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ABSTRACT

This instructional guide, intended for student use, develops the concept of nuclear energy through a series of sequential activities. A technical development of the subject is pursued with examples stressing practical aspects of the concepts. Included in the minicourse are: (1) the rationale, (2) terminal behavioral objectives, (3) enabling behavioral objectives, (4) activities, (5) resource packages, and (6) evaluation materials. Following a development of atomic structure, radiation detection and safety are considered. This unit is one of twelve intended for use in the second year of a two year vocationally oriented physics program. (CP)

CAREER ORIENTED PRE-TECHNICAL PHYSICS

Nuclear Energy Minicourse

ESEA Title III Project

1974

dallas independent school district

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October 8, 1974

This Minicourse is a result of hard work, dedication, and a comprehensive program of testing and improvement by members of the staff, college professors, teachers, and others.

The Minicourse contains classroom activities designed for use in the regular teaching program in the Dallas Independent School District. Through minicourse activities, students work independently with close teacher supervision and aid. This work is a fine example of the excellent efforts for which the Dallas Independent School District is known. May I commend all of those who had a part in designing, testing, and improving this Minicourse.

I commend it to your use.

Sincerely yours,

Nolan Estes

General Superintendent

NE:mag

CAREER ORIENTED PRE-TECHNICAL PHYSICS

NUCLEAR ENERGY

MINICOURSE

RATIONALE (What this minicourse is about)

The constantly increasing demands for energy sources coupled with the necessity for obtaining clean, economical alternatives to our scarce and precious fossil fuels are among the forces which are hastening the development of usable nuclear energy today. While the use of nuclear energy is firmly established in industry, medicine, and agriculture as well as in many types of scientific research, many new and varied applications can be expected in the remaining quarter of the twentieth century. Both professional and technical level jobs are now available and can be expected to increase, in number and in variety.

Before any person can make an intelligent decision as to a chosen life's work, he or she needs to be familiar with as many of the available choices as possible. It also is important for a person who might choose a career in applied nuclear science to understand something about the basic structure of matter and how maximum energy is obtained from this matter. It is the purpose of this minicourse to introduce you to this fascinating study.

Each student will need to keep a folder or notebook containing the questionnaires, observations, charts, and other written work that is called for in this minicourse. This should be neat and complete, since it will enable the teacher to better evaluate your work.

In addition to this RATIONALE, this minicourse contains the following sections:

1) TERMINAL BEHAVIORAL OBJECTIVES (Specific things you are expected to learn from this minicourse)

2) ENABLING BEHAVIORAL OBJECTIVES (Learning "steps" which will help you to reach the terminal behavioral objectives)

3) ACTIVITIES (Specific things to do to help you learn)

4) RESOURCE PACKAGES (Instructions for carrying out the learning activities, such as procedures, references, lab materials, etc.)

5) EVALUATION (Tests to help you learn and to determine whether or not you satisfactorily reach the terminal behavioral objectives) These tests include:

   a) Self-test(s) with answers, to help you learn more.
   b) Final test, to measure your overall achievement.

TERMINAL BEHAVIORAL OBJECTIVES

Upon completion of this minicourse, you will be able to:

1) summarize briefly the outstanding events in the history of man's developing understanding of the atom.

2) use an accepted diagram or model of an atom to name its parts and their relation to one another.

3) operate simple radiation detection equipment.

4) identify and describe the functions and parts of some devices using nuclear energy.

5) list several career opportunities involving nuclear technology in agriculture, industry, medicine, military service, and scientific research.

6) explain the major dangers and the safety precautions they make necessary when radioactive materials are used.

7) list the major points used in debate by both proponents and opponents of additional use of nuclear energy in power generators.

Objective	Activity	Resource Package
ENABLING BEHAVIORAL OBJECTIVE #1: Write a summary of the development of man's knowledge of atomic energy.	ACTIVITY 1-1 Read the section on Atomic Energy-History in any standard encyclopedia or read Our Atomic World, one of the Atomic Energy Commission booklets.	
	ACTIVITY 1-2 Write the answers to questions in Resource Package 1-2.	RESOURCE PACKAGE 1-2 "Questions"
	ACTIVITY 1-3 (Supplemental) If you have not seen it previously, try to see the film from Disney Studio, "Our Friend, the Atom."	
ENABLING BEHAVIORAL OBJECTIVE #2: Name the parts of an atom from a model or drawing and describe the characteristics or function of each.	ACTIVITY 2-1 Complete Resource Package 2-1.	RESOURCE PACKAGE 2-1 "Diagrams of Some Atoms"
	ACTIVITY 2-2 Construct a three-dimensional model of an atom, as directed in Resource Package 2-2.	RESOURCE PACKAGE 2-2 "Making an Atomic Model"
		RESOURCE PACKAGE 2-3 "Periodic Chart of the Elements" and "Alphabetical List of Elements"

Enabling Behavioral Objective	Activity	Resource Package
<u>ENABLING BEHAVIORAL OBJECTIVE #3</u>: Use your school's Civil Defense radiation detection equipment to measure alpha, beta, or gamma radiation from a known laboratory source and from various objects in the environment.	<u>ACTIVITY 3-1</u> Perform laboratory experiment in Resource Package 3-1, 3-2, and 3-3.	<u>RESOURCE PACKAGE 3-1</u> "Detecting Radiation: Background" <u>RESOURCE PACKAGE 3-2</u> "Detecting Radiation: Known Radioactive Source" <u>RESOURCE PACKAGE 3-3</u> "Determining Radiation Levels Around the School"
<u>ENABLING BEHAVIORAL OBJECTIVE #4</u>: Describe the function of the major components of a nuclear reactor and identify these parts on a drawing.	<u>ACTIVITY 4-1</u> Draw, label, and describe nuclear reactors as directed in Resource Package 4-1.	<u>RESOURCE PACKAGE 4-1</u> "Nuclear Reactors"
<u>ENABLING BEHAVIORAL OBJECTIVE #5</u>: Prepare a list of occupations in which a knowledge of nuclear energy is necessary or helpful.	<u>ACTIVITY 5-1</u> Do Resource Package 5-1.	<u>RESOURCE PACKAGE 5-1</u> "Careers and Atoms"
<u>ENABLING BEHAVIORAL OBJECTIVE #6</u>: Describe the danger involved in using radioactive materials in terms of (1) individual health,	<u>ACTIVITY 6-1</u> Do Resource Package 6-1 and 6-2	<u>RESOURCE PACKAGE 6-1</u> "Atomic Safety"

