State of Iowa
1950

PREPARING ELEMENTARY PUPILS for the ERA OF ATOMIC ENERGY

A Source Book
for
Elementary School Teachers

Volume II

The Iowa Plan for the Study of Atomic Energy

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PREPARING ELEMENTARY PUPILS FOR THE ERA OF ATOMIC ENERGY

(A Source Book for Elementary School Teachers)

Volume II

The Iowa Plan for Atomic Energy Education

Issued by the Department of Public Instruction
Jessie M. Parker
Superintendent
Des Moines, Iowa

Published by the State of Iowa

The release of atomic energy constitutes a new force too revolutionary to consider in the framework of old ideas — President Harry S. Truman. *Message to Congress,* October 3, 1945.

CHAIN REACTION

Before

During

FIFTH GRADE CLASS, MR. JAMES WAILES, INSTRUCTOR
CAMPUS SCHOOL, IOWA STATE TEACHERS COLLEGE, CEDAR FALLS, IOWA

IOWA PLAN FOR TEACHING ABOUT ATOMIC ENERGY

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James R. Wailes, Iowa State Teachers College, Cedar Falls

FOREWORD

A little over ten years ago man learned how to release the energy of the atom. His ability to unlock this new and powerful force has produced and is producing a number of attendant social, economic and political problems. It appears reasonable that our schools should be in the vanguard in bringing an understanding of these problems to the American public. In the opinion of the Iowa State Department of Public Instruction, elementary school children are an important part of this public.

The Department of Public Instruction, through the early encouragement of Mr. Robert Blakeley, now of the St. Louis Star Telegram, embarked upon a program called *The Iowa Plan for the Study of Atomic Energy*. Committees were formed to prepare instructional materials all the way from the elementary school to the adult education level. This publication is the result of a rather intensive study of the problem at the elementary school level.

The elementary committee has chosen to emphasize the preparation needed for *successful living* in the era of atomic energy. Although realizing the difficulty of delving very deeply into the scientific aspects of the problem, it has included suggested instructional materials which can be adapted to local situations. Major attention, however, has been given to the building of social understandings and personal traits which seem to be especially important in today's world.

It is the hope of the committee and the State Department that this publication will be used wisely and evaluated in terms of its purpose. This handbook is a pioneering venture on the part of the committee. Theirs has been an honest and laborious effort to prepare a source book for elementary teachers who, through its use, may be stimulated to consider certain phases of atomic energy and its social implications as part of the elementary school curriculum.

Jessie M. Parker
State Superintendent of Public Instruction
Des Moines, Iowa

TABLE OF CONTENTS

GENERAL INTRODUCTION

This publication presents suggestions for teaching about atomic energy (more accurately, nuclear energy) and its related social implications at the elementary school level. *It is expected that some of the materials will be found to be more applicable to the junior high school.*

Some parts of this Iowa Plan have already been tried out in classroom situations. The plan in its entirety, however, makes no effort to present a grade-by-grade or day-by-day program of instruction. Teachers will need to adapt it in the light of their own professional preparation, pupil background, the local curriculum organization, and available instructional materials.

Schools giving emphasis to current events as a part of their social studies program will find it relatively easy to carry out many of the suggestions presented in this handbook. In schools which also have strong science programs, the children should welcome an opportunity to study atomic science and the problems which center in and grow out of it.

The committee members who prepared this publication at first felt that they were exploring in a "desert" of content and instructional materials. Recognizing the importance of the problem, however, they accepted the challenge to discover what could be done with atomic science and its related problems at the elementary level. While they have not found an "oasis" of ideas they have explored far enough to uncover, compile, and refine the materials herein contained.

As a *source book*, this publication should serve a useful purpose. Through its use, elementary teachers should be better able to help their pupils to gain an awareness of the significant things that are going on in this era of Atomic Energy. It is fully expected that this fast-moving age will quickly reveal many ways in which the publication can be improved. The worth of this source book will be attested by the constructive experiences which its use may bring to the elementary classrooms of the state.

The Production Committee
Guy Wagner, *Chairman*

CHAPTER I

A PLACE FOR ATOMIC ENERGY INSTRUCTION IN ELEMENTARY SCHOOL PROGRAMS

INTRODUCTION

Atomic Energy! Shall children in our elementary schools study about it? Is there anything about atomic energy that may become a legitimate part of the elementary school curriculum?

At first thought it appears that the study of atomic energy has no righful place at the elementary school level. Some may ask, "Are you trying to use the atom bomb to frighten children?" If such were the case, the study of atomic energy in our elementary schools would certainly be most tragically misplaced.

But the discovery of how to release nuclear energy has clearly brought the world into a new era. Never before has mankind faced a future so potentially fraught with possibilities for man's advancement or man's destruction. It is said that we are standing on the bridge of time with the question on the lips of every thinking person, "Has the Atomic Age ushered in an era of untold benefits for the human race or one of catastrophe?"

The committee planning the elementary school section of *The Iowa Plan for Teaching About Atomic Energy* is fully aware that it is faced with a most difficult problem—that of thoroughly exploring the area of atomic energy in an effort to discover what, if any, understandings, attitudes, and skills, directly or indirectly related to atomic energy, should be included in the elementary school curriculum. At first, the committee seemed to feel that its explorations would take place largely in a vacuum of instructional and learning materials. On the other hand, the importance of the problem was a challenge that could not be lightly brushed aside.

Fairly early in our study, we found it necessary to accept certain basic assumptions which have guided us in the planning of this report. In a sense, these basic assumptions may be called the philosophy which has undergirded and given direction to the more specific suggestions found later in this publication. Those basic assumptions which have been most instrumental in determining the content and nature of this report follow:

BASIC ASSUMPTIONS

1. *Maturity is not acquired "suddenly" in adult life.* Concepts, attitudes, habits, and skills are learned step by step throughout our childhood and youth. A good educational program will discover as clearly as possible the first age at which children should have certain experiences. These experiences will serve as foundations for continuing the development of related experiences. There are certain concepts, attitudes, habits, and skills, which, if developed at the elementary level, will not only be valuable in themselves and thus make a wise use of the children's time—they will also serve as necessary foundation experiences for atomic energy learnings at the high school level.*

*This idea is taken in part from Ligon, Ernest M., A Greater Generation, Macmillan, New York, 1948, P. 34.

2. *Premature educational experiences are frustrating and may have a crippling effect upon the individual.* Consequently, one of the aims of this committee will be to caution against pushing down to the elementary school level that subject matter which would be more efficiently learned at a later age. Those who plan the curriculum for elementary school children should always keep in mind Herbert Spencer's question: "What knowledge is of most worth?"
3. *Children of the same age vary widely in their capacity to learn.* Consequently, teachers will need to adapt atomic energy instructional materials and activities to the capacities, achievement levels, and interests of the children.
4. *As a general rule, elementary schools may find it desirable to study atomic energy as only one part of a broader study of ENERGY.* An analogy would be that air transportation is usually studied in its relationship to the broader study of TRANSPORTATION. It is possible, however, that simple Resource Units may be developed for use at the fifth, sixth, seventh and eighth grade levels.
5. *Elementary teachers need to be conversant in the area of atomic energy.* This information should probably go somewhat beyond the level of that acquired by the intelligent layman. Such knowledge will give teachers the power to help children satisfy their natural curiosity regarding "atomic-energy" questions which have arisen in the normal course of their daily experiences.
6. *Teachers should be especially aware of the "vocabulary" necessary for an understanding of atomic energy.* A glossary of selected terms is included in this report.
7. *Emphasis will be placed upon "social implications of atomic energy" although there should be some study of the "science of the atom" per se.*
8. *Children can understand and will be interested in many ideas that to the casual adult observer are "beyond them."* We are often amazed at the wisdom they display about a subject that has challenged their interests.
9. *The subject of atomic energy is likely to be integrated with* (as David Lillienthal says, "run through") *several curriculum areas.*
10. *Emphasis must be upon an optimistic, constructive view of the atomic age—not a fearful, pessimistic treatment concerned mainly with atomic bomb destruction.* However, it should be realized that a serious concern about the problems of the atomic age, even to the extent of some worry about them, is preferable to indifference based on ignorance.
11. *Our atomic energy handbook will stress ways of using the ordinary curriculum to develop foundation concepts related to atomic energy and to living successfully in an atomic age.*

12. *This publication will no doubt contain much more material than will be used by any elementary school.* It is assumed that this publication will be a reservoir of ideas from which individual teachers may obtain suggestions, which in turn can be adapted to their local situations.

13. *Children's activities which are carried on in connection with atomic energy should be as objective, specific and concrete as possible.*

14. *"In a democracy, atomic energy must belong to the people;* and the people will have to make the decisions that govern its use. If their decisions are to be wise ones, they must be based on knowledge of what atomic energy is and what it can do." (Quoted from David Lillienthal.)

15. *We have conquered many of man's enemies in the past by the use of hard work and intelligence.* In the same way, man will some day conquer the dangers that are connected with the development and use of atomic energy. Each of us has a part to play in working out a program for protecting the world from its possible destructive uses.

OBJECTIVES

It appears to the committee that the following objectives will give helpful direction to any elementary school system interested in planning for atomic energy instruction:

A. Understandings

1. All matter is made up of about 100 different elements.
2. The sun's light and heat are believed to be the result of atomic reactions.
3. Atoms are exceedingly small.
4. Each atom is probably constructed somewhat like a tiny solar system.
5. Most atoms have a heavy center (nucleus) made of protons and neutrons. Electrons revolve about the nucleus at tremendous speeds.
6. The nucleus and the electrons in an atom are very small in comparison with the distance between them.
7. When heavy atoms are split new elements are produced and a great amount of energy is released. When certain light atoms are fused, a far greater amount of energy is released.
8. Scientists are usually able to control the release of atomic energy during nuclear fission.
9. Atomic energy is one of several forms of energy. It is the most recent form of energy made available to man—and by far the most intense.
10. The amount of energy released by the breaking down of atoms is tremendously greater than the energy we can obtain by ordinary burning or other chemical methods; it is largely for this reason that our knowledge of how to release atomic energy will bring about great changes in our ways of living.
11. There are definite patterns in the arrangement of all particles that make up matter.
12. Some radioactive materials are dangerous and must be handled with care.
13. Many scientific experiments and discoveries require much work and long periods of concentrated study.
14. Scientific experiments usually require very careful and accurate measurements.
15. Scientists in other countries are highly competent; therefore, we do not have any monopoly on atomic energy. The problem of releasing the energy of atoms was not solved by American scientists alone—it was solved by cooperative efforts of many scientists from many other countries.
16. Atomic energy has possibilities for making life better for us all. It can bring about many advancements in such fields as medicine, agriculture, and power production.
17. There needs to be developed some plan whereby all people will use atomic energy only for human welfare.
18. The United Nations is a world organization that may some day have the necessary power and wisdom to effectively limit the use of atomic energy.
19. There is a great gap between mechanical invention and social changes. The development of atomic energy makes more important the need for speeding up social changes.
20. People in all lands and throughout the ages have had fears about both present happenings and new ideas. The causes for these fears have been eliminated only through the understanding and the facing of facts. It will be up to the children in our schools today to solve the problems brought about by man's new knowledge of how to release nuclear energy.
21. Children now in school will face new ways of living and working together in a smaller, fast-moving and complex world. They must be prepared with the necessary knowledge, ideals, skills, and conduct patterns to deal with new issues. They must learn how to think independently, creatively, and with the good of their fellowmen at heart. They must be guardians of that which history has shown to be permanently good, and, at the same time, be ingenious and daring in planning new ways for constructively solving new problems which face mankind.

B. Attitudes

The following characteristics are presented in such a way as to be readily observable. It may be, of course, that pupils will often have feelings and mental sets which are less easily recognized. We may feel fairly certain, however, that valuable attitudes are being developed whenever we find that the pupils are:

1. Showing a beginning interest in reading about and discussing atomic energy and its attendant social problems.
2. Learning to understand and have a respect for the good characteristics of people of other races, creeds and nations.

3. Trying to do things which make life more pleasant for members of their own families, for their friends, for their classmates, and for their neighbors.
4. Carrying on a constructive kind of correspondence with children in other lands.
5. Giving evidence that they realize that atomic energy facts are not in the realm of the magical and that there are many important facts about atomic energy that they can understand.
6. Showing a desire to become better informed about world events.
7. Showing a beginning concern for doing what they can to work for a world in which all nations are friendly toward each other.
8. Facing their immediate problems with optimism and constructive action.
9. Putting into practice the philosophy of "a good turn daily."
10. Showing a concern and a respect for knowledge.
11. Developing those personal qualities which will enable them to meet changing conditions with constructive action and without any loss of personal integrity.

C. Skills (Initiation of these skills is inferred, of course, not mastery)

1. The ability to read with understanding, science materials that deal with elementary ideas related to atomic energy.
2. The ability to interpret pictures and diagrams effectively.
3. The ability to discuss "debatable questions" with logic and in a friendly way.
4. Skill in the use of large numbers.
5. Skill in searching for and recognizing authoritative information.
6. Skill in analyzing the daily news—distinguishing fact from opinion and detecting propaganda.
7. Skill in using the scientific method in forming and testing conclusions.
8. The ability to express ideas clearly, both in writing and in speaking.
9. The skill of behaving appropriately in varying social situations.
10. Beginning skill in the use of one or more foreign languages.
11. Skill of inter-acting with other cultures so that friendship and confidence will result.

CHAPTER II

ATOMIC ENERGY IN ELEMENTARY SCHOOL SCIENCE

A. Some General Areas of Emphasis

There are some areas of emphasis in science teaching which contribute, in general, to all phases of the elementary school science curriculum including any investigation of atomic energy which might be undertaken there.

1. Learning the Scientific Method of Problem Solving

The first of these areas of emphasis is the habit on the part of the pupil of doing his or her thinking in terms of the "scientific method" of problem solving. The steps which are often listed as phases of the scientific method are somewhat as follows:

a. The ability to sense the existence of a problem, to isolate and define the problem to be dealt with, and to have a desire to solve the problem.
b. The gathering of facts (data) which are closely related to the problem to be solved.
c. The formulation of suppositions (hypotheses) in an effort to arrive at a possible or partial explanation of the problem; and then testing these hypotheses so they can be accepted, rejected, or revised on the basis of evidence.
d. The acceptance of conclusions which are supported by a logical interpretation of the data gathered; and the rejection of conclusions which are not supported by dependable evidence.
e. Applying the principle to many and varied situations.

Youngsters also must be encouraged to arrive at understandings of science inductively insofar as possible—that is, by forming their conclusions according to the direction of thinking demanded by the scientific method. Working out applications of a new concept or principle should be attempted by deductive thinking only after the principle itself has been arrived at because of evidence which supports it.

The following few statements will illustrate inductive thinking. Suppose a fifth grade class was about to begin a unit on magnetism. At the beginning of the unit there should be an opportunity for the youngsters to bring up questions (problems) about magnetism to which they would like to find answers.

Suppose that one such problem suggested was "What things can be magnetized?" The teacher should encourage the youngsters to formulate a plan of attack that might solve this problem. The pupil-suggested plan of attack might be somewhat as follows: "We could bring things to class and experiment to find out if they can be magnetized." Questioning on the part of the teacher could formulate a list of the materials to be tested, such as, glass, paper, cloth, iron, steel, a penny, a nail, and so on. By testing these and other materials there is provided a concrete experimental way of gathering data to solve the problem being considered.

The data gathered could be tabulated on the blackboard. Then the pupils could be encouraged to generalize on the basis of the data they have collected. In other words, the pupils could be encouraged to come to some conclusions on the basis of their data in order to solve the original problem: "What things can be magnetized?"

The technique suggested here is not intended to be a complete account of the class activities that could go on in order to help solve the problem suggested. However, the technique does illustrate the inductive method of science, that is, proceeding from a problem which has been clearly defined through a data gathering stage, to conclusions made on the basis of the data gathered.

2. Acquiring Scientific Attitudes

The second of these areas of emphasis in all science teaching is upon the acquisition of such scientific attitudes as: (1) judging primarily on the basis of first-hand evidence, (2) willingness to withhold judgment, (3) freedom from superstition and prejudice, (4) willingness to accept the opinions of people who have studied a certain problem for an extended period of time.

3. Developing Basic Techniques

Third, is the development of some proficiency in such basic techniques as the following: (1) techniques of expressing one's ideas, (2) data gathering techniques and skills, for instance, discussion, ability to carry on an interview, care in observation, and ability to plan and carry through experiments.

4. Considering Social Implications

Fourth, is the habit of always considering the social implications of science facts and principles. This would appear to be a necessary phase of elementary school science in that it would help utilize the findings of science in terms of human betterment.

5. Developing the Habit of Conservation

Fifth, is the habit of mind which places a high value upon the conservation and proper use of living things and non-living materials.

6. Understanding the Great Goods of Life

Sixth, is the understanding on the part of the pupils of some of the great "goods" of life, such as: (1) health knowledge, (2) work which is of a creative nature, (3) fellowship, (4) honesty, and (5) love. Such understandings on the part of human beings would seem necessary as prerequisites to the utilization of atomic energy for human betterment.

B. Atomic Energy: An Integral Part of Elementary School Science

Many science concepts which are related to atomic energy can be taught in the elementary school. It would appear wise to deal with these concepts mainly as an interrelated part of elementary school science rather than emphasizing separate units which are concerned only with atomic energy.

The science curriculum in the elementary school can deal with concepts which contribute to the understanding of atomic energy in two ways: (1) by teaching background science concepts and facts which are necessary for the understanding of atomic energy when it is studied more directly in later school years, and (2) in the higher grades of the elementary school, there are some possibilities for the direct teaching of atomic energy considerations. The remainder of this chapter deals with the teaching of these background science concepts, and some of the possibilities for the teaching of concepts which are directly related to the release of atomic energy.

The sections of this chapter which follow presuppose that the science curriculum of the elementary school is organized on a basis of science concepts and principles, the understanding of which is expanded as the youngster goes up through the elementary school. This is the curricular organization which was suggested in the National Society for the Study of Education, "A Program for Teaching Science," *Thirty-First Yearbook, Part I*, Bloomington, Illinois; Public School Publishing Company, 1932.

