an atomic weight of 14 results. Carbon-14 actually gives off beta particles in order to stabilize.

Answers to chart on page 14.

Element	Symbol	Atomic Number	Atomic Weight (rounded off)	No. of Protons	No. of Electrons	No. of Neutrons
Helium	He	2	4	2	2	2
Carbon	C	6	12	6	6	6
Cobalt	Co	27	59	7	27	42
Radium	Ra	88	226	88	88	138
Plutonium	Pu	94	242	94	94	148

Radiation and Living Things

The plants grown from irradiated seeds differ in striking ways from those plants grown from normal seeds. The ways in which they differ will vary from instance to instance and it is not possible to predict how they will differ.

Show 5 — Society and Things Nuclear

Distance Can Help

Radiation loses its energy over distance. This is analogous to the dimming of light as you move from the source. Loss of energy is inversely proportional to the square of the distance (1, ½, ¼, ⅛, 1 / 16).

Shielding is Important

The density (mass per unit of volume) and thickness provides its radiation shielding capability. Thus, a piece of paper is both thinner and the atomic weight of its atoms is much lighter than the copper pan or sheet of lead.

Copper and lead of the same thickness will show lead stopping approximately three times as much radiation as copper because of the atomic weight differential.

Finding Public Shelter

Provisions should be made in public fallout shelters for these items: food, water, medical supplies, sanitation facilities, radiation detection equipment.

Show 6 — Bombarding Things

Beta Particles at Work

The amount of radioactive emissions which penetrate metal, plastic, or paper coming from a manufacturing plant, when the capability of penetration of the radioactive emission is previously known, would tell an interpreter how thick is the metal, plastic, or paper.

Radioactive emissions penetrating a practically filled tank of liquid could be used to operate an automatic shut-off valve by setting it so that the shut-off valve would be actuated when the radioactive emissions fail to penetrate the tank because it has been filled with liquid.

Understanding Half-Life

After eight years, the percentage remaining in the box would be 6¼ percent; two years would be 50 percent; four years would be 25 percent. When each time period represents five days, it will take five days before only 50 percent are left in the box.

Predicting With Half-Life

Fifty percent of the maximum strontium-90 level will be left after twenty-eight years, twenty-five percent after 56 years, and 12½ percent after 84 years.

Fusion: Power of the Future?

One neutron marble and one proton marble glued together represents the element, hydrogen, and isotope deuterium, with an atomic weight of 2.

A marble atom containing three protons and three neutrons represents the element lithium, with the atomic weight of 6.

ATOM DICTIONARY

Alpha Particle — Two protons and two neutrons; a helium nucleus. Carries a positive charge.

Atom — The smallest particle of matter having all the characteristics of an element.

Atomic Number — The number of protons in the nucleus of an atom.

Atomic Weight — The weight of the protons and neutrons in the nucleus of an atom.

Beta Particle — An electron thrown off in radiation.

Civil Defense — Protection for society in a time of emergency.

Cloud Chamber — A container in which the paths of nuclear particles can be observed.

Chain Reaction — A self-sustaining reaction. Atoms that are split with a neutron during fission throw off other neutrons to split other atoms.

Dosimeter — An instrument used to detect radiation.

Electrons — Negative particles orbiting around an atom's nucleus.

Electroscope — An instrument used to detect electrical charges.

Fallout — Radioactive dust and debris that falls back to earth after a nuclear explosion.

Fission — The splitting of an atom into more or less equal parts, creating energy.

Fusion — The combining of very light atoms to create energy.

Gamma Rays — Most powerful and penetrating rays of energy known. Given off in radiation.

Geiger Counter — Device to detect presence of radiation.

Half-Life — Time it takes for one-half of a radioactive substance to decay.

Ion — Electrically charged particle.

Isotopes — Forms of atoms with different weights.

Moderator — Substance used in a reactor to slow down neutrons.

Neutron — A particle of matter in the nucleus of an atom that carries no charge.

Nucleus — The massive central part of an atom.

Proton — Positively charged particle in the nucleus of an atom. Number of protons determines the element.

Rad — A measure of radiation absorbed by the body.

Radiation — Rays and particles given off by unstable atoms.

Radioactive — Describes unstable atoms that are giving off radiations as they decay.

Radioactive Decay — Process by which unstable atoms throw off a part of themselves and change into other atoms.

Radioisotopes — Radioactive forms of atoms.

Reactor — Device used to change matter into energy.

Scintillations — Quick, small flashes of light.

Shelter — A protected area.

Shielding — Materials used to block radiation.

Spinthariscope — Device used to watch sparks of light produced when radioactive substances in certain chemicals disintegrate.

Symbol — Letters used by scientists to represent elements.

Tritium — Form of hydrogen containing two neutrons.

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