(2) community health, and
(3) environment. Consider both present and future when preparing a list of safety precautions that are necessary when dealing with nuclear energy.

ENABLING BEHAVIORAL OBJECTIVE #7:

Give some of the main points advanced by the major groups that favor the increased use of nuclear energy and those that oppose it.

ACTIVITY 7-1

Learn how some of the people in your community feel about atomic power plants by conducting the survey given in Resource Package 7-1; then bring in the views of the "experts" as you complete Resource Package 7-2.

RESOURCE PACKAGE 6-2

"News Clippings on Safety"

RESOURCE PACKAGE 7-1

"Community Survey"

RESOURCE PACKAGE 7-2

"The 'Experts' Say: Pro and Con"

RESOURCE PACKAGE 1-2

Identify the following people by listing each one's nationality and principal contribution(s) to our knowledge of the atom and of nuclear science:

1. Democritus
2. John Dalton
3. J. J. Thompson
4. Henri Becquerel
5. Ernest Rutherford
6. Wilhelm Roentgen
7. Marie Curie
8. Fredrick Soddy
9. James Chadwick
10. Albert Einstein
11. Enrico Fermi
12. Glen T. Seaborg

Answer each of the following questions in a complete sentence:

1. What occurs in a fission reaction? In a fusion reaction?
2. Which type of reaction is more widely used today? Why?

3. When and where was the first self-sustaining nuclear reactor put into operation?

4. List five ways in which nuclear energy is presently being used.

5. Name at least three possible future uses of nuclear energy that are now being investigated.

RESOURCE PACKAGE 2-1

DIAGRAMS OF SOME ATOMS

The size of an atom, even the largest atom, is so small that man has not been able to see one with existing optical assistance. However, from the behavior of atoms in many different experiments, scientists have been able to make several inferences about their structure. Some of these are:

1. All atoms, from the lightest, which is hydrogen, to the heaviest which occurs naturally, uranium, are composed of subatomic particles.

2. All atoms have a compact central structure called the nucleus, which has one or more protons (positively charged particles) in it.

3. All atoms except hydrogen also have one or more neutrons present in the nucleus. These neutrons have no charge.

4. Negatively charged particles, much smaller than protons and neutrons, move in "orbits" around the nucleus. These are electrons.

5. These electrons are arranged at varying distances from the nucleus in energy levels referred to as "shells."

6. The 92 elements that occur in nature, along with the 11 transuranium elements formed by man in the laboratory, are arranged into a "Periodic Chart of the Elements." An element's position on this chart is determined by the number of protons present in the nucleus. This number is usually indicated in the square on the table along with the chemical symbol for the element.

7. The Atomic Mass Number (AMU) for each element is also found in the square with the letters that symbolize the name of the element. It is approximately the sum of the protons and the neutrons present in the nucleus. Therefore, it is the larger of the two numbers.

8. In drawings and models representing atoms, scale and proportion are not observed; but relative positions of particles and their numbers are shown.

9. Additional subatomic particles, with which we will not be concerned at this time, have been identified and/or postulated. Three new ones were indentified in late 1974.

One of the most frequently used two-dimensional diagrams of the atom was devised by Danish physicist and Nobel laureat, Niels Bohr. When this diagram is used, concentric orbits, or shells, surround the nucleus. If an electrically neutral (balanced) atom is to be shown, there will be one electron (–) in an orbit, or shell, for each proton (+) in the nucleus. The orbits may be numbered, I, II, III, etc. or designated with the letters, K, L, M, N, etc. In either case, orbit I or K is nearest the nucleus and has a maximum of two electrons in it. Each subsequent shell has a maximum number of electrons as shown below:

I or K = 2 electrons

II or L = 8 electrons

III or M = 8 or 18 electrons

IV or N = 32 electrons

V or O = 18 electrons

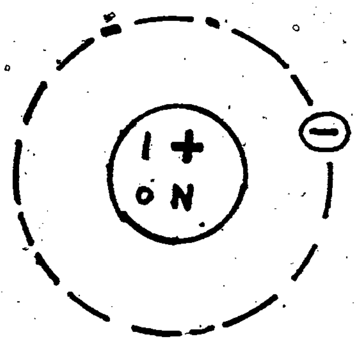
VI or P = 8 electrons

VII or Q = 2 electrons

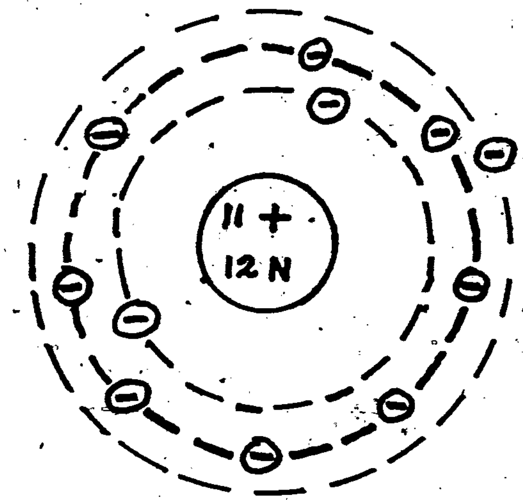
The electrons in orbits nearest the nucleus have the lowest energy levels and are the most stable (most difficult to pull away from the nucleus).