C. The Teaching of Foundation Concepts and Principles

1. In the General Area of Energy, Power, and Work
In this general area of the elementary science curriculum which is concerned with energy and power in the work of the world, there are many ways in which the teacher can lay foundations of principles that will aid in the understanding of atomic energy when it is later studied in a direct manner.

a. *In the primary grades,* such concepts (or ideas) as the following can be dealt with:

The idea that labor-saving devices (i.e. machines and tools) are useful to solve problems if they are intelligently used is an important one. This science concept applies to all labor-saving devices and the sources of energy which operate them. Atomic energy is related to this general idea, because it will one day be a source of energy for operating such devices. Another related idea is that electricity, steam, springs, wind, and water can be used to move things. Youngsters can see that such is the case, and those same youngsters may be able to understand that atomic energy can also be so used. It seems that one of the major obstacles to overcome here is the new vocabulary associated with atomic energy. As the years go by, this vocabulary ought to become familiar just as the word "electricity" has become a familiar one during the past ten or twenty years.

The general concept that the burning of coal, oil, and gasoline can cause machines to move is often dealt with in the primary grades. Here is a phase of the development of the general concept of energy, of which the power released through atom fission or fusion is one special kind.

The fact that the use of machines may make man's work easier and faster is also introduced in the primary grades. This is part of the general concept of the social usefulness of machines, if the motive behind their use is constructive. The intelligent use of all kinds of power, including atomic power, is allied to this general idea.

b. *In the intermediate grades* such concepts as the following can be dealt with:

A part of the continued development of the concept of energy is the idea that man's source of energy is the food he eats. Again, the understanding of energy as that which makes things "go" is a necessary background to the later understanding of nuclear energy.

The idea that man's skill in using heat, light, wind, electricity, and so forth, has contributed much to his civilization, applies to all sources of energy. This idea is part of the understanding of the mechanical basis of our civilization.

The concept that energy can be changed from one form into another is an important part of the understanding as to how power is developed. For instance, the energy of coal can be changed into steam, which in turn can be changed into the energy of motion in the wheels of a locomotive. Such an idea of power development, or energy transfer, is important in order to understand how nuclear energy can be harnessed in order to supply the energy necessary to "make things go."

2. In the General Area Dealing with the Universe

In the general area which deals with the solar system and other parts of the universe, there are science concepts which are a necessary basis to the understanding of atomic energy.

a. *In the primary grades*, the following ideas in this general area can be made a part of the work of the class.

Youngsters in the primary grades can get the concept that the sun is hot and gives off heat and light. They can also understand that the sun warms the earth and lights the earth. All of these concepts are important in helping to establish later in the elementary grades the idea that the sun is the source of most of the earth's supply of energy.

Primary grade youngsters can also be presented with the idea that the sun is composed of gases many times hotter than our hot days on earth. In addition to this, these youngsters can begin to understand that the stars are huge spheres of glowing gases like our sun. All of these concepts are important in building up finally to the general principle that the sun is the source of the earth's energy supply. In the secondary school, the sun's energy itself will be shown to be the result of nuclear fusion by which hydrogen atoms are probably changed to helium atoms. Foundation concepts as to the characteristics of the sun must be built in the children's minds before an understanding of the importance of atomic energy reactions in the sun can take place in the minds of secondary school students.

b. *In the intermediate grades,* such concepts as the following can be dealt with:

The fact that the temperature on the surface of the sun is about 10,000° F. or more is part of the basis for the understanding of the terrific heat that is possible with atomic energy reactions. Later in the science curriculum of the school this fact can be associated with the understanding that atomic energy reactions can heat water and make steam which can drive turbines; or, that atomic energy can supply heat for the heating of houses, etc.

3. In the General Area Dealing with Physical Conditions of Life

In this general area, there are science concepts which can be taught that are related to the energy derived from atoms. The development of these concepts can be initiated in the primary grades with more extensive and systematic study at the fourth grade level.

The fact that light is essential to green plants is a concept which can be tied up with the fact that the source of light in nature is the sun. This concept can be associated later with the idea that the very life of green plants is dependent upon the energy released by the fusion of atoms in the sun. Another idea that is closely related here is that life would be impossible on earth without the sun. Again we have the idea that the energy of the sun which we receive here on the earth is due to atomic energy reactions.

Some other ideas which form a basis for the understanding of the importance of atomic energy are these: the growth of plants is dependent upon sunlight, and the chlorophyl in green plants needs the light energy of the sun in order to make food. In these ideas, we have added the concept of growth taking place because of energy—the sun's energy. Previously, it has been shown that the sun's energy was a source of light. Here, the concept has been added that the sun's energy is also necessary for the manufacture of food in green plants. Again, all of these things are related to the way in which the sun's energy is released.

4. In the General Area Dealing with the Interdependence of Living Things

In the general area which deals with the dependence of living things one upon the other, there are science concepts which form a necessary basis to the understanding of atomic energy. Some limited experiences can be given in the primary grades.

In the intermediate grades, the following ideas in this general area can be dealt with:

One idea is that man's food, clothing, and shelter are largely derived from plant and animal materials or substances. This concept deals with man's dependence upon materials which have been built up by other living things. Of course, this ultimately goes back to man's dependence upon various energy combinations, and the source of this energy is the atomic energy released at the sun. Thus, from the standpoint of atomic energy, it is important to teach this concept in the elementary school.

Another idea that applies here is that man can plan and use natural resources wisely because he is an intelligent being. Atomic energy applies here as being one form of energy which is to be conserved and used wisely. An important thing to begin the understanding of in the elementary grades is that it is necessary to conserve and use wisely all natural resources and energy sources.

Still another concept which bears a relationship with atomic energy is the fact that there is a struggle for existence among living things. In the intermediate grades, the concept of this struggle possibly can be begun in terms of combat that takes place among living things. Probably some ideas can be left with the youngsters that there is also a balance between living things. Later in the school years the concept of this combat and cooperation to achieve balance can be broadened. Even later, in the secondary school, the principle can be dealt with that the struggle for existence among living things is in reality largely a struggle for energy. This struggle for energy ultimately goes back to the source of most energy on the earth—the atomic energy of the sun.

5. In the General Area Dealing with Health, Welfare and Safety

In this general area there are a number of science concepts which are related to atomic energy.

a. *In the primary grades,* the following ideas can be made a part of the work of the class.

The idea that we should be careful when we use electricity and gasoline, steam and other sources of energy, is a good understanding to have when one works with any form of energy. Later on in the science curriculum it can be shown that the handling of atomic energy and radioactive materials requires great care.

b. *In the intermediate grades,* the following ideas could be dealt with:

The simple statement that sunlight is good for us has relationships to atomic energy. In the lower intermediate grades, this concept can be understood in terms of the fact that a certain amount of the sun's energy is healthful. Later this can be extended to show that atomic energy, when used properly, could act toward promoting better health.

Another concept that is related here is the fact that man has controlled many diseases because he has used his knowledge to fight disease. This is an important idea to understand in the intermediate grades because of the worthwhileness of the concept itself, and also because it can later be expanded to include the possibilities for man's knowledge of atomic energy to be used against disease. Some of these possibilities are controlled radiation, use of radioactive isotopes as tracers in animals, use of the radioactive isotopes as tracers in plants, use of these isotopes to improve soil fertilizers, etc.

Another idea that is related here is the fact that man has learned to protect himself from wind, heat, and other forms of energy. The understanding that protection is sometimes necessary when using energy sources is an important one. Later in the science curriculum of the school the possibilities for protecting one's self from overexposure to atomic energy can be discussed. In this sense atomic energy is but one of the forms of energy, but has possibilities of being a very intense form.

6. In the General Area Dealing with the Social Implications of Science

In the elementary grades, especially from the third grade on, such concepts as the following can be dealt with:

The facts that men must learn to be better social beings, that they must learn to exchange information which has benefit to all men, that men must learn more about the values of planning and working together, are all concepts which point to the necessity of fostering the brotherhood of man regardless of nationalism or race lines. Of course, this is very important in so far as working toward the control of atomic energy, and all other forms of energy, is concerned.

D. The Direct Teaching of Atomic Energy Considerations

In the area dealing with chemical and physical changes, certain concepts which are rather directly related to atomic energy can be dealt with in the elementary school science class. Most of these experiences, however, will wait until *the intermediate grades.*

An approach can be made to the nature of matter with such ideas as these—all substances are composed of molecules; molecules can be made to move faster and faster. When these ideas are being dealt with, approaches are being made to the direct teaching of atomic energy. Understandings of the make-up of matter and the movement of particles of matter must be arrived at before the release of atomic energy can be dealt with. It is but a step from the consideration of molecules to the consideration of atoms. It would seem that children in the higher grades of the elementary school could actually give a simple definition of an atom and begin to arrive at an understanding of what they were defining.

Other concepts that can be dealt with in the intermediate grades are: The fact that there are about 100 different elements, (different kinds of basic substances); that oxygen is a very active element chemically, that hydrogen is a very light element, that helium will not burn, (if these things are shown to them by means of classroom demonstrations); and, through science demonstrations in the classroom that there are many ways to produce chemical changes and that man can produce many combinations of elements. There are many other ways that the teacher and the pupils can broaden their concept of the makeup of materials on the earth and the different kinds of atoms and molecules.

They can also begin to understand that elements and compounds (atoms and molecules) can store energy. It is suggested that the fact that energy is stored in chemical compounds can be demonstrated to the higher intermediate grade youngsters. For instance, wood can be burned and heat and light energy are the result. Gasoline can be burned and heat and light energy will be released, and the gasoline as such will disappear. It can also be discussed that the food which people eat gives them the energy by which they are allowed to do their daily activities.

They can also begin to discuss how metals, (some of the elements), are separated from their ores. For instance, the separation of iron from iron ore, the separation of radium and uranium from pitchblende.

In the magazine, the Young Citizen, issue of February 21, 1949, an article appeared which described in a very general way the idea of atom splitting. The terms nucleus, electron, neutron, fragment of nucleus, are introduced and defined in the article, both by words and diagrams. A concept of the large amount of space in the atom as compared to the total size of its particles was also dealt with in the article. The simple and clear presentation in this article suggests the possibility of beginning some of the more elementary considerations concerned with atom splitting at about the fifth or sixth grade. It is certainly possible at that time to show some evidence that molecules and combinatons of atoms, and atoms themselves contain stored energy. It is also possible to illustrate, by referring to the energy of the sun, that an enormous amount of energy is stored in the center or nucleus of the atom.

In Chapter VII of this report will be found a description of the fifth grade unit taught by Mr. Wailes. This illustrates some of the concepts and activities which may be a part of a unit on atomic energy for fifth or sixth grade pupils.

CHAPTER III

ATOMIC ENERGY AND THE ELEMENTARY SCHOOL SOCIAL STUDIES PROGRAM*

Los Alamos Is Pointed Out
(Fifth Grade Class, Campus School, Iowa State Teachers College)

I. POINT OF VIEW

For elementary school children the first great need produced by man's discovery of how to release nuclear energy is an understanding and appreciation of world unity. This entails a realization of the essential "humanness" of all peoples; of the reality of boys and girls, of men and women of other cultures in their needs and problems, their hopes and desires. No longer can American boys and girls be taught that the people of Holland are essentially a quaint people who wear wooden shoes and skate on the canals. They must realize the Dutch people as basically like ourselves in ways that are important, *and different from ourselves in ways that are often interesting and desirable.*

The development of these understandings and appreciations require certain factual knowledge to be used as a means, and much actual experience in understanding other people.

A second great need in connection with atomic energy is a knowledge of and appreciation for the tremendous benefits to mankind that atomic energy may bring. That atomic energy, uncontrolled, may bring devastation is being constantly presented through the press, radio, and movies and should not be emphasized with elementary school pupils.

Again, a mass of factual knowledge and as much actual experience as possible will be used to develop this concept.

Good schools and good teachers everywhere have long been aware of the need for better understanding of other people both at home and abroad. It is not a new idea. *It has, however, been intensified by the development of the use of atomic energy.* It includes an appreciation of the worth of the individual, a fundamental concept of democracy.

From the earliest school years respect for others should be constantly developing. The kindergarten child must recognize the rights of his classmates. He must learn to take turns, to respect the property of others. As he goes on through the grades he must learn to understand and appreciate children of different races, different religions, different economic status, different abilities and different interests. In some homogeneous communities the child will find most of his classmates very like himself in racial, national, economic, and religious background. However, there will always be substantial differences in abilities and interests. It is as important that children learn to appreciate and enjoy others with these differences as it is that they respect those of another race. It is a basic step upon which may later be built an appreciation for an entirely different culture. To be specific, the ability to quietly carry out plans of the group, to cooperate, to follow, or to give loyal friendship, is as sure an indication of individual worth as is the ability to read the hardest book, to paint the best picture, or to run the fastest.

*See Chapter IX for important citizenship goals.

Experiences in the classroom which give children the opportunity to work creatively and cooperatively with others while producing a class play, a school newspaper, or in building bookshelves help them to learn respect for the abilities of others.

After the child in the early grades has established himself in his family, his school group and in his community, he begins to learn about people of other lands. This usually occurs in the third or fourth grade. He studies the home life and tribal life of primitive peoples living under different geographic conditions. He learns to respect the skill and ingenuity which enable these people to wrest a living from nature without the mechanical devices with which he is familiar. He learns to appreciate the courage and hardihood required to maintain a good living in the cold mountainous regions of northern Europe or in the overpopulated Yangste Valley of China. Children naturally admire the abilities that enable people to make a living under difficulties. It is necessary to lead the child to recognize such people as real people with thoughts and feelings like our own and deserving of our consideration in world affairs. He must also be led to realize the contributions these people make to our own lives.

In studying the different geographic areas of the U. S. the child should be led to understand the reason for the differences in attitudes, in values, and in living conditions. He can learn to appreciate and enjoy these differences.

As his studies carry him all over the world; to Latin America, to South Africa, to Japan, his biggest interest should be the people; how they live, why they live as they do, what their needs and desires are, so that he shall think of them as real people. Then he will be prepared to know them, as well as himself, as world citizens.

None of these ideas is new. It is the emphasis that is new and the fact that an *action program* is urgent due to the advent of atomic energy.

Elementary school children are quite able, with the above concept of the oneness of people, to understand the purpose and meaning of the United Nations. Its function as the central agency equipped to promote world peace and world unity should be made clear to them. UNESCO, WHO, FAO, and such member organizations, can and should be studied as agents for promoting the welfare *of all peoples.* The United Nations and its subsidiary organizations are also an excellent source of material for learning about other parts of the earth. Writing to the United Nations and receiving literature about other nations forms a convincing activity in recognizing the reality of the rest of the world.

The United States Atomic Energy Commission and its efforts to promote world control of atomic energy should also be known by elementary school children. It is not necessary that they follow all of the steps in the development of the United Nations Atomic Energy Commission, but they should realize that it is only through this organization that world control of atomic energy, so essential to the welfare of man everywhere, can be achieved.

Elementary school children are now talking glibly about the hydrogen bomb. In many instances they may understand more about the atom bomb than their teachers do. Teachers must learn quickly in order to help children understand that there is more to atomic energy than just the production of bombs.

Atomic energy is already being proved to be useful in the three great fields of medicine, industry, and biological science. Under world control atomic energy may become the greatest boon to humankind since the invention of the wheel. Our children must learn to greatly desire such control and be willing to work toward it.

In the world of medicine, atomic energy will make possible the diagnosis and cure of many human ailments as soon as they appear. Radioactive isotopes applied to the human body make it possible to observe action within the body. Thus the causes of such obscure diseases as cancer and arthritis can be better understood. Through such knowledge, these diseases will be better controlled and may eventually be conquered.

In the April, 1950, issue of *Consumer Reports* there is an excellent article which describes the use of radioactive isotopes in medicine. Much of this material can be understood by children in the intermediate and upper elementary grades. According to this article there has yet been found no peacetime use of the fusion process which leads to the hydrogen bomb, but the fission process offers a number of radioactive isotopes which are extremely useful in biological and medical research and the treatment of disease. The field has not been explored extensively. There is promise that many more uses of isotopes will be found.

Some isotopes occur naturally; others can be made artificially. The capture by a stable material, such as phosphorus or iodine, of neutrons released in the process of atomic fission often makes the material radioactive. Radioactive isotopes emit radiations which are similar to X-rays in their effect on normal and abnormal cells. They can inhibit cell growth and even destroy cells if their intensity is high enough.

Phosphorus isotopes are used in certain blood diseases, for instance, where there is an over-production of red or white blood cells. Iodine isotopes have proved to be particularly successful in the treatment of thyroid cancer, especially when surgery is not possible.

Radioactive isotopes are useful in diagnosing disease, before beginning treatment. Isotopes are introduced into the body, either by mouth or through the veins. Their progress through the body can be detected by the use of a Geiger counter which registers the presence of radioactivity by clicking audibly. The medical scientist is able to determine just what is going on in the body almost as if he could see the process.

The U. S. Atomic Energy Commission puts certain restrictions on the use of radioactive isotopes. They are dangerous and must be handled with great care. There are only about 100 hospitals which have met the requirements and now receive and use radioactive isotopes. The *Consumer Reports* warns against radioactive frauds which are now being found on the market, such as "radioactive bath salts" and "atomic shin plasters." "While most of these are pure fakes, a few have been found to have dangerous radioactive properties. Both types have been seized by the Food & Drug Administration."*

In the field of industry new metals with almost incredible strength have been produced through the use of atomic energy. Radioactive isotopes have been used to locate new petroleum fields and to measure their size and volume. Although atomic energy as fuel has not yet been developed for practical or general use, it is expected that this will be accomplished in the near future. Such development will greatly change conditions in this industrial age, and the boys and girls who are in the elementary schools today will find their lives immensely affected. They are old enough to understand much of this.

Atomic energy in the field of biology will be even closer to the boys and girls of Iowa. Radioactive isotopes are being used to study disease in plants. It is promised that fertilizers and soil balancers will be greatly improved by the use of atomic energy. For instance, it will be possible to determine exactly how much lime a certain field needs. Crops will be increased, and lawns and gardens will be more luxuriant. Through atomic power much wider use of irrigation will be possible. Underground water that is now buried too deeply to be touched will be brought to the surface by atomic power so that desert areas can be watered, fertilized and cultivated.

The use of atomic energy for peacetime uses has not been developed as far as it should have been since the advent of the atomic bomb mainly because of the constant threat of war; the need of using atomic energy for defense purposes. World control of atomic energy will release many scientists for the development of constructive peacetime uses. It is essential that elementary school boys and girls of today understand the possibilities of atomic energy for they will live out their lives in the atomic world be it for good or for evil.

II. EMPHASIZING FOUR IMPORTANT GOALS

As indicated earlier the social studies curriculum is likely not to be changed fundamentally by the advent of man's ability to release the energy of the atom. There are, however, certain goals which must be given a new and more urgent importance when evaluated in terms of the world of today. These goals are:

(1) The achievement of skill in human relationships.
(2) The achievement of skill in solving group problems.
(3) The development of understandings of our contemporary world.
(4) The development of the right kind of loyalties.

The above goals have been inherent in our social studies programs of the past. It is the job of today's teachers to see to it that the children in their classrooms do more than mildly pursue these goals. It is up to us to see that they "go to town" in trying to achieve them.

If the above goals are to have meaning to the teacher, it is necessary that he be aware of the important learnings which children must attain if they are to achieve these goals. Of equal importance, the teacher must be informed regarding practical activities which can be carried on in the pursuit of these learnings and goals.

Consumer Reports, April, 1950, 170-172.

During the remainder of this chapter the four goals listed above will be presented in some detail. For each of these goals there will be a suggested list of learnings (understandings, attitudes, skills and habits), as well as an implementing list of pupil activities.

It should not be the purpose of the elementary school to have the pupils *master* the learnings which are suggested in this chapter. It is the responsibility of the elementary school, however, to give pupils a substantial start in the development of these understandings, attitudes, skills and habits. Only as these learnings are rooted in the early experiences of children, can we have any assurance that they will be developed properly, or that they will not be crowded out by experiences of an undesirable or even antithetical nature.

Developing Skill in Human Relationship

A. Desirable Learnings

1. Children everywhere need an opportunity for the expression of their creative abilities, for the development of wholesome friendships, and for seeking new experiences and adventures.
2. Although people of different nations have the same needs, they have arrived at many ways of meeting these needs because of varying resources and opportunities found in different regions of the world. The differences are, however, in the superficial aspects of their way of life rather than in their human nature traits.
3. There are interesting and colorful differences among people of various nations: ways of celebrating holidays; favorite forms of recreation and pastimes; costumes; arts; favorite foods; and home furnishings. Exchange of ideas among different groups enriches living and contributes to the charm and graciousness of community life.
4. Scientists and social scientists have found evidence that seems to show that no race or group of people is superior in mentality or native ability to any other race or group. Differences which appear to exist can be traced to differences in the opportunity to develop and are an adjustment to living in the type of region in which the group is found.
5. The greatest resource which any nation has is its people.
6. Human personality is always worthy of respect. If we wish to be understood and accepted, we must endeavor to understand others and treat them with respect and courtesy.
7. Ridicule and criticism are damaging to ourselves as well as to those about whom our remarks are made. Our criticisms should be centered around the ideas of people with whom we disagree rather than the people themselves.
8. Misunderstanding of differences causes fear and distrust, which, in turn, tend to produce quarreling among smaller groups, and war among nations.

9. People have always been curious about the world in which they live. Younger people especially look for new experiences and seek adventure.
10. Modern means of communication and transportation have made the world smaller in terms of travel and communication. All nations of the world today are near neighbors. It is important that we understand other peoples whose lives are now so much more closely related to our own lives and welfare.
11. Belief in the principles of equality, justice and right have world-wide application. Loyalties to persons or smaller groups is a step in our progress toward this broader loyalty to principles.
12. People in civilized nations have a knowledge of what is right and what should be done in dealing fairly with others. If these ideas were put into practice we would eliminate fear concerning the development of atomic power.
13. Human traits are socially acquired. We tend to adopt the values and characteristics of the group of which we are a part.
14. There are many good reasons for the differences which are found among nations. For instance, unfavorable climate and lack of resources make it impossible for some nations to have a standard of living as high as ours. Emphasis should be placed on the skill with which each group is meeting their problems in view of the circumstances and opportunities open to them.

B. Suggested Activities*

1. Use many committee and small group projects in order that the children may develop the ability to plan, compromise, and cooperate in carrying a project to completion. Cooperative activity may involve committee reports; group making of murals, posters, pageants; planning and conducting of experiments; and arranging of exhibits. Emphasis should be placed on the gracious acceptance of majority rule.
2. Children representing different nationality backgrounds should be encouraged to bring to school art objects, anecdotes, costumes and artifacts from the country which they represent. National songs may be sung, games played, music of famous composers enjoyed, favorite foods of the nationality served, and occasionally a celebration of a foreign holiday conducted as it would be in that country.
3. Prepare an exhibit of book jackets for a bulletin board display showing the contributions of national groups to literature of the world.
4. Have the pupils suggest a number of different courteous and constructive ways of offering suggestions and criticisms to their classmates. Choose the statement which is probably the most tactful and constructive suggestion.
5. Pupils should read widely in children's literature stories dealing with life in foreign lands in which the characters are true-to-life children experiencing the same problems and anxieties which American boys and girls experience (watch copyright dates). Here they will find many examples of "foreign" children who learn to solve their problems by the use of resourcefulness, pluck, and courage.
6. Pupils should exchange letters with children in other parts of the United States and in foreign countries in order to secure direct information about the problems, hopes, aspirations, successes, and sources of satisfaction for these children. (Many school systems, such as the Waterloo public school system, have developed a fairly extensive program of correspondence with children in other lands.) One source of addresses for pen pals abroad is International Friendship League, 40 Mt. Vernon Street, Boston, Massachusetts. Enclose a self-addressed stamped envelope. Indicate age and hobbies.
7. Arrange for some school camping experiences in order to give children more extensive opportunity for informal group cooperative living. (See State of Iowa Student Activity Handbook.)
8. Have the children report on visits they have made to communities quite different from their own and in which they had become sensitive to the problems which confront other groups. For instance mining towns or poor districts in cities offer marked contrast to most Iowa rural communities.
9. Bring resource visitors who have lived in foreign countries or in regions in the United States which differ from the local region into the school to present problems of other groups as they see them. These visitors will be able to bring details about everyday life which will make the people where they formerly lived seem real and human to the children.

*Activities listed under one goal often can be recognized as useful in the achievement of other goals.

Developing Skill in Solving Group Problems

A. Desirable Learnings

1. In solving a group problem it is essential that the problem be defined and analyzed so that it will be clear to all.
2. Members must be able to collect and evaluate their past experiences relative to a problem which has been defined. History will frequently give valuable information concerning man's past successes and failures with many problems.
3. The formulation of an hypothesis or possible plan of action for solving the problem must be made on the basis of the group's previous experience.
4. There is need to develop resourcefulness in making plans for testing hypotheses which have been formulated.
5. Principles formulated on the basis of an hypothesis that has been found to be true may often be used in solving new problems.
6. It is important to set up and evaluate, through group discussion, various possible courses of

action which are open to the group. Skill in the use of discussion techniques which will bring out points of view of many of the members of the group concerning a real and immediate problem confronting the group is essential.

7. In the case of disagreements concerning a desirable course of action to follow for groups of which we are members, there is usually some good and truth in both sides of the question. The best solution to our problems can usually be found through an open discussion through which a course of action satisfactory to both sides can be adopted.

8. Pupils need practice in discovering areas of living in their own community in which problems exist and for which cooperative activity can lead to an actual improvement in community living. Problems may deal with fire prevention, community beautification, recreation, or similar activities.

9. Similar problems exist in more distant localities than the immediate community, and it is the responsibility of all thinking people to be concerned about helping others to solve their problems.

10. Pupils need to experience in varying situations the satisfaction that comes to one who is kind and helpful to others—especially to those who may be somewhat less fortunate.

11. The peoples of the world have made great progress in methods for settling disagreements among individuals and groups. At first disagreements were settled by individual combat. Later plans were developed for solving problems among tribes, city-states, and nations. Now the logical expansion of governmental units for solving problems and settling disagreements is a world-wide organization among civilized nations such as the United Nations.

12. Freedom involves responsibility. Irresponsible freedom is dangerous.

B. Suggested Activities

1. Have the pupils survey the school or the local community to discover areas of living in which problems exist. In the case of the school the pupils may make and carry out a plan for improving the situation. In the community have the pupils discover what is being done to improve conditions. Where nothing is being done the pupils may work out possible courses of action. In some instances they may be able to carry out their plans. In others their interest may stimulate their parents or some local agencies to action.

2. Be alert to problems that arise in the group. See that they are solved by the members of the group, not by the teacher. Be sure that the chidren get full information as to the extent of the problem, the cause of the trouble, and the seriousness of it. Then guide them in planning a solution, trying it out and evaluating the success of their solution. Allow them freedom to make mistakes and to discover and correct them.

3. Encourage children to bring up current problems in the news about which there may be a difference of opinion among members of the group. Conduct discussions over these problems in which the items involved are clarified and possible courses of action suggested.

4. Organize and conduct a paper drive or some similar drive to secure money for sending supplies to some school in a foreign country or to send gift boxes to foreign children. (Pupils need experiences in organizing and carrying out concrete projects which are socially useful.)

5. The pupils might organize and conduct a drive for securing used shoes and clothing to send to needy countries in Europe or in other parts of the world. They should be sure that the clothing is clean and in good repair before sending it.

6. Have the pupils prepare and present a pageant showing the history of their own community and the contributions made by the different nationality groups which have come to live in the community.

7. Make use of teacher-pupil planning of the learning experiences to be undertaken by the group. The children may assist in planning the specific questions which they wish to have answered, sources of information to be consulted, and the job assignments for each member of the class.

8. Encourage the children to form a service club which is willing to help in worthwhile school and community projects, e.g., helping to serve lunches for the younger children, organizing games for younger children, and finding chairs and books for parents who visit school.

9. Have pupils compare accident rates in atomic energy plants with those of various other industries. (Accident rate is lowest in atomic energy plants.)

Developing Understandings of Our Contemporary World

A. Desirable Learnings

1. The elementary school pupil should have knowledge of the location of the world's chief sources of uranium today.

2. He should have some understanding of the importance of power and energy in modern industry. He should be helped to realize that the advent of atomic power is likely to produce extensive changes in business and industrial organization.

3. He should begin to realize the role propaganda techniques play in the modern world. He should recognize the use of some of the more obvious propaganda techniques in newspapers, magazines, and in radio, such as associating the propaganda idea with something that is known to be held in favor by the majority of the readers or listeners and the commonly used technique of name-calling.

4. The elementary school pupil should be familiar with world leaders who direct the affairs of national and international groups, including musicians, authors, artists, scientists and political leaders.

5. The elementary school pupil should become familiar with the customs and habits of many national groups throughout the world and have an elementary understanding of the historical development of these national modes of living.

6. The elementary school pupil should have information concerning UNESCO, Junior Red Cross and other international organizations which are working for world peace.

7. The elementary school pupil should have considerable information about products in everyday use in his home and community which must be supplied to us by foreign nations.

8. The elementary school pupil should have information on the level of his maturity concerning previous attempts to organize nations into a central governmental unit which will promote the welfare of all.

9. Through the study of history the child should learn that the world has been faced with serious problems before and that satisfactory answers have often been found.

10. The elementary school pupil should begin to understand that sweeping changes in form of government or in social organizations take place because there are serious unsolved problems which the old order of government has not solved, and that individuals such as dictators in countries of the modern world are able to arise because these problems have not been solved. Individuals can not make constructive changes in the course of history except through sensing the needs of the time and finding a solution which appears to be acceptable to the social group.

11. New scientific discoveries and inventions change the value of resources which are available on the earth. Any element or resource has the potentiality of becoming of crucial worth in the world economic system. It is therefore impossible to predict which nations may in the future possess the most crucial products for the era (the importance of uranium today is a good example).

12. Small nations as well as large nations may be able to afford to make bombs and to use atomic energy. The wealth of a nation may have decreasing significance in the ability of a given nation to protect itself from aggression.

13. Modern means of transportation are such that no region in the world is so remote that it can feel secure from attacks by planes.

14. Polar regions are well adapted to air transportation. These regions may prove of greater world significance as a result. Canada and Alaska appear to be increasing significantly in world importance.

15. Differences in national customs, holidays, and modes of living add charm and interest which can enrich the living of all peoples in the civilized world.

16. There is now no adequate protection from atomic attack. The only sure means of protection is international control of the use of atomic energy and in the growth of the spirit of world brotherhood.

17. Atomic science promises untold good in the cure of cancer, arthritis, and certain blood diseases.

18. The energy and creative ability of many talented people can be devoted to the development of a higher type of civilization when fewer human beings will be required to perform necessary labor and more people can spend their time in inventing and making things which will make life happier and more secure.

19. One of the reasons why Ancient Greece reached such a high level of civilization was that a number of capable people were freed from drudgery and could devote their time to the cultural aspects of civilization such as philosophy, art, music, and literature.

20. The advent of atomic energy gives promise of an era in which want can be banished from the world. Science is showing the way to a world with plenty for all. It is up to the people and governments of the world to use their new opportunities with wisdom.

21. Periodically in the history of mankind a new social point of view or a scientific discovery has changed a whole social order. Among former outstanding discoveries which have changed the world are the ability to make and control fire, the invention of spoken and written language, the introduction of Christianity, the invention of power machines, the invention of gunpowder and dynamite, discovery of the germ theory of disease, and practice of the democratic theory of government.

22. Atomic energy holds promise of far surpassing in value most previous scientific inventions or discoveries which have been made.

23. The United Nations is a great world organization which holds some promise of uniting the world in the common purpose of human welfare everywhere. It is up to all of us to learn more about it and to support it in its efforts toward bringing about a world at peace.

B. Suggested Activities

1. Locate on an outline map of the world (1) the places in which uranium can be found, and (2) where atomic energy plants are located.

2. Prepare a graph representing the potential amount of uranium in various areas of the world. (Upper grade pupils)

3. Prepare a class biography of people from various nations who have made notable contributions to our understanding of atomic science. Prepare a picture chart illustrating the steps of progress. (Upper grade pupils)

4. Prepare a historical date line depicting the lapse of time between important discoveries which led to the discovery of how to release the energy

action which are open to the group. Skill in the use of discussion techniques which will bring out points of view of many of the members of the group concerning a real and immediate problem confronting the group is essential.

7. In the case of disagreements concerning a desirable course of action to follow for groups of which we are members, there is usually some good and truth in both sides of the question. The best solution to our problems can usually be found through an open discussion through which a course of action satisfactory to both sides can be adopted.

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3. Encourage children to bring up current problems in the news about which there may be a difference of opinion among members of the group. Conduct discussions over these problems in which the items involved are clarified and possible courses of action suggested.

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6. Have the pupils prepare and present a pageant showing the history of their own community and the contributions made by the different nationality groups which have come to live in the community.

7. Make use of teacher-pupil planning of the learning experiences to be undertaken by the group. The children may assist in planning the specific questions which they wish to have answered, sources of information to be consulted, and the job assignments for each member of the class.

8. Encourage the children to form a service club which is willing to help in worthwhile school and community projects, e.g., helping to serve lunches for the younger children, organizing games for younger children, and finding chairs and books for parents who visit school.

9. Have pupils compare accident rates in atomic energy plants with those of various other industries. (Accident rate is lowest in atomic energy plants.)

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4. The elementary school pupil should be familiar with world leaders who direct the affairs of national and international groups, including musicians, authors, artists, scientists and political leaders.

5. The elementary school pupil should become familiar with the customs and habits of many national groups throughout the world and have an elementary understanding of the historical development of these national modes of living.

6. The elementary school pupil should have information concerning UNESCO, Junior Red Cross and other international organizations which are working for world peace.

7. The elementary school pupil should have considerable information about products in everyday use in his home and community which must be supplied to us by foreign nations.

8. The elementary school pupil should have information on the level of his maturity concerning previous attempts to organize nations into a central governmental unit which will promote the welfare of all.

9. Through the study of history the child should learn that the world has been faced with serious problems before and that satisfactory answers have often been found.

10. The elementary school pupil should begin to understand that sweeping changes in form of government or in social organizations take place because there are serious unsolved problems which the old order of government has not solved, and that individuals such as dictators in countries of the modern world are able to arise because these problems have not been solved. Individuals can not make constructive changes in the course of history except through sensing the needs of the time and finding a solution which appears to be acceptable to the social group.

11. New scientific discoveries and inventions change the value of resources which are available on the earth. Any element or resource has the potentiality of becoming of crucial worth in the world economic system. It is therefore impossible to predict which nations may in the future possess the most crucial products for the era (the importance of uranium today is a good example).

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14. Polar regions are well adapted to air transportation. These regions may prove of greater world significance as a result. Canada and Alaska appear to be increasing significantly in world importance.

15. Differences in national customs, holidays, and modes of living add charm and interest which can enrich the living of all peoples in the civilized world.

16. There is now no adequate protection from atomic attack. The only sure means of protection is international control of the use of atomic energy and in the growth of the spirit of world brotherhood.

17. Atomic science promises untold good in the cure of cancer, arthritis, and certain blood diseases.

18. The energy and creative ability of many talented people can be devoted to the development of a higher type of civilization when fewer human beings will be required to perform necessary labor and more people can spend their time in inventing and making things which will make life happier and more secure.

19. One of the reasons why Ancient Greece reached such a high level of civilization was that a number of capable people were freed from drudgery and could devote their time to the cultural aspects of civilization such as philosophy, art, music, and literature.