On a piece of notebook paper, copy the drawings below; then make the additional drawings that are requested (refer to Resource Package 2-3 for a Periodic Table of The Elements and a Table of International Relative Atomic Masses).

1) Hydrogen (1 proton, no neutrons, 1 electron)

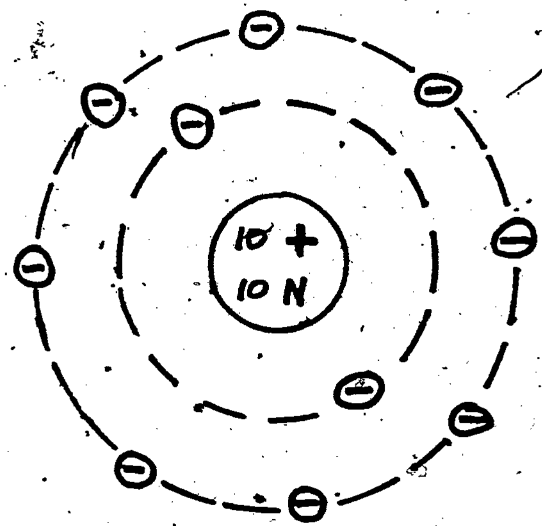


2) On the Periodic Chart (Resource Package 2-3) locate sodium (symbol Na), whose atomic number is 11 (meaning it has eleven protons) and whose atomic mass is about 23 (meaning that protons plus neutrons total 23, ∴ there are 12 neutrons). Since this atom has 11 protons, it will have 11 electrons also. On the following page is another drawing.



Three orbits are required to accommodate 11 electrons. The one lone electron in the third orbit is an indicator that this element may be chemically very active. If you are familiar with sodium, you know that it is.

3) Next, let us look at neon (symbol Ne), which is often used to fill electric light tubes and bulbs. How many protons, neutrons, and electrons does it have? Here it is:



We see the second (outer) shell (II or L), which can hold only 8 electrons, filled to capacity. This is an indicator of low (or no) chemical reactivity. In fact, neon belongs to a group of elements that naturally occur in the gaseous state and whose members are called "inert gases." "Inert" means inactive chemically or not likely to react with other elements.

4) Draw a Bohr diagram of carbon (C). How many shells will it need? Will it probably be reactive with other elements?

5) Draw oxygen (O). How many electrons are "missing" from its outer shell? That is, how many would be needed for that shell to be "full"? We say that oxygen has a valence of -2: it needs two negative particles to have a complete outer shell. Does oxygen combine (react) readily with other substances?

6) Last, draw magnesium (Mg) with only two electrons in the third shell. This third shell (Shell M) can hold up to 18 electrons. This atom is much more likely to combine by "giving up" its two outside electrons. We therefore usually assign Mg a valence of +2.

If you would like practice in writing and balancing chemical equations, ask your teacher for some individual materials to study.

RESOURCE PACKAGE 2-2

MAKING AN ATOMIC MODEL

Use your imagination! And use materials that are available free or very cheap.

First, decide whether you wish to show electrons moving in several different planes or "flattened" out, as they are in the drawings.

Next, choose the atom which you wish to represent. If you choose mercury or uranium, you will be making and/or attaching an enormous number of balls (neutrons and protons).

Then use encyclopedias and science books to get some ideas as to how your model can be most attractively presented. When you have finished, your teacher may wish to keep the models as part of a permanent display.

Some materials that you might use are: styrofoam packing material, old ping-pong balls, marbles or round beads from a broken strand, children's "stringing" beads, cardboard, wire, thread, etc. The list is almost endless. Look around!

PERIODIC TABLE OF THE ELEMENTS

Key: 200.6 — atomic mass; Hg — symbol; Mercury — name; 80 — atomic number

1.008 **H** Hydrogen 1																	4.00 **He** Helium 2
6.94 **Li** Lithium 3	9.01 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminum 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulfur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	88.9 **Y** Yttrium 39	91.2 **Zr** Zirconium 40	92.9 **Nb** Niobium 41	95.9 **Mo** Molybdenum 42	98.9 **Tc** Technetium 43	101.1 **Ru** Ruthenium 44	102.9 **Rh** Rhodium 45	106.4 **Pd** Palladium 46	107.9 **Ag** Silver 47	112.4 **Cd** Cadmium 48	114.8 **In** Indium 49	118.7 **Sn** Tin 50	121.8 **Sb** Antimony 51	127.6 **Te** Tellurium 52	126.9 **I** Iodine 53	131.3 **Xe** Xenon 54
132.9 **Cs** Cesium 55	137.3 **Ba** Barium 56	138.9 **La*** Lanthanum 57	178.5 **Hf** Hafnium 72	180.9 **Ta** Tantalum 73	183.8 **W** Tungsten 74	186.2 **Re** Rhenium 75	190.2 **Os** Osmium 76	192.2 **Ir** Iridium 77	195.1 **Pt** Platinum 78	197.0 **Au** Gold 79	200.6 **Hg** Mercury 80	204.4 **Tl** Thallium 81	207.2 **Pb** Lead 82	209.0 **Bi** Bismuth 83	(210) **Po** Polonium 84	(210) **At** Astatine 85	(222) **Rn** Radon 86
(223) **Fr** Francium 87	226.0 **Ra** Radium 88	(227) **Ac†** Actinium 89	**#** 104	**#** 105													

*	140.1 **Ce** Cerium 58	140.9 **Pr** Praseodymium 59	144.2 **Nd** Neodymium 60	(145) **Pm** Promethium 61	150.4 **Sm** Samarium 62	152.0 **Eu** Europium 63	157.3 **Gd** Gadolinium 64	158.9 **Tb** Terbium 65	162.5 **Dy** Dysprosium 66	164.9 **Ho** Holmium 67	167.3 **Er** Erbium 68	168.9 **Tm** Thulium 69	173.0 **Yb** Ytterbium 70	175.0 **Lu** Lutetium 71
†	232.0 **Th** Thorium 90	231.0 **Pa** Protactinium 91	238.0 **U** Uranium 92	(237) **Np** Neptunium 93	(242) **Pu** Plutonium 94	(243) **Am** Americium 95	(245) **Cm** Curium 96	(245) **Bk** Berkelium 97	(251) **Cf** Californium 98	(254) **Es** Einsteinium 99	(254) **Fm** Fermium 100	(256) **Md** Mendelevium 101	(254) **No** Nobelium 102	(257) **Lr** Lawrencium 103

The most stable known isotopes are shown in parentheses

The discovery of elements 104 and 105 has been claimed by both American and Russian scientists The Americans have suggested the names *rutherfordium* and *hahnium*, the Russians have suggested the names *kurchatovium* and *nielsbohrium*

TABLE OF INTERNATIONAL RELATIVE ATOMIC MASSES

Element	Symbol	Atomic Number	Atomic Mass	Element	Symbol	Atomic Number	Atomic Mass
Actinium	Ac	89	(227)	Mercury	Hg	80	200.6
Aluminum	Al	13	27.0	Molybdenum	Mo	42	95.9
Americium	Am	95	(243)	Neodymium	Nd	60	144.2
Antimony	Sb	51	121.8	Neon	Ne	10	20.2
Argon	Ar	18	39.9	Neptunium	Np	93	237.0
Arsenic	As	33	74.9	Nickel	Ni	28	58.7
Astatine	At	85	(210)	Niobium	Nb	41	92.9
Barium	Ba	56	137.3	Nitrogen	N	7	14.0
Berkelium	Bk	97	(245)	Nobelium	No	102	(254)
Beryllium	Be	4	9.01	Osmium	Os	76	190.2
Bismuth	Bi	83	209.0	Oxygen	O	8	16.0
Boron	B	5	10.8	Palladium	Pd	46	106.4
Bromine	Br	35	79.9	Phosphorus	P	15	31.0
Cadmium	Cd	48	112.4	Platinum	Pt	78	195.1
Calcium	Ca	20	40.1	Plutonium	Pu	94	(242)
Californium	Cf	98	(251)	Polonium	Po	84	(210)
Carbon	C	6	12.0	Potassium	K	19	39.1
Cerium	Ce	58	140.1	Praseodymium	Pr	59	140.9
Cesium	Cs	55	132.9	Promethium	Pm	61	(145)
Chlorine	Cl	17	35.5	Protactinium	Pa	91	231.0
Chromium	Cr	24	52.0	Radium	Ra	88	226.0
Cobalt	Co	27	58.9	Radon	Rn	86	(222)
Copper	Cu	29	63.5	Rhenium	Re	75	186.2
Curium	Cm	96	(245)	Rhodium	Rh	45	102.9
Dysprosium	Dy	66	162.5	Rubidium	Rb	37	85.5
Einsteinium	Es	99	(254)	Ruthenium	Ru	44	101.1
Erbium	Er	68	167.3	Samarium	Sm	62	150.4
Europium	Eu	63	152.0	Scandium	Sc	21	45.0
Fermium	Fm	100	(254)	Selenium	Se	34	79.0
Fluorine	F	9	19.0	Silicon	Si	14	28.1
Francium	Fr	87	(223)	Silver	Ag	47	107.9
Gadolinium	Gd	64	157.3	Sodium	Na	11	23.0
Gallium	Ga	31	69.7	Strontium	Sr	38	87.6
Germanium	Ge	32	72.6	Sulfur	S	16	32.1
Gold	Au	79	197.0	Tantalum	Ta	73	180.9
Hafnium	Hf	72	178.5	Technetium	Tc	43	98.9
Helium	He	2	4.00	Tellurium	Te	52	127.6
Holmium	Ho	67	164.9	Terbium	Tb	65	158.9
Hydrogen	H	1	1.008	Thallium	Tl	81	204.4
Indium	In	49	114.8	Thorium	Th	90	232.0
Iodine	I	53	126.9	Thulium	Tm	69	168.9
Iridium	Ir	77	192.2	Tin	Sn	50	118.7
Iron	Fe	26	55.8	Titanium	Ti	22	47.9
Krypton	Kr	36	83.8	Tungsten	W	74	183.8
Lanthanum	La	57	138.9	Uranium	U	92	238.0
Lawrencium	Lr	103	(257)	Vanadium	V	23	50.9
Lead	Pb	82	207.2	Xenon	Xe	54	131.3
Lithium	Li	3	6.94	Ytterbium	Yb	70	173.0
Lutetium	Lu	71	175.0	Yttrium	Y	39	88.9
Magnesium	Mg	12	24.3	Zinc	Zn	30	65.4
Manganese	Mn	25	54.9	Zirconium	Zr	40	91.2
Mendelevium	Md	101	(256)				

Numbers in parentheses give the mass number of the most stable isotope.