20. The advent of atomic energy gives promise of an era in which want can be banished from the world. Science is showing the way to a world with plenty for all. It is up to the people and governments of the world to use their new opportunities with wisdom.

21. Periodically in the history of mankind a new social point of view or a scientific discovery has changed a whole social order. Among former outstanding discoveries which have changed the world are the ability to make and control fire, the invention of spoken and written language, the introduction of Christianity, the invention of power machines, the invention of gunpowder and dynamite, discovery of the germ theory of disease, and practice of the democratic theory of government.

22. Atomic energy holds promise of far surpassing in value most previous scientific inventions or discoveries which have been made.

23. The United Nations is a great world organization which holds some promise of uniting the world in the common purpose of human welfare everywhere. It is up to all of us to learn more about it and to support it in its efforts toward bringing about a world at peace.

B. Suggested Activities

1. Locate on an outline map of the world (1) the places in which uranium can be found, and (2) where atomic energy plants are located.

2. Prepare a graph representing the potential amount of uranium in various areas of the world. (Upper grade pupils)

3. Prepare a class biography of people from various nations who have made notable contributions to our understanding of atomic science. Prepare a picture chart illustrating the steps of progress. (Upper grade pupils)

4. Prepare a historical date line depicting the lapse of time between important discoveries which led to the discovery of how to release the energy

of the atom. Illustrate the date line with pictures of means of transportation, kinds of homes, costumes, and cultural progress throughout these historical periods, e.g., Democritus of Ancient Greece dates back to about 400 B.C. Pictures of Greek life and costumes of the time should be used to illustrate his era. (Democritus was the person who formulated the theory that all matter is made up of atoms.) (Upper grade pupils)

5. On a large outline map of the world draw lines to five important cities or places on each continent. Indicate the length of travel time required to reach each of these places by the various modes of transportation described on your history date line. Indicate the travel time required today using our fastest mode of transportation. (Upper grade pupils)

6. In a series of large outline maps of the world show by pictures:
   (1) The kind of recreation children enjoy in each region;
   (2) The types of homes in which the children live;
   (3) The kind of clothing the children wear;
   (4) The animals and birds typical of the region;
   (5) The products which we use which come from the region;
   (6) Artistic productions from the region;
   (7) World famous people from each region;
   (8) National festivals that are celebrated in each region.

7. Prepare a large picture chart showing progress in each of several areas leading up to the era of atomic energy. Along the left-hand margin indicate the historical period; at the top the area of progress, such, for example, as: source of energy, means of transportation, methods in agriculture, means of communication, sources of fuel for heating homes. (Upper grade pupils)

8. Collect and exhibit examples of propaganda which tend to create fear and distrust of other people in the world. These may be examples of the "name-calling" device, pictures of foreign people which present them as undesirable or suspicious characters, games which cast reflection on some minority group (such as a ball throwing game in which the ball is to be thrown through the mouth of a comic Negro character), anecdotes which ridicule a supposed trait of some minority group, or slogans which incite ill will.

9. Pack gift boxes for children in some foreign school. Send the children of the school a description of your own community and school. Invite the children of the foreign school to tell you about their homes, school, and community.

10. Prepare a summary of ways in which your class in school can cooperate in the program of UNESCO, CARE, and Junior Red Cross. Ask the local Junior Red Cross Chairman (or county chairman) to give you suggestions.

11. Prepare an exhibit of products from your homes and community which have come from some foreign region. Have a pupil prepare a brief and interesting sketch about the habits, customs, and manner of living of the people in the region from which each product has come.

12. Select what your class considers the ten most important inventions and discoveries which have been developed by human inventiveness and creativity. Prepare a chart or poster to illustrate the changes which resulted from each invention or discovery.

13. Prepare a story book map of the world by indicating on a large outline map favorite stories, the scenes of which are laid in various continents and countries. The map may be illustrated with pictures of characters and scenes from the stories.

14. Have a story book character guessing contest in which each member of the class impersonates a story book character from a foreign country. Have members of the class guess the character and the country represented from incidents told in the story and from customs prevailing in that country.

15. On a series of large maps of the world indicate the territorial extent of various previous federations and leagues which endeavored to establish peace, e.g., the Delian League, the Holy Alliance, the League of Nations, the United Nations. (Upper grade pupils)

16. Present a program of music from different nations in which records from many countries are played. Tell briefly about life in each country and, if available, the story of the composition before each is played.

17. Arrange an exhibit of costumed dolls representing people of many nations.

18. Study the nationality backgrounds of the children in the class. Have each child present interesting information concerning the customs, art and habits of the country from which his ancestors came.

19. Prepare a chart listing privileges and freedoms which we enjoy. Opposite each privilege or freedom list a responsibility which we must assume if we are to enjoy that privilege.
   e.g. Riding a bicycle—Riding carefully and on the right side of the road
   Borrowing a library book—Handling book carefully and returning at proper time
   Having a picnic on public property—Extinguishing fire thoroughly and picking up waste

20. Have pupils bring to class newspaper clippings that are concerned with peacetime uses of atomic energy. Ex.: medicine, agriculture, transportation, and power.

21. On an azimuthal-type map with the North Pole (or center of U. S.) as the center have pupils measure the shortest distances from central U. S. to various capitals of the world.

22. Arrange a bulletin board display of pictures from various foreign countries. Have a contest among the pupils to see which child can find the largest number of objects or customs which would not typically be found in his own community.

23. Have the children find and arrange two collections of pictures of foreign people. In one collection place those pictures which encourage us to like them. In the second collection place those pictures which tend to arouse our fear or dislike. Discuss with the children the need for evaluating pictures as well as print.

Developing the Right Kind of Loyalties

A. Desirable Learnings

1. Democracy is a way of life which must be expressed in daily living.
2. Individuals maintain their own self respect only as they are loyal to the principles which they accept.
3. Loyalty to friends and family does not necessarily mean unquestioning acceptance and defense of their actions in all instances.
4. It often takes courage and will power to remain loyal to what we may know to be right.
5. The democratic individual strives constantly for those courses of action which are beneficial to the largest group in his society. At times it will be necessary for the individual to sacrifice his own personal desires or personal gains in the interests of group welfare.
6. The individual who lives in accordance with democratic principles has faith in human personality. He is convinced that human nature strives for high ethical values and will not willingly tolerate wrong nor condone injustice.
7. A belief in the principles of justice and a determination to promote these principles.
8. Everyone should deliberately and thoughtfully develop his own standards to which he will be loyal.
9. Acceptance of the principles of justice and right simplify the problems of the individual because the individual now has a measuring stick with which he can evaluate his responses in any given situation. His conduct becomes consistent as he applies these principles to everyday life situations.
10. Material goods can never insure the happiness and welfare of an individual. Therefore, it is unwise to attach too much *loyalty* to material success. The greatest satisfactions come from a feeling of oneness with the social group of which the individual is a member.
11. Modern means of communication and transportation have expanded the size of the social group to which an individual belongs. In the modern era, humankind throughout the world has become one social group integrated through common problems, needs, and desires.
12. Lasting satisfactions and real happiness are often set aside in an effort to discover and experience brief, temporary pleasures. In seeking too hard for these temporary situations, the individual often destroys the possibility of securing the great "goods" of life.
13. Conflicting systems of value persist side by side in our nation today. It is therefore difficult to develop a wholesome and consistent system of values.
14. Each individual's system of values is developed as a result of the experiences which the individual has. Rewarding and satisfying experiences tend to be repeated and frustrating experiences avoided. The right kinds of experiences must be available to the child if a wholesome system of values is to be developed.

B. Suggested Activities

1. Encourage the children to read the biographies of outstanding people who have exemplified principles of justice and fairness in their contacts with all other people.
2. Present to the pupils for reading and discussion simple case studies involving some ethical principle. The case studies should represent problems similar to those found in the local school, but should be sufficiently different from any local school situation that the discussion can center impartially around principles involved in the case apart from personalities.
3. Provide opportunity for the pupils to decide how to settle certain problem situations which arise in the school when these problems do not involve a situation in which a pupil in the school may be humiliated by the decision which is made. (For younger children the problems may be those of cutting across lawns near the school house, tampering with flower gardens, or whether extra change given by mistake at a store should be returned to the storekeeper.)
4. Encourage the children (but do not compel them to do so) to learn The American Creed, the Athenian Oath, slogans, poems, and short selections in prose which embody some fundamental truth well expressed.
5. Recognise among the pupils any instances in which they are practicing the principles of fairness and consideration in dealing with others in the school. Help them to realize the value of what they are doing.
6. Present through simple dramatizations worked out by the pupils and presented to the group, the courteous and gracious way to handle social situations such as introductions, telephone conversations, making necessary interruptions, thanking a hostess for a good time and other social amenities which provide techniques for treating others with respect and courtesy.
7. Provide opportunity for committee and small group work in the school in order that feelings of group unity and solidarity are encouraged.
8. On a picture time line trace the growth of democratic concepts and the formulation of great documents which have highlighted the advance of human freedom. Examples of documents which might be included are Hammurabi's Code

of Laws, Justinian's Code, the Magna Charta, the Declaration of Independence, and the Atlantic Charter. (Upper grade pupils)

9. Have the pupils prepare a booklet containing a collection of biographies of world leaders who have made significant contributions to the welfare of mankind. Each pupil may select his own favorite character for a chapter in the book.

10. Collect pictures of men and women who have made significant contributions to the welfare of mankind. Use these pictures in preparing an electric identification chart in which the pupil identifies the picture of each with the name and a statement of an important achievement of the individual.

11. Prepare a picture date line depicting improvement in the treatment and cure of disease. Include the names of famous scientists who have made outstanding contributions to the cure of disease. Bring the chart up-to-date by indicating how knowledge of atomic science is being used in studying disease today.

12. Have the pupils set up standards for the qualities which they desire in officers and class representatives which the group will have occasion to select.

13. Arrange that all children in the classroom group have the opportunity to be responsible for some routine classroom tasks in which there is opportunity to develop traits of reliability and responsibility.

14. Present motion pictures which dramatize a problem situation such as those of race relations, differences among socio-economic groups, and differences in customs. Have the pupils discuss principles of justice and right which should be applied in the problem situations which were presented.

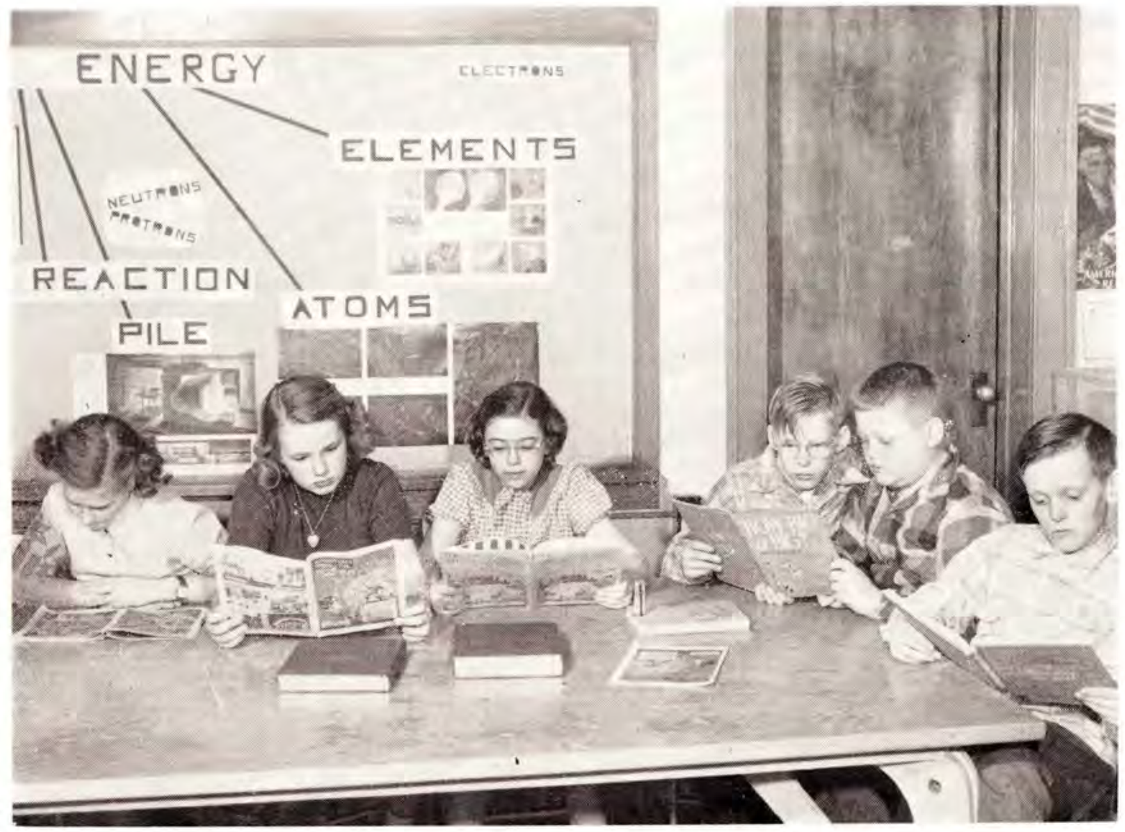
15. Whenever possible bring into the classroom foreign visitors, displaced persons who have been brought to the United States or people who have lived in foreign countries who can give pupils first hand information about the "humanness" of people who live in foreign countries and whose problems are basically the same as ours.

16. Prepare a bulletin board display of common dangers to mankind and common causes of suffering and sorrow. The pictures should represent different countries and regions of the world and may include such common enemies as floods, fires, droughts, illness, poverty, and accidents. Discussion among the pupils should center around possibility for world cooperation in overcoming these common dangers.

17. Prepare a class booklet entitled *Great Americans*. Have the class select the persons for this American "hall of fame" only after the class members have presented their candidates and given the reasons for their choices. A biography should be written for each person selected. It might be made more interesting by the inclusion of pictures or sketches.

CHAPTER IV

ATOMIC ENERGY IN ELEMENTARY SCHOOL LANGUAGE ARTS



Fifth Grade Pupils Do Research Reading
(Campus School, Iowa State Teachers College)

INTRODUCTION

In the language arts program we attempt to develop the skills which make language an adequate means of communicating ideas and a satisfactory tool for thinking. The language arts have little content material in themselves, but the skills which they develop serve as tools to be used in developing understandings in subjects such as elementary science and social studies.

In the language arts program atomic energy materials may be used if the learnings resulting are valuable for children, and if they are challenging enough to be good media for developing the language skills. Any materials which contribute indirectly to the building of attitudes and qualities desirable for a citizen in the atomic age may also be used.

OBJECTIVES

The Commission on the English Curriculum, National Council of Teachers of English, gives the following as two of the objectives of English instruction in terms of the major purposes of education: (1) The cultivation of wholesome personal living, (2) the development of social sensitivity and effective participation in group life.

Skills which would contribute to the development of these major purposes of education and which we can help to develop in our language arts classes are:

1. The ability to read with understanding science and social studies materials that deal with elementary ideas related to atomic energy.
2. The ability to base judgment on authoritative information.
3. Skill in discussing "debatable questions" with logic and in a friendly way.
4. The ability to discuss clearly various issues related to atomic energy.
5. Skill in the interpretation of pictures and diagrams.
6. The ability to get along with people.

The development of the following skills—the ability to persuade, to explain clearly, to make reports, to plan in groups, to defend a point of view, to engage in group discussion, and to interview others—are necessary in order to discuss clearly the issues involving atomic energy and its uses.

In order to read with understanding science materials that deal with elementary ideas related to atomic energy, these abilities should be developed: ability to use reference materials, skill in note taking, outlining, adapting reading techniques to the material and purpose in hand, organizing materials from several sources into one report, the ability to determine the relative importance of different facts.

Some of the attitudes which we can help to build in language arts are:

1. We all need to understand better the people who live in other lands.
2. We need to work for a world in which all nations are friendly towards each other.
3. We need to learn to respect people in other nations for their good qualities.
4. Nations, as well as individuals, should be judged only on their merits.

ACTIVITIES

The following activities may justifiably be carried on during the language arts period:

1. Current articles on energy, its transformation from one form to another, the use of radium, the spectroscope, and the cyclotron from such periodicals as *My Weekly Reader, Young America, Junior Scholastic, Young Citizen, Junior News Review, Popular Science,* and *Current Science and Aviation,* may be used as source material in the preparation of individual reports.
2. In preparation of these reports children may outline material found.
3. A summary of the main points in pertinent magazine and newspaper articles may be given.
4. Articles from the sources listed above may be read in preparation for class discussion or group discussion on the problems of atomic energy, its use and its potentialities. For example such articles as "The Atom Power Plant of the Future," *Young America,* October 6, 1949, can be read in preparation for class discussion on the science of atomic energy and its peace-time uses in power and medicine.
   "Controlling Atom Power," *The Young Citizen,* February 21, 1949, might be read as a part of the preparation made for a group discussion concerning the control of atomic energy.
5. A specialist might be interviewed concerning the value of atomic energy in power, in medicine or in agriculture, with a report of the interview given to the class or written for the school paper. For instance, a doctor might be interviewed concerning possibilities for the use of man's knowledge of atomic energy in combating disease. (An example is the use of radioactive isotopes as tracers.)
6. A radio program, such as a radio quiz, could be worked out on the peace-time uses of atomic energy or on the control of atomic energy. (At the elementary school level this would probably be a mock radio program.)
7. An assembly program on the many uses of atomic energy can be organized and presented.
8. An article about atomic power can be written for the school paper.
9. Children can read about the lives of famous scientists who have made important discoveries in the field of atomic energy.
10. Original dramatizations can be worked out based on the lives of some of the scientists who have contributed to our knowledge about atomic energy.
11. A vocabulary of terms necessary in the discussing of atomic energy can be developed.
12. A "spell-down" can be carried on in which the terms developed in the vocabulary may be spelled. (Also a spell-down on "meanings" of the terms.)
13. Book recommendations can be written or given orally on such books as *You and Atomic Energy* and its wonderful uses by John Lewellen and *Picture Book of Molecules and Atoms* by Jerome S. Meyer.
14. A class notebook showing interesting information about atomic energy might be developed. This notebook could contain clippings and written materials classified under appropriate headings.

DEVELOPMENT OF ATTITUDES

Through guiding the reading and providing an opportunity to discuss matters of personal, local, national, and world interest we can extend the interests of children and lead them to a recognition of the inter-dependence of people and nations in the world of today, a respect for people in other nations because of their good qualities, and a better understanding of people who live in other lands.

The exchanging of letters between schools or students of other countries may help to develop desirable attitudes toward other nationalities or races. A "Pen Pal Club" is one way in which this may be done.

In developing desirable attitudes toward people of other countries the literature period may be used to advantage.

The following list* of books may be useful in developing such attitudes:

Primary Grades

Beskow, Elsa, *Pelle's New Suit*
Buck, Pearl S., *Chinese Children Next Door*
Fabres, Alice, *Anne and Maryke*
Flack, Marjorie, *The Story About Ping*
Lattimore, Eleanor, *Three Little Chinese Girls*
Perkins, Mrs. Lucy F., *The Dutch Twins*

Intermediate Grades

Arason, Steingrimur, *Smoky Bay, the Story of a Small Boy of Iceland*
Bothwell, Jean, *The Thirteenth Stone*
Buff, Conrad, *Kobi, A Boy of Switzerland*
Chrisman, Arthur B., *Shen of the Sea*
Davis, Robert, *Pepperfoot of Thursday Market*

*Selected from "The Iowa Reading Circle" list for 1949

Dodge, Mrs. Mary M., *Hans Brinker or the Silver Skates*
Evans, Eva Knox, *All About Us*
Evernden, Margery, *The Secret of the Porcelain Fish*
Fisher, Lois, *You and the United Nations*
Hillyer, Virgil M., *Child's Geography of the World*
Lattimore, Eleanor F., *Little Pear*
Lide, Mrs. Alice, *Yinka Tu the Yak*
Lownsbery, Eloise, *Marta the Doll*
Moon, Mrs. Grace, *Chi Wee*
Rankin, Mrs. Louise, *Daughter of the Mountains*
Shannon, Monica, *Dobry*
Sperry, Armstrong, *Bamboo, the Grass Tree*
Sperry, Armstrong, *Coconut, the Wonder Tree*
Spyri, Johanna, *Heidi*
Stefansson, Evelyn, *Here is Alaska*
Von Hagen, Christine, *The Forgotten Finca*
Voronkova, L., *Little Girl From the City*

CHAPTER V

A CLASSIFIED LIST OF ILLUSTRATIVE ACTIVITIES

Introduction

Learning experiences which contribute to atomic energy education are to be found in various parts of this source book. This chapter is designed to classify a number of these activities in such a way that they will be readily accessible.

For instance, a teacher may be interested in preparing a bulletin board and may want to find quickly some useful suggestions. This classified list will, in a sense, serve as a "cafeteria" of ideas.

Bulletin Boards

1. Keep a section of the bulletin board up to date with items concerning atomic energy. This can be done by a class committee.

2. Prepare a bulletin board spread on the various types of energy, including electrical, chemical, heat, muscular and nuclear energy. Find pictorial illustrations from newspapers, magazines, and discarded science textbooks. The bulletin board should be planned with the children.

3. Post a list of elements and their atomic weights. Include the name of the discoverer and his native country.

4. Post graphical illustrations of the make-up of atoms.

5. Prepare a display on the bulletin board to show the principle of chain reaction.

6. Post the atomic energy illustrations taken from *Life Magazine*. (See Appendix I) Use illustrations found in other periodicals.

7. Make a cartoon collection on atomic energy and arrange it on a bulletin board. Such cartoons may be found in current events papers for children. The *Young Citizen*, Vol. IX, Number 23, March 6, 1950, contains cartoons that could be used.

8. Have a committee of children prepare a bulletin board based upon drawings made by the pupils. These drawings might include (1) the structure of various atoms, (2) chain reaction, and (3) peacetime uses of atomic energy. These illustrations might also be patterned into a mural.

9. Prepare a bulletin board which includes pictures of scientists who have contributed to our knowledge of atomic energy. Many magazines and newspapers will present both formal and informal photographs of such men and women as Einstein, Fermi, Madam Eve Curie, Lise Meitner, and Lawrence. This bulletin board display might include a map of the world showing the native countries of each of these scientists. Such a bulletin board would be a good culminating activity for an atomic energy unit.

10. Prepare a bulletin board which compares mining for gold in 1849 and mining for uranium today. If the class cannot find an adequate number of illustrations from discarded textbooks, rotogravure sections of Sunday newspapers and periodicals, they could make their own illustrations.

Constructional Activities

1. Make posters on world citizenship or on the international control of energy.

2. Plan a mural showing the peacetime uses of atomic energy.

3. Make drawings which help explain the structure of the atom.

4. Make a date line showing when different men discovered different facts about the atom.

5. Prepare a chart which shows applications of the various types of energy. For instance, electrical energy could be shown at work in the operation of motors, flashlights, electric stove, telephone, telegraph, electric bell, etc.

6. Collect pictures of scientists who have made important contributions in the field of atomic energy. Use these in making an electrical identification chart in which the operator identifies the picture of each individual with his name and statement of the contribution which he made.

7. Make a historical date line showing the lapse of time between important discoveries which led to the discovery of how to release the energy of the atom.

8. Make a large picture chart to show the differences among different races and cultures in the world today in the use of power and energy. The chart may show means of transportation in such different regions as the United States, Belgian Congo, the Amazon region, a desert area, and the far north. Other topics which the chart might picture include differences in household conveniences and differences in communication.

9. Have the children find the design used for the flag of each country of the civilized world. Children who are interested in the project may sew small flags according to each design. Display the flags in the classroom grouped in accordance with whether the country is a member of the United Nations or a non-member. The flags may be rearranged to show various friendship groups or different political ideologies.

10. Make a chart to show the process of plant growth through the use of energy from the sun. The teacher may obtain suggestions from the parts of science textbooks dealing with photosynthesis.

11. Have the pupils construct a water wheel to illustrate how energy is secured through running water. The wheel may be constructed by fastening tin blades or fins to a large size fruit juice tin can or to a wire spool. A rod extending through the center of the two ends of the can will permit the "wheel" to revolve as running water is permitted to strike the blades.

12. Have the pupils compile an illustrated book about child life in foreign lands. Encourage the pupils to collect first-hand information about recreation, transportation, holidays, and customs in various countries of the world. Draw pictures to illustrate the book. Each child or a committee of children may be responsible for the different chapters in the book.

13. Make a historical picture date line to show the changes in mode of life brought about by each new scientific development which increased man's source of energy. The date line may illustrate changes in home conveniences, changes in industry and occupations, changes in transportation and communication, and changes in number of hours devoted to work and to recreation and leisure time activities.

14. Have the pupils construct a steam turbine to demonstrate methods of securing energy from steam. The steam turbine can be made by cutting a wooden disc to which are nailed six blades or fins against which the steam is to be directed. Fasten a glass bearing in a hole cut in the center of the disc. Arrange a standard and a pole with a nail on the top of which the disc might revolve readily. Equipment for generating steam to be directed against the blades might be a tin oil can heated over an electric plate and fitted with a rubber tube for directing the steam against the blades. An experiment with steam should be carried on with extreme caution. (Upper grade activity.)

15. Secure a large outline map of the world. The size of a map may be expanded through placing a smaller map under an opaque projector and tracing the outline as the map is projected on the wall. On the large outline map show by pictures the location of important sources of energy in the world. Water falls, dams, and supplies of uranium may be shown on the map.

16. Prepare a series of picture maps depicting various aspects of life in countries throughout the world. One map may show recreational activities popular in different parts of the world, one may show methods of cooking and heating homes, one may show celebration of national holidays throughout the world, one may show dress and costumes in various parts of the world, and one may show famous people from various countries of the world.

17. Analyze the nationality backgrounds of the people in the community in which you live. Attempt to determine how many people of each nationality are found in your community. Indicate your findings on an outline map of the world using the pictograph idea for indicating the number of people in the present community whose ancestors lived in each of the countries on the map.

18. Have each pupil learn as much as he can about his ancestors. Information about the nationality background, occupations, size of family, and interesting anecdotes and facts about the family should be included. Have the children write these family histories and combine them into a book about the class. Photos and drawings would add interest value to the book.

19. Prepare an exhibit of objects from various countries of the world. Solicit the assistance of the children in collecting objects for exhibit from as many different countries of the world as possible.

20. Have the pupils plan small parties or lunches in which the food from a different country is featured in each one. Recipes can sometimes be secured from people of different nationality backgrounds who live in the community.

Discussion Activities

1. Discuss the characteristics of a good discussion period. (Everyone understands the question to be discussed, attentive listening, respect for others' opinions, etc.)

2. Provide a daily or weekly current event period in which reports on current articles read may be given. These will include articles on atomic energy.

3. Discuss the atom, comparing it with our solar system.

4. Discuss the achievements of and some of the difficulties encountered by the United Nations.

5. Discuss the peacetime uses of atomic energy.

6. Discuss new kinds of jobs that will result from continued research and development of atomic energy.

7. Discuss how people live (especially the children) in communities where there are atomic energy plants.

8. Discuss what seem to be the most important things we should know about atomic energy.

9. Discuss how atomic energy may help to bring about conditions of world friendship and good will.

10. Discuss the meaning of the word *democracy*. Discuss ways in which we can make our living together at home, in the classroom, and on the playground more democratic.

11. Read and discuss poems, stories, and folk tales of various countries. Notice the similarity to each other and to our own folklore.

12. Discuss the basic needs of all mankind. What do the children in your class think they are? What relationship is there to the satisfying of these basic needs and world peace? What connection does atomic energy have to helping people throughout the world satisfy their basic needs?

Dramatizations

1. Dramatize a meeting of the General Assembly of the United Nations. Of possible equal importance would be to find out about the functions and the accomplishments of some of the specialized agencies, such as WHO, FAO, and UNESCO and present in dramatized form.

2. Present a skit of an imaginary trip to Venus or some other planet. Such a trip *might be taken* in a space plane powered by atomic energy.

3. Dramatize life in other countries such as a Mexican Christmas celebration, including the pesado and the pinata.

4. Plan and present a play of prophecy showing life at some future date with atomic energy under world control.

5. Plan to present a pantomime showing what kind of work people do in various countries throughout the world.

6. Plan a series of assembly programs in which several grades present dramatizations based upon the stories found in such books as those listed in Chapter IV of this publication.

7. Dramatize a historical event that has had or is having some effect on the development of *basic freedoms*.

8. Plan and present an original dramatization based upon the theme, "Our Class Learns About Atomic Energy." At junior high level the class might wish to consider such a title as "Atomic Energy: Man's Masterpiece or Man's Master?"

Exhibits

1. Arrange a display of various elements such as mercury, sodium, carbon, iron, mica, nickel, copper, aluminum, gold, zinc, and lead.

2. Collect samples of chemical compounds such as salt, sugar, baking soda, washing soda, glycerine, vinegar, and the like.

3. Make a collection of tools that are simple machines. Tell what kinds of simple machines they are and how they help people do work.

4. Prepare an exhibit, either of pictures or of models, showing the various forms of energy.

5. Prepare an exhibit of commodities in everyday use which have come from different regions and parts of the world. The exhibit can be made more interesting and colorful by having the pupils sew a flag for each country represented in the exhibit. Examples of products which may be included in the exhibit are coffee from Brazil, tapioca prepared from manioc roots of Paraguay, sugar from Cuba, coconut from India or the Guianas, bananas from Jamaica, sardines from Norway, olives from Spain, and dates from Arabia.

6. Arrange an exhibit of newspapers from as many different countries of the world as possible. Prepare a small card of information about each telling the cost, frequency of publication, circulation figures, proportion of space devoted to advertising and the various sections included in each.

7. Arrange a display of children's books which deal with life in various parts of the world. A large map of the world used as a background for the exhibit may indicate the part of the world with which each book deals. A few examples of books which may be included for different continents, countries, or regions include: *EUROPE—Dobry* by Monica Shannon (Bulgaria); *The Good Master* by Kate Seredy (Hungary); *The Cottage at Bantry Bay* by Hilda Van Stockum (Ireland); *AFRICA—The Cow-Tail Switch* by Harold Courlander and George Herzog, *Kinter* by Elizabeth Enright; *ASIA—Young Fu of the Upper Yangtze* by Elizabeth Foreman Lewis (China); *Little Pear* by Eleanor Lattimore (China); *Gay-Neck* by Dhan Gopal Mukerji (India); and *Eastern Stories and Legends* by Marie Shedlock (India).

8. Arrange a display of books for interpreting various minority groups such as the American Indian, the American Negro, migrant workers, and other groups. Pictures may be used to add to the interest value of the display. Authors whose books may be examined in selecting books for the exhibit include Eva Knox Evans, Eleanor Frances Lattimore, Arna Bontemps, Jesse Jackson, John Lewis, Florence Crannell Means, Laura Armer, Florence Hayes, May Justus, Grace and Carl Moon, and Valenti Angelo.

Experiments

1. Experiment with such elements as mercury, carbon, iron, mica, nickel, copper, aluminum, gold, zinc and lead to discover whether they could be attracted by a magnet, to see how they compare in weights, and to see whether they burn. This would show some of the ways in which we can tell elements apart.

2. To show molecular motion in a liquid, fill a fairly tall glass vessel with water and allow it to stand until all apparent motion has stopped. Pour in gently a small amount of dye. Do not disturb. Notice the progress of dye through the water.

3. To show molecular motion in gas, open a bottle containing anything with a pronounced odor. With all windows and doors closed note the length of time required for the odor to reach all parts of the room.

4. To show the difference between a physical and a chemical change, melt some paraffin or wax. Then allow it to cool. Notice that it changes back to a solid when it cools. However, it is still wax and not another substance. A chemical change results when the material changes its composition. Example: When wood is burned, part of it becomes ashes, which cannot be changed back into wood.

5. Chemical energy may also be shown by using baking soda and vinegar. Their chemical reaction will produce carbon-dioxide gas.

6. Sunlight provides energy that causes a plant to grow in the direction of the sunlight. Place a plant in the same position for two or three weeks in a window that has sunlight. Change the position of another plant of the same kind each day. Observe the difference in the proportion of the two plants. The plant that remained in the same position will have abundunt growth on the side exposed to the sun while the other side will appear dwarfed. The plant that received the same amount of light to all parts will have a well proportioned appearance in growth.

7. To show that sunlight provides energy that the clorophyll in plants uses, cover some leaves of a plant by tying a paper sack around a plant. After a week's time remove the covering to observe the loss of green coloring.

8. Place a box over a place on the lawn and observe in a week's time change in color of the grass.

9. In order to show that when substances change form there is a transfer of heat energy, place equal weights of water, at freezing temperature (32° F.) and at boiling temperatures, in the same container. With a thermometer record the resulting temperature of the mixture.
Next place the same weights of *ice* and boiling water together and again record the temperature of the resulting mixture.
The lower temperature of the second mixture may be explained as follows: Heat is taken from the water, first to melt the ice to water at the same temperature. More heat is then taken from the hot water to warm the ice water. The resulting temperature will be lower than was the case when freezing water was mixed with boiling water.

10. Fasten a silk thread six or eight inches long to a pithball. Hang it from a support made of wood. Rub a hard rubber rod with a piece of wool cloth. Bring the rod close to the pith ball. At first the rod attracts the pith ball. In a short time when the rod touches the pith ball the ball is repelled. Like charges repel and unlike charges attract.

11. Electrical charges may attract or repel each other. It is a well-known law that like charges repel and unlike charges attract. This law can be illustrated by the following experiment: Place the North poles of two bar magnets about 1 inch from each other. Put a piece of cardboard on top of the magnets and sprinkle iron filings lightly on the cardboard. Tap the edge of the card lightly and notice that the iron filings form into a pattern representing the magnetic lines of force of the two poles. It will be evident that these magnetic lines of force are repelling each other. If the North pole of one magnet is placed near the South pole of the other magnet, the iron filings will line up in such a way as to show that these unlike poles are attracting each other. This experiment will provide background knowledge which will help the pupils to better understand how the positive charge in the nucleus of an atom may hold the negatively charged electron in its orbit.

12. To clarify further how an electron may be kept in its orbit, the pupils could perform the following experiment: Fasten a thread to a small rubber ball. Have one of the pupils whirl the ball perpendicular to the ground. The speed of the ball will keep the string tight while at the same time, the string will prevent the ball from flying off into space at a tangent to the circle it is making. If the speed of the ball's whirling motion becomes great enough, the thread will break and the ball will fly away from the circle. If the nucleus of an atom lost its charge, the electron would probably leave its orbit in a similar fashion.

13. Use mouse traps and corks to clarify the idea of the chain reaction. See frontispiece and Chapter VI. This experiment can also be found in *Chemistry*, February 1949, p. 17.

14. Dominoes can also be used in demonstrating the idea of chain reaction.

15. Illustrate atoms smashing by the use of marbles. Fill a shallow wooden bowl with marbles representing the nucleus of an atom. Throw a marble into the bowl and notice what happens. If one or more marbles pop out of the bowl this will demonstrate the fission of the nucleus, i.e., the nucleus will be releasing neutrons.

Intergroup Activities

1. Exchange letters with boys and girls of other countries or in other parts of the United States. (Letters make friends across the oceans.) This may be done through the help of such organizations as (1) The Junior Red Cross and (2) The Caravan, 132 East 65th Street, New York, N. Y., and (3) *Playmate* magazine. In introducing international correspondence, it is important to explain that letters sent abroad often give the recipient his most vivid impression of people of the United States, consequently, these letters should be written thoughtfully. Enclosures such as snapshots and small regional souvenirs add interest.

2. Exchange costumed dolls, school work, and art work with children of other countries. This may be done through the Junior Red Cross.