RESOURCE PACKAGE 3-1

DETECTING RADIOACTIVITY: BACKGROUND

Radioactivity, you may recall, was discovered in 1896 by the French scientist, Henri Becquerel, who observed that a photographic plate (film) was clouded and ruined when it was stored near pitchblende, the ore from which radium is extracted. It is now known that radiation emitted by such substances may be of three types: alpha particles, which have little penetrating ability and are easily stopped by a few sheets of paper or a few inches of air; beta particles, which are more penetrating but still can be stopped by thick cardboard or metal, and gamma rays, similar to X-rays, which can penetrate several inches of heavy metal.

If the Grossit All-Color Guide to Atomic Energy, by Gaines, is available in your classroom or library, read pages 10-13 and pages 100-103 at this time.

The detection of radioactivity can still be accomplished by using photographic film. Other methods are more commonly used, however, at this time. In your school there probably is a "Radiological Survey Kit" supplied by the Office of Civil Defense. Get that kit, or other equipment that your school has, examine the equipment, and read the operating instructions that accompany it.

MAKING A BACKGROUND RADIATION COUNT

Purpose: To determine the ordinary level of radiation present (1) in your classroom and (2) on the grounds of your school.

Procedure: Using equipment according to directions supplied with it, expose the chamber of the Geiger tube, connect the head phone to the counter, turn it on, and listen for isolated or occasional "clicks." When you have established that you are hearing these "clicks," prepare to use a stop watch or watch with a second hand to measure short time intervals while you count clicks. Now, select five or more different locations within your classroom. At each, count the number of clicks that occur during a one-minute period. Record these figures on notebook paper using a chart similar to the one below, and average the count. This average will be your "indoor" background count in future exercises.

<u>Results</u>:

	Time (Min.)	Location	No. of Clicks
Trial #1			
Trial #2			
Trial #3			
Trial #4			
Trial #5			
Average			

Secure permission to go outdoors and repeat the data gathering procedure. Record these also. When these counts of your five 1-minute observations are averaged, you will have an "outdoor" background count.

Note: A separate chart should be made for indoor and outdoor observations. If the average time interval is not one minute, then the average time must be divided into the average number of clicks to obtain the number of clicks per minute.

Observations: (Write your observations, guided by responses to these questions, on the sheet with the <u>Results</u> charts.)

Where was the background radiation greatest? Least? Do you think most people are aware that there is radiation around them most of the time? How could you explain the difference in numbers of counts that you observed? Would you be likely to get different counts if several readings were taken at the same location? Why?

RESOURCE PACKAGE 3-2

DETECTING RADIATION: KNOWN RADIOACTIVE SOURCES

In this exercise you will again need to use the Geiger counter and stop watch. You will also need a meter stick or tape, several small sheets (6" x 6") of poster board or thin cardboard (you can try pieces from boxes or tablet backs), and several sheets of metal. Aluminum foil can be substituted for the heavier metal, if none is available. Calipers will be needed to determine thickness of materials.

Secure radioactive samples from your teacher, and be sure that you know the correct methods of handling these.

Purpose: To determine the penetrating characteristics of radioactive particles under a variety of conditions.

Procedure: Make charts like the one shown on the next page for recording the data you accumulate. Plan to make three or more trials using each set of conditions.

Part I. First, expose the open Geiger tube to the sample at the shortest distance at which you can actually count the clicks. Count for one minute (or count for 10 seconds and multiply by 6) and record this as "count" for trial #1. The "transmitting medium" here, of course, is air; and the "thickness of medium" is the distance, in meters, from sample to the surface of the Geiger tube. Make two more trials at the same distance; record and average results. Next, double the distance and make three trials. Then make three final measurements at three or four times the distance apart.

Results: You will need nine or more of these tables. (At least three, and perhaps more, can be placed on one sheet of notebook paper.)

Radioactive Source ______				
Trial #	Transmitting Medium	Thickness of Medium	Count Clicks/Minute	Maximum Meter Reading
1				
2				
3				
Average				

Part II: Use cardboard as the "transmitting medium," with the sample in contact with the cardboard on one side and the Geiger tube on the other. Repeat procedure above, increasing "thickness of medium" by adding sheets of cardboard.

Part III: Do the same thing as in Part II, using the sheet metal or foil as "transmitting medium."

After all data is collected, make three graphs on one sheet of paper, one for each transmitting medium. Label the vertical axis (ordinate) "counts/minute" and the horizontal axis (abscissa) "thickness of medium."

Observations:

1. What material that you used permitted the maximum passage of radioactivity?
2. Which material most effectively blocked that transmission?
3. Do you know of any material that is even more effective in preventing the passage of radiation? What?
4. What type of radiation was emitted by your source(s)?
5. If more than one source was used, which showed the highest penetration?
6. When air was the transmitting medium, were all clicks due to radiation from your laboratory source? Explain this answer.

RESOURCE PACKAGE 3-3

DETERMINING RADIATION LEVELS AROUND THE SCHOOL

Measure and record radiation levels inside and outside the building. The following are some places to check:

-- Outside the building, sunny side, close to wall

-- Outside the building, shady side, close to wall

-- Under electrical transformer or near large electrical equipment

-- Cafeteria

-- Inside hallway

Want to have some fun?

1) Take a radioactive sample along in a student's pocket. Convince a sophomore that the physics student is radioactive.

2) Be very serious about your work. When someone asks what you are doing, begin your reply with these words: "Now, there is absolutely nothing to be concerned about. (Pause.) We are just checking for the presence of radiation."

RESOURCE PACKAGE 4-1

NUCLEAR REACTORS

1) Use encyclopedia, Atomic Energy Commission booklets, and your textbook, to find drawings of several types of reactors. Examine the drawings carefully and read the description of each type.

2) Select two different reactors, sketch, trace, or draw each and label the parts. Each of these drawings should be on a separate sheet of paper.