3. Prepare Junior Red Cross boxes.

4. Write the local or county chairman of the Junior Red Cross asking for suggestions as to other ways in which the school can cooperate in the Junior Red Cross program.

5. Plan for the class or school to sponsor a needy child or family in some foreign country.

6. Write to the United Nations for literature about other nations.

7. Invite displaced persons who are living in the community or visitors from a foreign country to meet with the pupils to tell about life in their home country and to answer the questions of the children about the mode of life in other countries.

8. Prepare a snap shot picture book which requires a minimum amount of writing to send to a group of foreign children. Include pictures of the pupils, the school building, school activities, in-

dustries and farms of the region, means of transportation, wild flowers, trees and other vegetation, celebration of such holidays as Christmas, the Fourth of July, or Thanksgiving Day, as well as homes and other aspects of living in America which may prove interesting to foreign children.

9. Make a box movie roll to be sent to a foreign school in which the children illustrate through drawings a typical day for the American child. The movie might include pictures of any aspects of the environment or community life which the children are interested in drawing.

10. Discover through correspondence with some foreign school what favorite American foods the children of the foreign country have not had the opportunity to enjoy. Endeavor to send by air mail a "treat" for some foreign classroom group. It may be necessary to send directions for completing the preparation of the treat. Possibilities may be such foods as candies, jello, powdered malted milk, prepared pudding, or boxes of cake and cookie mix.

11. Make and send to a foreign school with which the children have had correspondence, costumes which the foreign children might use in dramatization of stories from American life. Examples might include Colonial costumes, costumes for "Uncle Sam," Indian costumes, or Pilgrim costumes.

12. Prepare a large chart on heavy wrapping paper so that it can be folded on which development of certain aspects of American life are depicted. The chart might include such topics as the development of transportation—including pictures of stage coaches, post riders, conestoga wagons, old trains, etc., with modern means of transportation also pictured—styles of homes from Colonial days to the present, changes in household equipment and conveniences, changes in the industries and occupations of the community in which the pupils are living, changes in styles of dress, changes in popular recreation and sport, and other topics in which the pupils are interested.

Map and Globe Projects

1. On a map of the world show the location of the known chief deposits of uranium and where atomic energy plants are located.
2. Prepare a map showing from what countries different atomic scientists came.
3. Measure distances with a string on an azimuthal-type map. Measure the shortest distances from central U. S. to various countries or cities of the world. This will help to show how near our neigbors really are.
4. Show on a map the native countries of discoverers of some of the elements.
5. Prepare map showing the location of plants and universities conducting atomic research. *Supplement to School Life*, Vol. 31, March 1949, p. 10.
6. Locate the members of the United Nations on a globe or map and notice their physical relation to each other.
7. Plan and develop a pictorial map having trade routes which show the contributions of various nations or world regions to each other.
8. Trace on a cartograph globe the shortest distance from New York City to various major cities in Russia and China. Show how by taking the shortest route we must revise our ideas of direction and distance.

Reading Research

1. Ask children to look around the room and pick out things that they think are not made of elements. Each child can then look up his selected compound. For instance, if cellulose were looked up it would be found that it consisted mostly of carbon, hydrogen and oxygen. This would help to show that all things are composed of elements.
2. Read the story of the Curies as well as other nuclear scientists.
3. Read to find out about the gold miners of 1849 and the uranium miners of 1950, so that a comparison between the two can be made as to equipment, profit, etc. You will note frequent references to uranium prospectors in current newspapers.
4. Read about wind, water, and steam as sources of power in order to make a comparison as to availability, dependability, cheapness, and exhaustibility. Also read to find uses which are being made of these sources of power.
5. Read to compare accident rates in atomic energy plants with those of other industries.
6. Read to find about scientists who have contributed knowledge about atoms and atomic energy, such as Sir Ernest Rutherford, Lise Meitner, and Ernest O. Lawrence.
7. Investigate to find out how boys and girls of the member United Nations are being educated. Are their systems of education *democratic*?
8. Use science books and a dictionary to find out the meanings of certain words that are closely related to the study of atomic energy.
9. Secure a number of newspaper accounts of developments concerning power or atomic energy. (Children's comic books might also be used.) Through group reading and discussion classify each statement in the article as to whether it is a statement of fact (something which actually occurred or was discovered) or a statement of opinion (statement of belief). Discuss with the children the fact that some words arouse a favorable reaction (Christmas, home, picnic, etc.) and other words arouse unfavorable feeling (pain, sorrow, traitor, spy).
10. Have the children record descriptive words, names, or comparisons which are used in radio and newspaper accounts about people and nations which tend to give the reader an unfavorable reaction toward them.
11. Have the pupils list simple machines found in the room. Examples might be pencil sharpen-

ers, staplers, revolving chairs, roller skates, etc. Have the children classify these machines by studying descriptions and illustrations of the major classes of simple machines. Read about and discuss advances likely to be made in the development of machines due to the uses of atomic energy.

12. Have the pupils read biographies of some of the leading world scientists. Have the pupils indicate how each scientist proceeded to (1) define and delimit the problem (2) review his own and others' past experiences with the problem (3) draw up a hypothesis, theory, or belief concerning the problem (4) test or verify his hypothesis and (5) discover and state the new generalization, principle or discovery which resulted from the work of the scientist.

Preface to Chapter VI

The following story* was prepared by Mr. James R. Wailes and used as the basis of an experimental unit in a fifth grade class at the Campus School, Iowa State Teachers College.

The United States Atomic Energy Commission has informed this committee that it receives twenty to thirty letters daily from elementary school children requesting information about atomic energy. Apparently many schools throughout the country are trying to find out if there is available material on the subject at the elementary and junior high school level.

There appears to be evidence, also, that there is a growing fear of atomic energy among children and youth. The truth of the matter is that newspaper headlines and radio broadcasts are likely to play upon the fearsome aspects of atomic energy since a calm and subdued approach does not attract attention and the jitters of adults may readily filter down to our children and develop feelings of worry and insecurity. Thus it becomes increasingly clear that teachers throughout our country have a clear-cut "job to do" in acquainting children at the elementary school level with the true story of atomic energy. Understanding and informed opinion are the best weapons for combatting fear.

Here are stories which may help both teachers and children learn about atomic energy. The stories may be used as supplemental materials in a general unit on energy or in any other manner the teacher desires.

Suggestions are included throughout this bulletin and also with the stories for illustrative activities and teaching aids.

*This story is published also under separate cover. Thus it is available for class use with children.

CHAPTER VI*

BARBARA AND HOWARD DISCOVER ATOMIC ENERGY**

The Twins Get Interested

Howard Dawson picked up the *Daily Record*. His eyes grew big as he read the headline, "Atomic Engine To Take Rocket to Moon."

"Say, Barbara," he exclaimed, "How would you like to fly to the moon? Here's an article that says it'll take just four days to make the trip! Isn't *that* something!"

"Why that's impossible," Barbara answered, "And perfectly silly!" But when Howard handed her the paper, she read the story from beginning to end. "My, I wonder what the earth would look like if we were on the moon. Do you really think that people will take a trip to the moon some day?"

"Well," replied Howard, "according to the paper there's a chance that rockets will travel to the moon before 1975. Of course, it'll probably be many years before one of these rockets will carry *people*. Scientists are moving so fast with atomic energy that they're planning a lot of things with atomic energy power plants."

"Well, Howard," asked Barbara, "just what is an atomic energy power plant? The newspaper mentions it twice. It tells about the rocket. And then it goes on to talk about making electricity with an atomic energy powerplant."

Howard was proud of being "electricity wise" and that was an easy one for him to answer. "A power plant is where we get power. The motor in an automobile is its power plant. The electric power plant downtown makes electricity to light our homes, run the refrigerator, and run our electric train."

"There are different kinds of energy,"[1] he continued. "We've studied about chemical energy, heat energy, and electrical energy. Energy that is found in coal, gasoline, and wood is 'stored' energy. 'Moving' energy may be a waterfall or a moving object. Energy, of course, is needed before any work can be done."

"Okay for *power plant* and *energy*. But what does *atomic* mean?"

"You've got me there. I'm stuck. Let's look it up."

*The Production Committee is grateful for the many useful suggestions made by Mrs. Joyce Wailes and Miss Margaret Day in the development of this story. Miss Ruth Wagner, Assistant Editor of the Midland Schools, Iowa State Education Association, was of invaluable help in the final editing of the manuscript.

**All superscripts in this story refer to *suggestions for the teacher*. These suggestions are found at the end of this chapter.

They went to the living room and got the big dictionary. Barbara located the word *atomic*. "Here it is, Howard! It means, *pertaining to atoms*. That doesn't help much, does it? So let's see what the word *atom* means!"

"Here's the word *atom*. It is 'the tiniest particle of a thing and all elements in the world are made of atoms.' Now, what are elements?"

"I don't know that either," answered Howard. "I'll look in the encyclopedia."

"An element is a part that cannot be separated into any other element. Gold and silver are elements," Barbara read.

Howard read on a little further. "Look, here's a whole list of elements and the names of the people that discovered them.[2] Just look at all the different countries they represent! And here are some interesting pictures of elements and the places where they are used."[3]

Iron Chain | Gold Ring | Helium Gas | Neon Gas in Signs | Uranium | Iodine

After they had looked at the pictures, Howard continued, "The encyclopedia says that everything in the world is made of elements, and that elements are made of atoms."[4]

"Okay, then let's find out just what atoms are," said Barbara.

Howard took the "A" volume from the shelf and found the word *atom*. The twins both began to read. In a few minutes Howard remarked, "Atoms are certainly not new! In 400 B.C. a Greek, Democritus (de-moc' ri-tus), said that everything in the world was made of tiny pieces. Democritus called these little pieces *atoms*.[5] He said that all trees, rocks, people, and everything was made of atoms. The people of Greece laughed at him. Another Greek, Aristotle (ar' is-tot'l), decided that everything was made of elements. He said that one element couldn't be changed to another element."

Barbara continued the story, "During the next 1500 years many men tried to make gold out of rock and copper. These men were called *alchemists*. They would mix secret mixtures and then boil a rock in the mixture. They would even speak magic words over the potion but they could not make gold. Aristotle's statement was correct!"

The children read further. As they read, they ran into such words as "electrons," "protons," "neutrons," and "nucleus."

At last Howard heaved a big sigh and closed the book. "Brother, I don't get it! This is too hard for me to understand!"

"Say, Howard," said Barbara, thoughtfully, "Remember when Father told us about the new man at the plant?"

"You mean Mr. Anderson?" answered Howard.

Cartoon Picture Book Tells Story of Atomic Energy Development in Understandable Way
From General Electric's *"Adventure Inside the Atom,"* Copr. 1948—General Comics, Inc.

"Yes, he worked at the atomic energy plant at Oak Ridge, Tennessee. I'll bet he'd tell us about atoms—and how a rocket could zip to the moon on atomic power. Let's call him."

"Sure enough," said Howard, "We might as well try."

Barbara ran off to telephone and in a few minutes came back carrying her jacket. "He'll see us right away, Howard. Let's go!"

As they left the house Howard said, "I know exactly what I'm going to ask Mr. Anderson! I want to know about the atom itself, of course, and then I want to know more about this business of splitting the atom and getting atomic energy."

"Are there other uses for atomic energy besides a rocket? That's my question," replied Barbara.

What Is an Atom?[6]

Several blocks later they entered a large, red brick building. The twins went directly to Mr. Anderson's office. A friendly voice answered their knock and invited them in.

Mr. Anderson smiled at his eager young guests. "Now, what's all this you have on your mind? Did I hear you say 'atoms' . . . and 'atomic energy'?"

"Yes," answered Howard. "It all began when we read this morning's newspaper. One thing led to another and Barb and I began reading about atoms and atomic energy, and—well, pretty soon we were lost!"

"I'll be glad to answer your questions *if* I can. There are still a lot of facts about the atom that we don't know, of course."

So Howard "kicked-off" the discussion with the question, "Mr. Anderson, how is an atom formed?"

Mr. Anderson leaned forward in his chair, lighted his pipe slowly, and began:

"Our scientists of today tell us the atom is made chiefly of protons, neutrons, and electrons. I'll draw a simple picture of them for you:

Proton | Neutron | Electron

We've not always known this. Democritus thought the atom was one tiny solid piece of material. In 1897, Thomson (Tom' son) of England said that an atom was made of *two* parts. He said an electron revolved around a nucleus, or the center of the atom."

"Another Englishman, Sir Ernest Rutherford (ruth' erford), decided there must be something like gravity to keep the electron from flying away. He decided there must be a positive charge of electricity in the atom's nucleus."

"Sometime later Dr. Bohr (Bōr) of Denmark developed an idea of what an atom might look like. Here is the picture that shows what he was thinking of," continued Mr. Anderson.

"Why, that looks something like our solar system! You could almost say that the nucleus was the sun and the electron was one of the planets!" exclaimed Howard.

"I wonder why Dr. Bohr thought an atom looked like that."

"He reasoned this way, Howard. If the electron revolved around the nucleus, something had to hold it there. Do you know what an electron is, Howard?"

"An electron is a negative charge of electricity and has a minus (—) charge. Sometimes it is called a negative charge. And a proton has a positive or plus (+) charge of electricity," Howard replied immediately.

"Doesn't that give you a clue?" Mr. Anderson asked.

"Oh, I get it!" exclaimed Howard. "They are opposite charges so they will attract each other. It would be something like taking the N pole and the S pole of two bar magnets and placing them together. They stick."[7]

"Now, you're on the right track. Lightning is a good example of attraction and the movement of electrons."[8]

"But what does lightning have to do with atoms?" asked Barbara.

"Lightning is electricity. Electricity has something to do with protons and electrons. And the atom is made of electrons and protons," said Howard.

Mr. Anderson was pleased with his "pupils." "There's a lot to think about, isn't there?"

"I get the picture so far. I see two parts of the atom in place. The proton is in the nucleus and the electron is revolving around outside. Now, what is the neutron, Mr. Anderson?" asked Howard.

"Does the word neutron look like any other word that you know?"

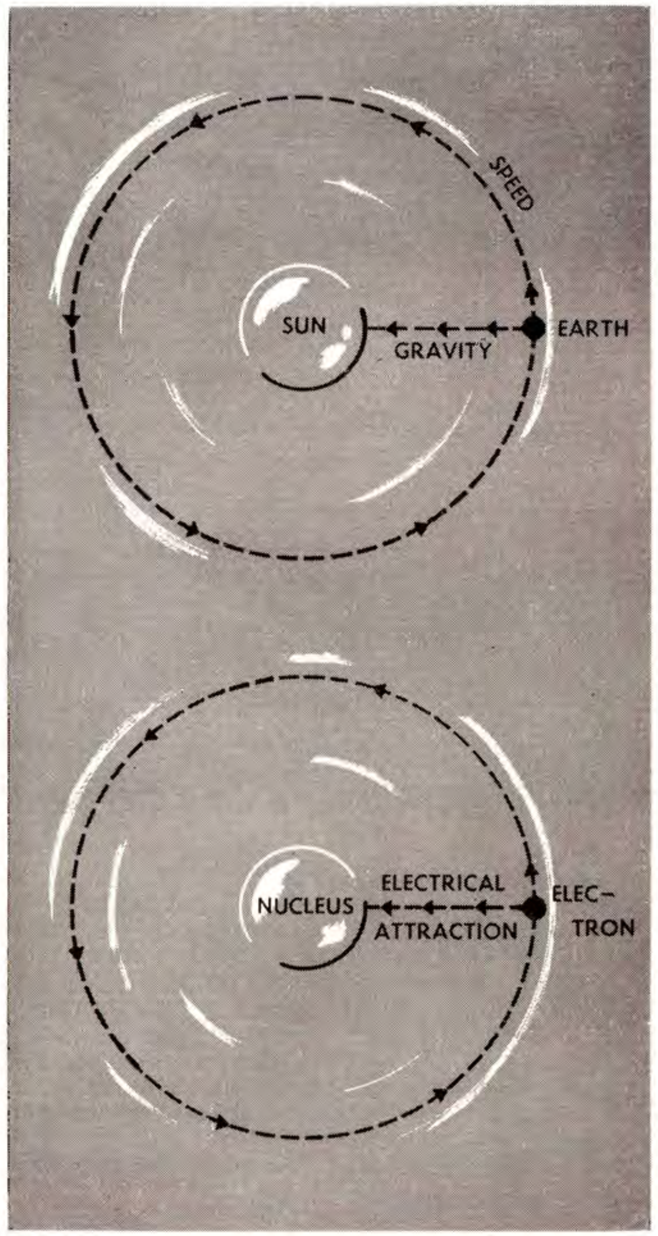
"Neutron—neutral! Say, when we put our car in neutral it doesn't move either forward or backward. Could a neutron be halfway between a positive and negative charge of electricity?"

"That's something like it, Howard! The neutron is made of one electron and one proton and it doesn't have any charge," said Mr. Anderson. "The protons and the neutrons make up the nucleus of the atom."

Barbara looked puzzled and said, "I think I can imagine the protons and the neutrons in the nucleus, but what's going to keep that electron from flying away?"

"It's something like our sun in relation to our earth," answered Mr. Anderson. "The sun's gravity is pulling on us all of the time. The same is true in the atom. The proton pulls on the electron by *electrical attraction*."

"Then, why wouldn't the electron be pulled into the nucleus of the atom?" questioned Barbara.



"It's because of the speed at which it revolves around the nucleus. Again it is something like our earth and sun. Our speed in revolving around the sun keeps pulling away, but the sun's gravity holds us."

"Can we look at an atom through a microscope, Mr. Anderson?"