3) On another sheet of paper, answer the following questions:

A. What are some of the methods and materials used to contain nuclear reactors?

B. What is the function of control rods? How do they accomplish this? Of what are they made?

C. In what <u>form</u> is the energy released in these reactors useful to man?

D. How is the energy usually transferred from the reactor to the machine which it is to run?

E. What are some of the fuels used today in fission processes?

F. What is a "breeder reactor"? What fuels does it use and what advantages does it offer?

RESOURCE PACKAGE 5-1

CAREERS AND THE ATOM

You will now need to go to your school library, or a public library, to learn about the various occupations that are related to nuclear energy. If possible, get the Occupational Outlook Handbook published by the U. S. Department of Labor, and read the topic, "Occupations in the Atomic Energy Field." (If this is not in the library, try your school's I. C. T. * coordinator or the counseling office.) Also, The Encyclopedia of Careers and Vocations Guidance, edited by William E. Hopke, has a good essay entitled "The Atomic Energy Industry." The Atomic Energy Commission booklet, Careers in Atomic Energy, should be available in your classroom.

When you have read the available materials, prepare a chart such as the one on the next page, classifying at least five (and preferably more) occupations in each educational category.

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* Industrial Cooperative Training

CHART OF CAREERS
IN
NUCLEAR ENERGY

Education Required	Job Title	Service	Manufacturing	Research and Development	Other		Work with People?	Work with Plants and/or Animals	Work with Machines	Other		Sounds Interesting	Not Interesting		Good Future	Poor Outlook	
High School Only	1.																
	2.																
	3.																
	4.																
	5.																
	6.																
	7.																
	8.																
	9.																
	10.																
High School Plus Technical Training	1.																
	2.																
	3.																
	4.																
	5.																
	6.																
	7.																
	8.																
	9.																
	10.																
College Degree(s)	1.																
	2.																
	3.																
	4.																
	5.																
	6.																
	7.																
	8.																
	9.																
	10.																

When you have listed the titles of the jobs, check as many columns as apply. Add your own columns.

RESOURCE PACKAGE 6-1

ATOMIC SAFETY

Answer the following questions on notebook paper. You will find the answers in encyclopedias, in your classroom set of A. E. C. (Atomic Energy Commission) booklets, and in Nuclear Power and the Environment, which should be available from your teacher. Also, there should be other books dealing with atomic safety in school and public libraries. Magazines, such as Reader's Digest (June, 1972, page 95), and newspapers (copies of two clippings are in Resource Package 6-2) also provide much up-to-date information and varied opinions about atomic safety.

1) What are some units in which nuclear radiation is measured?
2) In what ways are excessive dosages of radiation harmful to animals?
3) What are some of the natural sources of radiation in the environment?
4) What is meant by "critical mass"?
5) List at least five steps that are taken to assure that no atomic reactor can become a "bomb."
6) What kinds of waste problems accompany nuclear reactors? Tell some of the methods proposed to solve these problems?

RESOURCE PACKAGE 6-2

NEWS CLIPPINGS ON SAFETY

-34-

Sunday, June 23, 1974 The Dallas Morning News.

Habitat

Measuring The Risks

By DOROTHIE ERWIN

No one claims that nuclear power plants can be built at no risk to the public.

The environmental and safety reviews of proposed new plants are intended to accomplish two things: first, to minimize the risk by assuring built-in protections against exposure of workmen and the public to radiation from accidents and routine operation of the plants; and then, to measure that irreducible minimum of risk so that it can be balanced against the promised benefit.

LARGE AMOUNTS of radiation are known to cause cancer and genetic damage. Since the "threshold" of harm from low-level exposure is not known, the conservative assumption must be make by public health protectors that any exposure may be harmful and the risk should not be taken unless there are compensating benefits.

In generating plants, of course, the benefit claimed is the large amount of power that can be produced from small amounts of uranium fuel.

The applicants for the Comanche Peak plant (the three-company system that includes Dallas Power & Light Co.) say the only practical alternative to increase the power supply for their Texas territory is the importation of coal—which they say carries higher costs and environmental risks of other kinds.

IT IS IN THAT context that the Atomic Energy Commission's recent environmental study of the nuclear station at Glen Rose quantifies the risks that can be predicted for the million people living within a 50-mile radius when the plant begins operations about 1980.

Its summary conclusion is that radiation by all pathways from the plant will amount to a tiny fraction of the existing background radiation, producing an increase that is less than the normal fluctuations in the dose this population receives from cosmic radiation, radioactivity in soils and minerals, and other existing sources.

RADIAION CAN reach the public from the plant by three main pathways: from the routine low-level emissions of gases and liquids; from exposure to the radioactive wastes that must be removed periodically and shipped to processing and storage sites up to 1,500 miles away; and from any accidental releases resulting from malfunctioning of the plant.

The biologically-effective dosage of radiation is measured in rems (Roentgen Equivalent in Man) and in millirems (mrems), which are thousandth parts of rems. In the environmental study, final dosage estimates are in man-rems, a summation of whole-body doses to the affected population. (If 1,000 people receive a dose of 1 mrem each or if two people receive doses of 500 mrems each, the total exposure is 1 man-rem).

THUS, SINCE background radiation (excluding any medical exposure) averages about 100 mrems a year in this part of Texas, one million people are receiving 100,000 man-rems here now from natural sources. (On a national average, people receiver 50 mrems or more a year from medical and dental X-rays and therapy.)

Radiation by all pathways from the plant is estimated to add only 15 man-rems a year to that 100,000 man-rems.

AS ANOTHER point of reference, the Federal Radiation Council's recommended limits on exposure from all sources other than background and medical are 500 mrems a year for any individual and an average 10 mrems per year per capita.

The most significance routine radiation doses to the public here will be from emissions of gases and particulates to the air. From these sources, when both reactors of the plant ar operatings, radiation is estimated at less than 5 mrems a year to a person at or beyond the plant site boundary and less than 15 mrems a year to a child's thyroid through the pasture-cow-milk cycle (the humans) from a cow in the nearest potential pasture.

The estimates are based on the experience of other plants and on the planned control systems at Comanche Peak. They assume, of course, that serious accidents in waste handling and in the plant operation will be prevented.

NEXT: Nuclear wastes and accidents.

Habitat

Accident Risk Seen

By DOROTHIE ERWIN

A uranium-fueled power generating plant cannot possibly produce a nuclear explosion. Each of the plants carries with it, however, the remote possibility of a serious accident that would expose the public to radioactivity.

The Atomic Energy Commission has promised sometime this year the final report on a long-running Reactor Safety Study by a team of 50 scientists who were asked to develop "realistic data" on the probabilities and sequences of accidents in water-cooled reactors.

MEANWHILE, IN environmental studies like the one just completed for the proposed Comanche Peak station in Texas, the AEC and the license applicants have tried to quantify the likelihood and predict the consequences of accidents. The texts and graphs for this plant boil down to an "extremely low" likelihood of harmful mishaps at the Somervell County site.

The total dose to the population within a 50-mile radius of the site, from the worst postulated accidents is judged by AEC to be smaller than the dose from naturally occurring radiation (cosmic rays, radioactive rocks and other background sources). When considered along with the probability of such an occurrence, the possible population exposure from all postulated accidents becomes an even smaller fraction of background and "in fact, is well within naturally occurring variations in the natural background," the AEC found.

CONSIDERING eight classes of accidents, ranging from the trivial (small spills or leaks) to the very serious (a loss of coolant in a reactor), the AEC found a possible dose of 410 man-rems to the total population as the result of a Class 8 accident.

This compares to about 100,000 man-rems of natural radiation exposure for the projected population of about 1 million within the 50-mile radius when the plant is in full operation.

(AVERAGE EXPOSURE to natural radiation in this region is about 100 millirems, or .1 rem, per year. A man-rem is a summation of doses to an entire population, not necessarily in equal portions. Federal standards recommend exposure of no more than 500 millirems a year to an individual, in addition to exposure received from background and medical sources, and a national average of no more than 170 millirems per capita.)

The estimates of exposure from the plant at Glen Rose take into account both direct and inhalation doses. They assume that continuous environmental monitoring of the plant would detect any abnormal radiation release promptly so that remedial action would be taken.

A Class 9 accident, involving a hypothetical sequence of failures more severe than Class 8, was judged too remote to consider.

RADIOACTIVE wastes stored for short periods in the site and then shipped to distant AEC burial grounds comprise another potential source of radiation exposure. AEC's estimate of cumulative doses from this source in normal operations is 4 man-rems per year per reactor for the 200 transportation workers involved and 3 man-rems per year per reactor for the general public.

When both reactors at the plant are in operation—projected at 1982 and thereafter 30 waste shipments per year will be required.

SPENT FUEL elements containing plutonium and highly radioactive fission products are stored underwater in tanks for a period of radioactive decay before being loaded into casks for transport.

Wet solid wastes, consisting mainly of filter sludges, spent demineralizer resins and chemical drain tank effluents, also require special shielding and handling and longterm storage.

Before shipment to AEC-licensed permanent disposal sites, these wastes will be combined with a cement-vermiculite to solidify them and will then be sealed in 55-gallon steel drums for 180 days of on-site storage to permit radioactive decay. The total volume of these shipments is estimated at about 800 drums per year per reactor.

In addition to detailed monitoring of all effluent discharged from the plant, the plant operators are responsible for offside monitoring of radioactivity and of any ecological effects it may have. This includes monitoring of fish, river water, groundwater, airborne particulates, river bottom sediment, milk, crops and other vegetation.

RESOURCE PACKAGE 7-1

COMMUNITY SURVEY

INSTRUCTIONS: Ask the following questions of at least 10 people who are out of school and of 5 people who are in school but are not enrolled in physics. Record the responses and tabulate them so that a summary of the opinions of your sample will be easy to see.

1) Do you know what the fossil fuels are?

2) Do you believe that our supply of these fuels from economically feasible sources is running out?

3) Do you think we should reduce any of the following to save fuel?

-- gasoline supplies for automobiles

-- fuel for jet planes

-- electrical generating capacity

-- fuel for pleasure vehicles (boats, motor homes, snow-mobiles, trail bikes, etc.)

-- fuel to power industrial plants

--fuel for heating homes, offices, and stores

4) Do you favor or oppose the building of nuclear powered electrical generating plants? Why? (One or more reasons)

5) Do you feel that nuclear power plants in ships and on land pose a serious threat to human life and health?

6) Do you approve of the medical use of radiation to detect and treat disease?

<u>To the Student</u>: Do you detect any inconsistencies in these answers? Were most people well enough informed to help make a decision? Did younger or older people seem to be more interested? Discuss this with your teacher.

RESOURCE PACKAGE 7-2

THE "EXPERTS" SAY: PRO AND CON

Draw a line in the center of a sheet of notebook paper to divide it into two approximately equal parts. Head one side "Pro," meaning in this case, "for the development of nuclear power." Title the other column, "Con," meaning "against." Now use the resources in your classroom, library, and community to list the major "talking points" in each column. The opinions of people you interviewed in doing Resource Package 7-1 may fit in here.