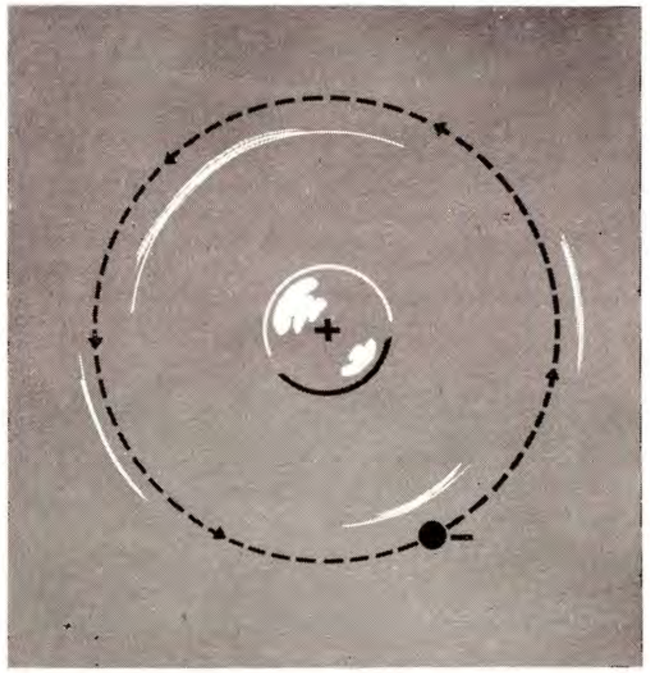
"No, Howard, we cannot *see* an atom. No one has ever seen one and probably no one will ever see one. Actually, it would take billions[9] of atoms to cover the dot over an "i." When we write with a pencil we leave a stream of lead atoms on the paper. Even the smallest mark you make with a pencil will contain billions of atoms."

"Jeepers!"[10] exclaimed Howard.

"It stretches your imagination, doesn't it?"

"I'll say it does!" replied the twins almost in unison.

"There's another fact about the atom that's hard to imagine. We've discussed how tiny the atom is and what parts it contains. We've said that it looks somewhat like a solar system. Now, you must remember that there's a lot of space between the sun and the earth and the same is true in the atom. Here's a drawing of the *hydrogen* atom:



"The nucleus of ordinary hydrogen has one proton and one electron revolving around it."

"Now kids, get your imaginations working!" said Mr. Anderson, "and then listen to this."

"If we were able to enlarge the nucleus of that atom to the size of a baseball, the electron orbit would have to be placed eight blocks away!"[11] Mr. Anderson measured the size of a baseball with his hands and then pointed out the window down the street.

"Golly," exclaimed Howard, "then an atom is almost all empty space, isn't it?"

"Right! The little nucleus of the atom is the only solid part of the atom."

"Then if everything is made of atoms, why does iron seem so hard and weigh more than aluminum?" questioned Barbara.

"It's because the atoms are different and some atoms weigh more than others. The story of how scientists discovered the weights of atoms is interesting, but I don't think we should take time to go into that now."

"I see!" exclaimed Howard. "An iron atom would weigh more than an aluminum atom. That's why there's a difference in weight."

"We can find out a little more about weights by looking at this table of the elements,"* said Mr. Anderson.[12]

"Here is a complete list of all the elements and their atomic weights. We have 98 elements now, but there may be more discovered anytime. In 1869 the scientists thought there were just 75 elements in nature. When I went to school, I learned that there were 92. In 1940, scientists discovered they could make some new elements. Since then they have made six new ones.

"Look at the atomic number. It tells us the number of protons in the nucleus. The first one, hydrogen, has only one proton and is the lightest known element.

It is lighter than air because air is made largely of nitrogen and oxygen. The atomic weight is the total number of protons and neutrons in the nucleus. Since hydrogen has just one proton, it has an atomic weight of 'one.'[13] The second element is helium which is also a gas. Helium is used in dirigibles because it is also lighter than air."

"Why don't they use hydrogen in dirigibles since it is lighter than helium?"

"There's another difference, Howard, besides the weight. Helium will not burn. Hydrogen is explosive and will burn. Therefore, even though helium is four times heavier than hydrogen, helium is used in dirigibles because it is much safer."

Barbara read the column marked *atomic weight* and then asked, "Hydrogen has an atomic weight of 'one' because it has one proton in the nucleus. Helium has two protons in the nucleus and an atomic weight of 'four.' Does that mean there are two neutrons in the nucleus with the protons?"

"Correct, Barbara! I will draw a picture of the first three elements in the table.

"There are always as many electrons as protons in the atom. The number of neutrons may be different as we have already seen in the case of lithium."

"Is atomic weight in pounds?"

"No, Howard, the atom was too small to weigh by any method we had.[14] The only thing we could do was to set up a new system of weights. When you talk about the weight of atoms always think in terms of *atomic* weight, rather than of pounds or ounces.

"Let's look again at the table of elements," continued Mr. Anderson. "The uranium atom has an atomic number of 92. That tells us that there are 92 protons in the nucleus and 92 electrons revolving around the outside. The atomic weight of one form of uranium is 238. Could either of you figure out how many neutrons are in the nucleus of the uranium atom?"

The children glanced at the picture of the helium atom and started subtracting numbers. Barbara had the answer first, "146 neutrons!"

"Good! Tell us how you arrived at that number?"

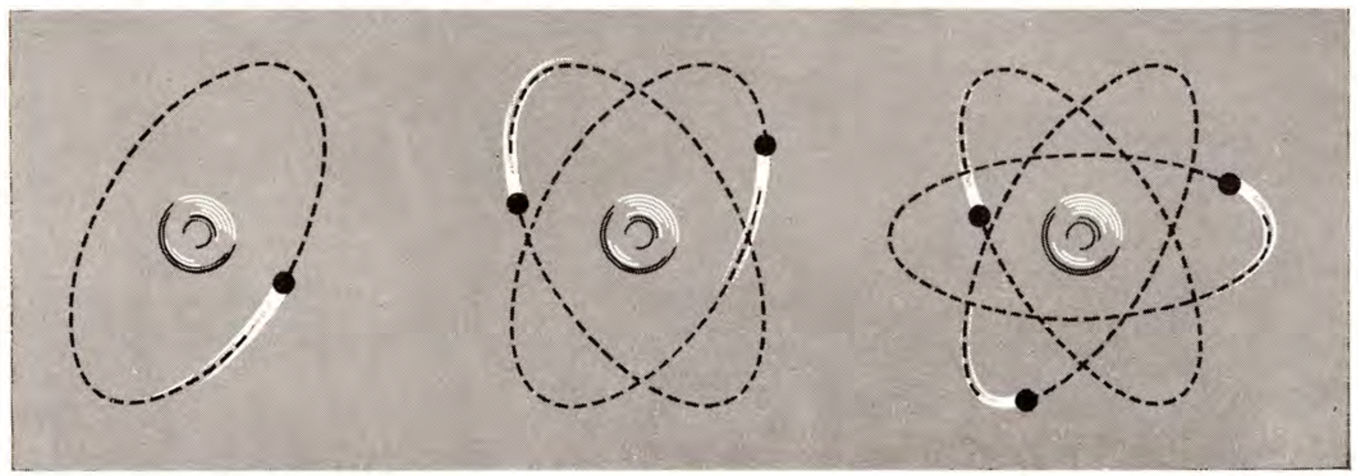
She explained, "The nucleus is where all the weight is and it is made of protons and neutrons. If there are 92 protons, the rest has to be neutrons."

"Fine! Do you know what an atom is now? Could you tell me?"

"Well," Howard began, "Everything in the world is made of atoms. Atoms are so tiny we can't see them with our most powerful microscope. Most of the atoms are made of three parts: the electrons revolving on the outside, and protons and neutrons in the nucleus, or the center. There's a lot of empty space in the atom. In fact, most of the atom is space. There are different kinds of atoms and they have different weights. That's all I remember, Mr. Anderson."

"But Howard, you forgot something! Different elements are made of different atoms. Also the number

*Elements Table will be found at the end of this story.



Hydrogen
Atomic Number—1
Atomic Weight—1
1 electron
1 proton
0 neutrons

Helium
Atomic Number—2
Atomic Weight—4
2 electrons
2 protons
2 neutrons

Lithium
Atomic Number—3
Atomic Weight—6 or 7
3 electrons
3 protons
3 or 4 neutrons

of protons and electrons in each atom of the same kind are the same, but there may be extra neutrons," added Barbara.

"Very good! But that's enough for today. Tomorrow we'll talk about splitting an atom to release atomic energy," continued Mr. Anderson.

"Good!" exclaimed Howard. "We'll be here! Will it be all right to come right after school?"

"Fine. It's a date!"

They all said "Good Night," and the twins chattered about atoms all the way home.

Splitting the Atom

The following afternoon Barbara and Howard were the first children to leave the school room. Very soon they arrived, out of breath, at Mr. Anderson's office.

Mr. Anderson was waiting for them. And right off the bat, he popped a "scientific" question. "What kind of energy did you kids use running from school?"

Howard replied, between deep breaths, "We used energy that we get from food. The energy is stored in our bodies. And just in case you didn't know it—running is work!"

"Anytime we work, we use energy. But where else do we use energy and what kinds?" smiled Mr. Anderson.

"I know," said Barbara. "Electrical energy gives us power. We use it in our homes. We use heat energy to cook with and keep us warm. And now, it looks like we'll be using atomic energy to supply power, and send a rocket to the moon!"

"But what I want to know is where do we get atomic energy?" said Howard.

"Atomic energy comes from the nucleus or the center of the atom. Yesterday we talked about how the atom was constructed. But it's also important to know that the protons and neutrons are held together by a form of energy."

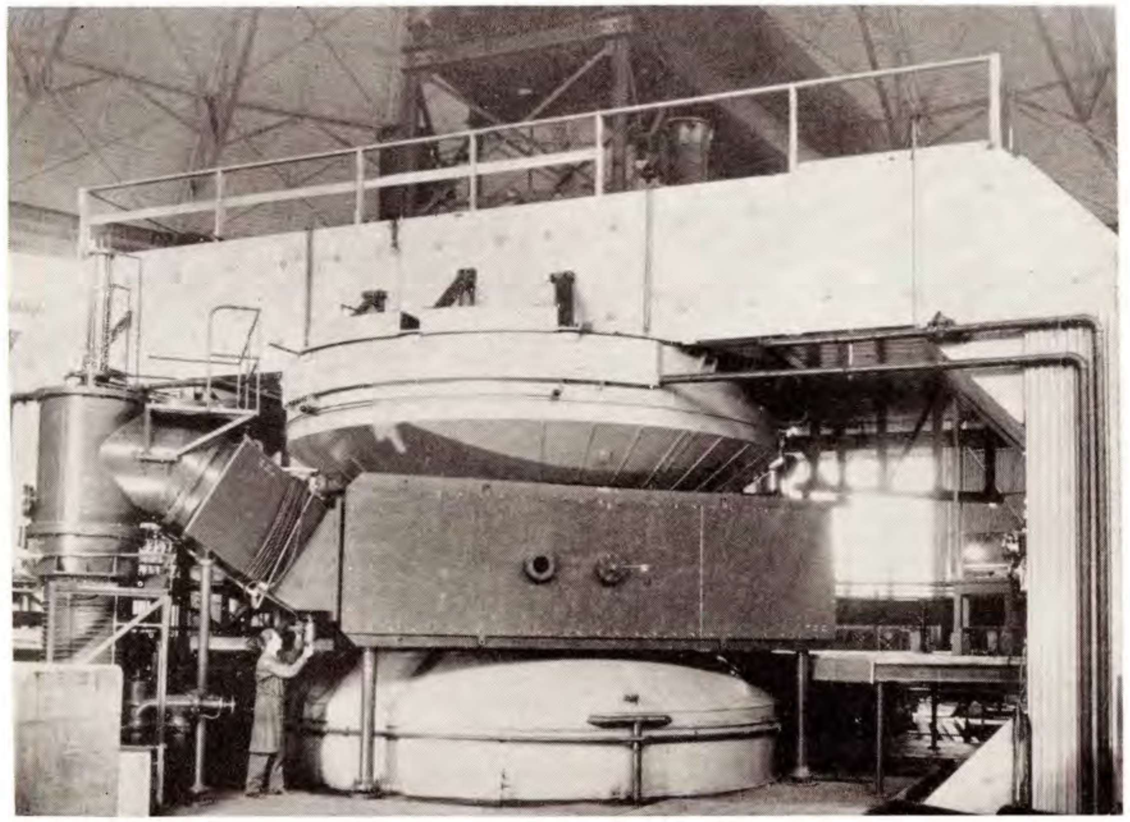
"How do they release that energy that is stored in the nucleus of the atom?"

"Here's the story," replied Mr. Anderson. "Sir Ernest Rutherford of England was the first to succeed in finding a little more about the atom. He took a piece of radium which is radioactive, and aimed the escaping particles at the element nitrogen. One of the particles stuck in the nucleus and changed the nitrogen to oxygen."[15]

"Wait a minute!" interrupted Howard. "You said 'radioactive.' That's a new one on me! What does it mean?"

"When an element is 'radioactive' it gives off different particles from the center of the atom. We have several radioactive elements in nature. Two of these elements are uranium and radium.[16] The particles that are given off by uranium and radium may be detected by an instrument called the Geiger counter. You'll probably read about it in the newspaper, especially when used by uranium prospectors."[17]

"If an atom loses particles from the nucleus, wouldn't that make a new element?" asked Barbara.



184-Inch Cyclotron at University of California
(Courtesy Atomic Energy Commission)

"Yes, but it takes billions of years for a chunk of uranium to lose enough particles so that it will look different. When that happens in nature, it is called a natural change. If man makes the change, it is called an artificial change."

"Rutherford," continued Mr. Anderson, "was the first man to make an artificial change. He succeeded where many alchemists had failed. Sir Rutherford did not make gold, but he did make oxygen out of nitrogen. Dr. Ernest Lawrence and other scientists made an atom smasher that they called a cyclotron. With this machine they changed elements to other elements. They even made gold."

"Boy, they could get rich in a hurry, couldn't they?" exclaimed Howard.

"No, it isn't that easy, Howard! It would take a long time to make enough gold to even start to pay for the cost of a cyclotron. Making gold this way is not a moneymaking proposition.[18]

"But now, let's go on with our story of how we obtain atomic energy. Some years ago two German scientists, Hahn and Strassman, managed to 'split' uranium atoms. Their experiments started with uranium atoms which had atomic weights of 238. When they split these atoms of uranium, they found that they had two elements rather than one. These elements were barium (atomic weight 137) and krypton (atomic weight 83).[19] These uranium atoms had been changed into these two new elements.

"When they added 137 and 83, the sum was only 220. Somewhere during the splitting of the uranium they had lost part of the atomic weight. They decided that it must have turned to energy. When this report reached the scientists at work in the United States, they started to work immediately. They had something to work on.

"Time passed, and our scientists were not successful in developing atomic energy in any quantities. They decided that there must be at least two types of uranium. One that would split and another that would not split. This was later proved to be correct. For every uranium atom that would split there were one hundred and forty that wouldn't split."

"Why would one type split and another not split?" asked Barbara.

"The nucleus of the U235 is different in some respects from the U238 atom. The U238 nucleus will either absorb the neutron or the neutron will bounce off," replied Mr. Anderson.

"Where do they get uranium?" asked Howard.

"Uranium is found in the crust of the earth just as many of our elements are," answered Mr. Anderson. "Uranium is mined and is found in the following places. Look at the map.

"In mining uranium, they discovered both forms, U235 and U238. They were then faced with the problems of separating the two types of uranium."

"But they did it, didn't they?" asked Howard.

"Yes, it was done by setting up a large separation plant at Oak Ridge, Tennessee.

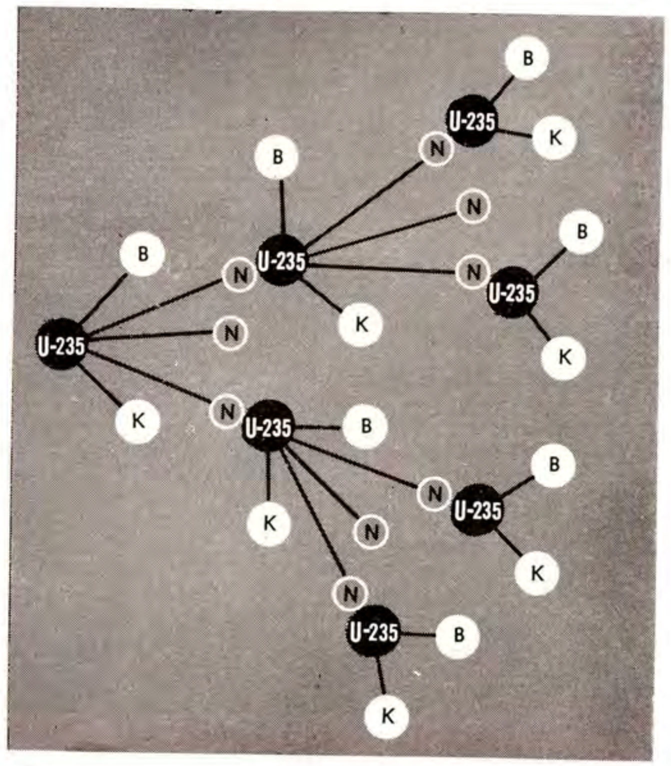
"While the scientists were working on this, the idea of a chain reaction came to them. They wondered if they would be able to get enough uranium 235 together so it would sort of start splitting itself. If this would happen they would have all of the atomic energy they could use."

Known Uranium Deposits

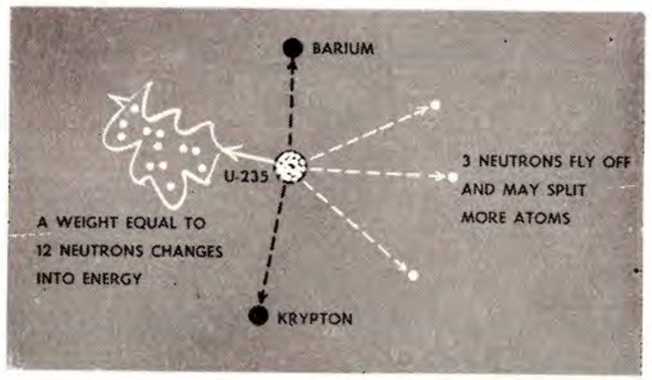
Atomic Energy Plant At Oak Ridge, Tennessee
(Courtesy Atomic Energy Commission)

"I don't understand what you mean by 'chain reaction'."