Do you find more "good arguments" for or against increased use of nuclear power? Phone or visit some of the persons or groups in your community who have a known position on this issue (E. P. A., local electric company, Sierra Club, Audubon Society, city officials, etc.). Learn their views and their reasons for them.

REFERENCES

1) Cooke, David C., How Atomic Submarines Are Made, Dodd, Mead & Co., New York, New York, 1967.

2) Gains, Matthew, Atomic Energy, Grosset and Dunlap, New York, New York, 1970.

3) Hopke, William E., The Encyclopedia of Careers and Vocational Guidance, Ferguson Publishing Co., Chicago, Illinois, 1972.

* 4) Nuclear Power and the Environment, American Nuclear Society, Hinsdale, Illinois.

** 5) U. S. A. E. C., The World of the Atom series and Understanding the Atom series, Oak Ridge, Tennessee.

6) U. S. Dept. of Labor, Occupational Outlook Handbook, B. L. S. Bulletin, 1700.

7) Vierbe, Frank L. and others, Physics, A Basic Science, American Book Co., Dallas, Texas, 1970.

* Free from the American Nuclear Society,
244 E. Ogdon Avenue
Hinsdale, Illinois 60521

** Obtain from U. S. A. E. C.
P. O. Box 62
Oak Ridge, Tennessee 37830

SELF-TEST ON NUCLEAR ENERGY

Answer these questions. Then, check your own answers, using the key which is on the next pages after this test. If your answers are 80% or more correct, you are probably ready to ask your teacher for the final evaluation (test).

1) Using the "Bohr atom," draw a diagram of oxygen (AMU = 16; atomic number = 8). Give the names of the particles that you illustrate.

2) What was (is) the nationality of each of these persons, and what is one of his/her major contributions to our knowledge of atomic science?

A. J. J. Thompson
B. Enrico Fermi
C. Marie Curie
D. Wilhelm Roentgen
E. Ernest Rutherford
F. Albert Einstein

3) Distinguish between "fission" and "fusion," telling generally what takes place, what fuels are used, and what problems are associated with each.

4) Which would be more likely to form compounds readily--an atom that has three electrons in the second shell or orbit, or one that has eight electrons in that shell? Why?

5) What are the three types of radiation detected with the usual survey equipment? Which possesses the greatest penetrating ability? The least?

6) What are some of the sources of "background" radiation? What are other sources of environmental radiation that could become dangerous to living organisms?

7) How are those who must work around radiation protected?

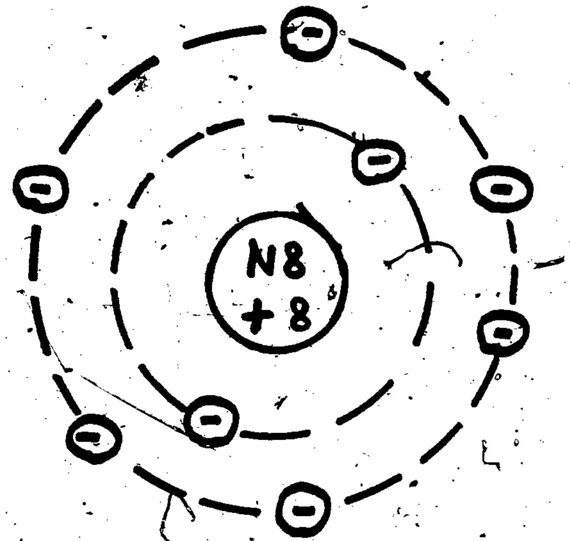
8) Name and describe two nuclear science related careers in each of these categories: requires high school education only, requires high school plus technical training, requires college degree.

9) What is meant by "critical mass"? Why are scientists reasonably confident that no industrial reactor is likely to become a "bomb"?

10) Which two "arguments" do you consider to be the most convincing for the development of more nuclear power facilities, and which two are most convincing "against"?

ANSWER KEY TO SELF-TEST ON NUCLEAR ENERGY

1) Your drawing should look something like this:



2) A. British - identified Electron and many of its properties

B. Italian - made "trans-uranium" element and helped develop the first self-sustaining nuclear reaction

C. French - discovered radium and polonium

D. German - discovered X-rays

E. British - discovered types of radiation and behavior of each and explained this in part with his new understanding of atomic structure

F. German - proposed the idea (later verified experimentally) that matter and energy are really two different manifestations of the same physical reality and expressed this idea in the equation, $E = mc^2$

3) Fission is the "splitting" of the atomic nucleus and is accomplished by accelerating particles into a massive nucleus (uranium, plutonium, etc.)--has been controlled satisfactorily for technical use, but problems remain in accident prevention and disposal of waste.

Fusion is the "putting together" of light nuclei (hydrogen, primarily) that results in the release of energy. Containing reaction at high temperatures and controlling reaction are problems that are still preventing widespread use of this source of power.

4) The atom with three electrons in the outer shell will form compounds more readily because it is less stable.

5) Alpha--least penetrating; beta; gamma--most penetrating

6) Background radiation from natural sources comes from the sun and from the radioactive decay of minerals in the earth. Environmental sources of radiation, other than those natural to the world, include industrial and medical X-ray, electronic devices (including color television sets), and nuclear installations.

7) Lead shielded rooms, protective clothing, and extensive decontamination procedures are used. Also, such employees wear badges that record total dose of radioactivity to give warning when the limits of tolerable radiation are approached.

8) See chart in Resource Package 5-1.

9) Critical mass is that quantity of fissionable material that will support a chain reaction under stated conditions. Fissionable materials are kept in small enough quantities that critical mass is not likely to be reached accidentally. Control rods and elements are situated so that they are inserted automatically into a pile at certain temperatures. They can also be inserted manually in the event of technical difficulty.

10) See Resource Packages 6-1, 6-2, and 7-1.