"I'll diagram it, Howard."



"When the barium and krypton are formed, we may have two or three or more neutrons flying off. Each of these may hit another atom and split it. Like this:



"It seems to me that there's a good chance that some of the neutrons would miss atoms and that we would not have quite such a nice pattern like that."

"That's perfectly right. We can learn something about that by doing an experiment with mouse traps and corks if you like."

"Don't tell us they have atomic mousetraps now?"

"No, Howard," laughed Mr. Anderson. "But it so happens that I have a box of mousetraps right here. I've been using them to illustrate some talks I've given to service clubs round about. For this experiment, we'll have to set each trap and put them all here on the table. Let's get busy!"

"Let the mice beware of this spot!" joked Barbara as the three of them set the traps.

In ten minutes there were 36 mousetraps on Mr. Anderson's desk. "Now," he began, "we want to place two corks on each one of the traps. Be very careful not to set any of the traps off, or we'll be picking up corks all over the room."

When they had finished, Mr. Anderson continued, "The mousetrap represents an atom. The corks are the neutrons. When we set one trap off, it will throw two corks up; and each cork will land on another trap and set it off. That one will go off and throw two corks; and that will continue until all the traps have been tripped.[20] That is called a 'chain reaction'.

"But before we set off our chain reaction, we'll put this wire screen over the top so we won't spend the rest of the evening picking up corks! Now we'll take one cork and let that be our neutron bullet."

"May I throw the neutron bullet into the atoms?" asked Howard excitedly.

"Yes, here's the cork. Now watch carefully, or you'll miss everything that happens. When a real chain reaction takes place there are trillions and trillions of atoms where we have only 36. Are you all set?"

"I'm ready. Throw the neutron, Howard!" exclaimed Barbara.

Howard threw the cork into the wire cage. There was a lot of clicking for a couple of seconds, and then it was all over.

"Does that help you in finding out how a chain reaction works?"

"Oh, yes!" replied the children.

"Notice that all of the traps did not trip. The same thing may happen in a regular chain reaction using uranium.[21]

"The scientists had to get enough U235 to try to make a chain reaction. The United States government was interested in the making of atomic energy. The government supplied money, men, supplies and everything that was needed to speed up the production of atomic energy.

"The scientists started gathering uranium from every place in the world where it was mined, except Germany. It was sent to Oak Ridge, Tennessee, where a huge plant had been built to process uranium ore. As they separated the U235 from U238 it was sent to the University of Chicago[22] in small lead containers."

"Why the lead containers?" asked Howard.

"Remember, uranium is radioactive, and the radioactive rays can be harmful to man. Lead absorbs the rays."

"What did they do with the uranium when they took it to Chicago?" questioned Barbara.

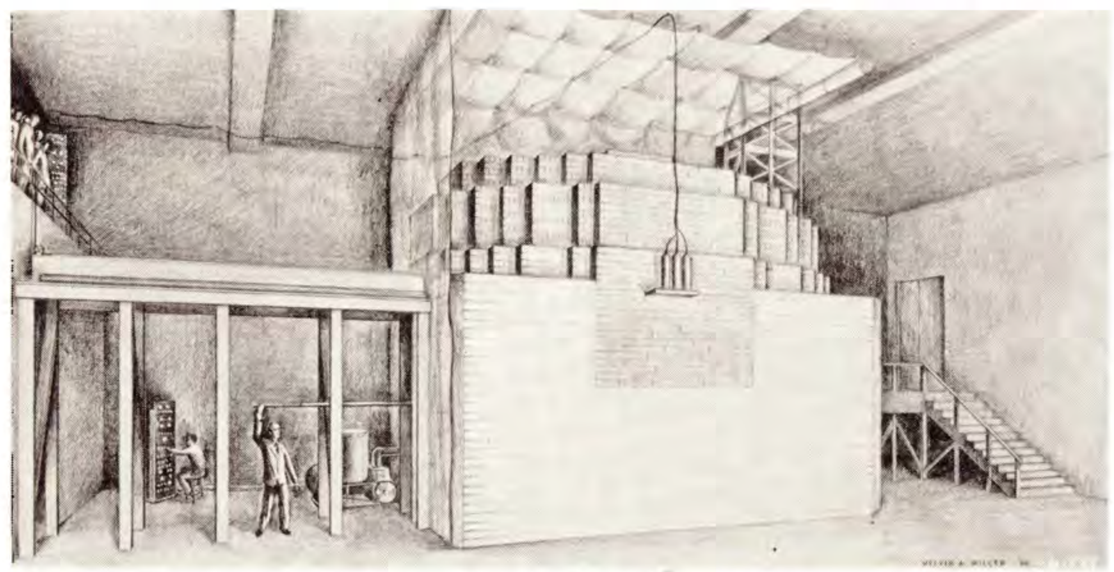
"They were building an atomic pile. It was an enormous pile of graphite bricks, uranium, and concrete. The uranium was placed in the bricks and then added to the pile. The scientists thought that when they had enough uranium in the pile a chain reaction would start."

"Why did it take so much uranium?"

"Remember that the atom is very small. The uranium that was placed in the pile was not all put in one place. It was distributed throughout the pile. When the tiny, tiny radioactive particles were given off and started sailing through the pile, there was a good possibility that they would miss the nucleus of other atoms. If they did manage to split an atom, the free neutrons might miss other atoms. But when enough uranium was placed in the pile, there was a greater possibility that neutrons would hit other atoms and the chain reaction would start. The graphite slowed down the neutrons. When they were going slower there was a better chance that they would split another atom. The concrete kept the radioactive rays from spreading out and harming people."

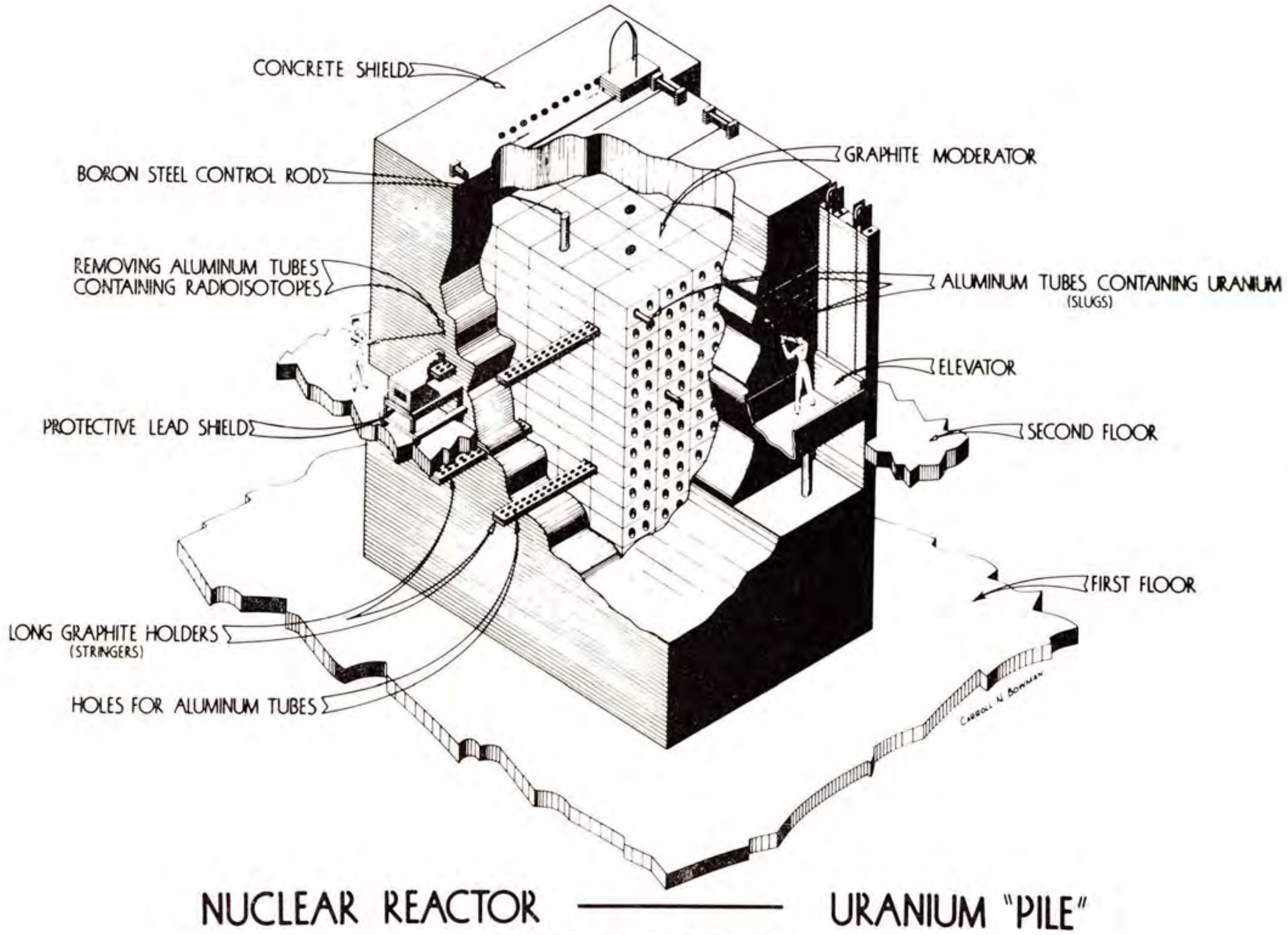
"Could they stop it if it got started, or would it keep on going like our mousetraps?" questioned Howard.

"The scientists wondered about that, too! They had discovered that the element cadmium would absorb the neutrons that were given off when an atom split. So they placed huge cadmium rods[23] in the atomic pile. After they added more uranium they stepped back and



Atomic Pile at Stagg Field, University of Chicago
(Courtesy Atomic Energy Commission)

pulled the rods from the pile. On the inside they had placed various instruments and one of these recorded the temperature. They knew that if the inside of the pile got hot, a chain reaction had started. They removed the rods many times and nothing happened. But the scientists did not give up. Then one day, after the U235 atoms that were in the pile had split and released neutrons. Some of these neutrons went to split other U235 atoms, but some of them hit atoms of U238. The uranium, with the added weight, became a new element named 'plutonium.' We call this a man-made element.



Nuclear Reactor—Uranium "Pile"
(Courtesy Atomic Energy Commission)

more uranium had been added, they removed the rods. The instruments began to spin, and the temperature suddenly shot up. Immediately, the rods were pushed back into the pile and the action was stopped. They had started a chain reaction and had stopped it.

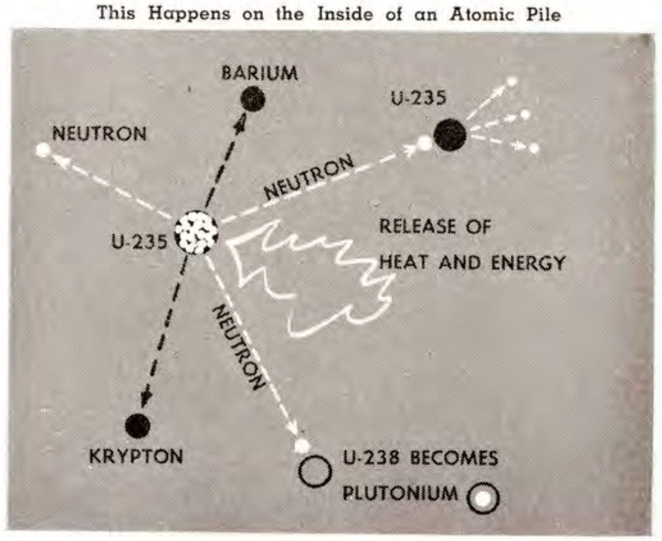
"Soon after the chain reaction had been stopped, one of the scientists, Dr. Arthur Compton, stepped to the telephone and made a long distance call to Washington, D. C. He said, 'The Italian navigator has discovered America.' The voice at the other end of the wire replied, 'Is the country safe to enter?' Dr. Compton then replied, 'Yes, Columbus finds the natives friendly'."

"Jeepers, they were talking in code!" whispered Howard as if it were still a secret.

"It was code all right! It meant the Italian scientist, Fermi, and his co-workers had succeeded in starting a chain reaction and that they were able to stop it.

"A new element was made in the atomic pile. Some of

This Happens on the Inside of an Atomic Pile



"The neutron hits the nucleus of the U235 atom and it splits, releasing energy, heat and other neutrons. When a free neutron hits a U238 atom it sticks and makes the new element plutonium.

"Plutonium acts the same as uranium and can be used to create atomic energy. We can split it and it is radioactive. The United States Atomic Energy Commission has set up a huge plant at Hanford, Washington, to make plutonium.

"The atomic pile can produce an enormous amount of heat. I don't believe we have time to go into the uses of atomic energy this evening. But how about tomorrow evening? And between now and tomorrow, I'd like for each of you to look carefully through the newspapers and listen to the radio. See if you can find the latest news on atomic energy."

"You bet we will! Good-night, Mr. Anderson!"

Uses of Atomic Energy

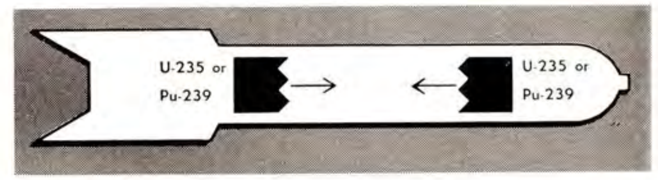
The children were loaded down with information from magazines and newspapers when they arrived at Mr. Anderson's office the next day.

"I see you've found quite a bit of information on the uses of atomic energy," said Mr. Anderson.

"Yes, we looked through all our magazines and newspapers. And we have enough information to last for quite a while! A lot of the clippings are about atomic bombs," said Barbara.

"How does an atomic bomb work?" asked Howard.

"Well to begin with you recall that we talked about a controlled chain reaction in the atomic pile and we are able to harness and use the heat energy in a controlled chain reaction. Now in an atomic bomb there are no graphite bricks, concrete, or cadmium rods to slow down the chain reaction. All the energy in the chain reaction of an atomic bomb is used for destruction. The bombs that were used during World War II probably contained from 10 to 50 pounds of uranium. The difficult part in making a bomb is to bring the uranium together at the right time to start a chain reaction. For example, if we have one pound of uranium it won't do a thing. But if we have somewhere between 10 and 50 pounds, that's enough to start a chain reaction. This is called a critical amount. And a long, large bomb has to be used. This is what an atomic bomb might look like:

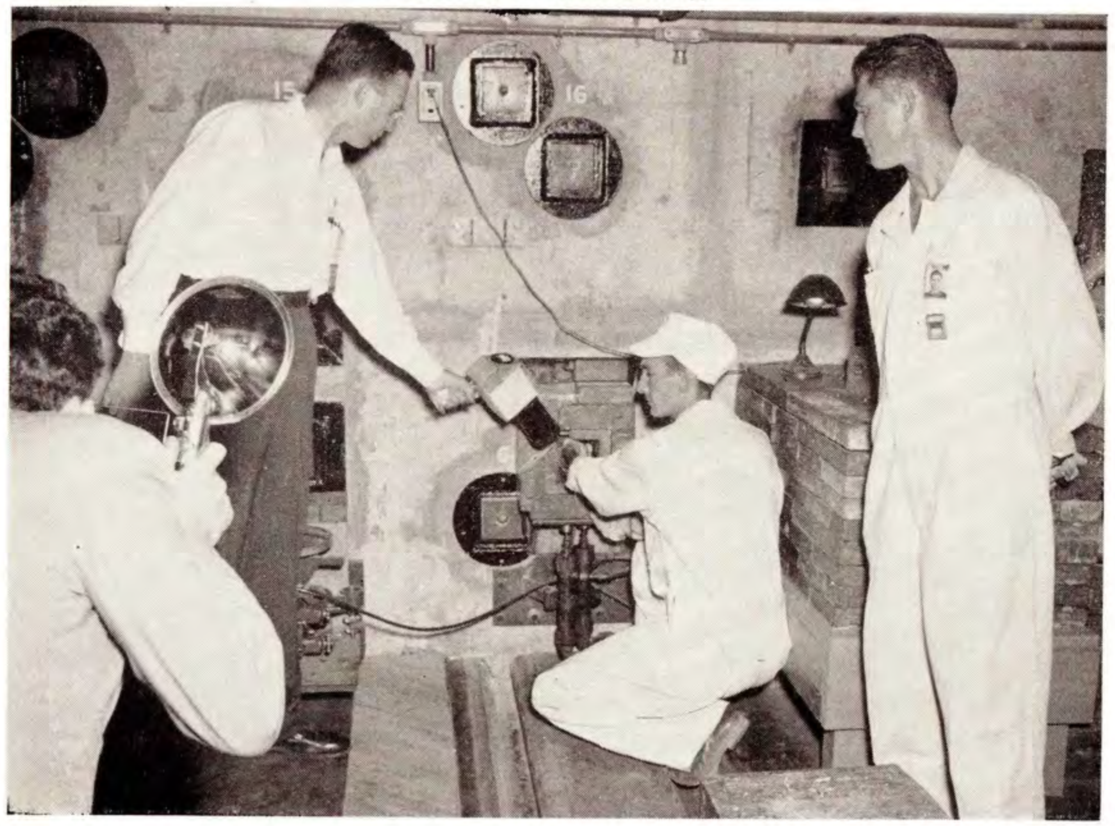


"The two parts of uranium or plutonium are forced together. When they strike each other, a chain reaction starts and energy and heat are released. Of course all

Atomic Energy Plant At Hanford, Washington
(Courtesy Atomic Energy Commission)

ABOVE: Getting elements ready to put in the atomic pile

BELOW: Removing shielding plugs from pile before removing isotopes
(Courtesy United States Army)



ABOVE: Removing isotopes from the atomic pile

BELOW: Putting radioisotopes in a lead shipping container
(Courtesy United States Army)

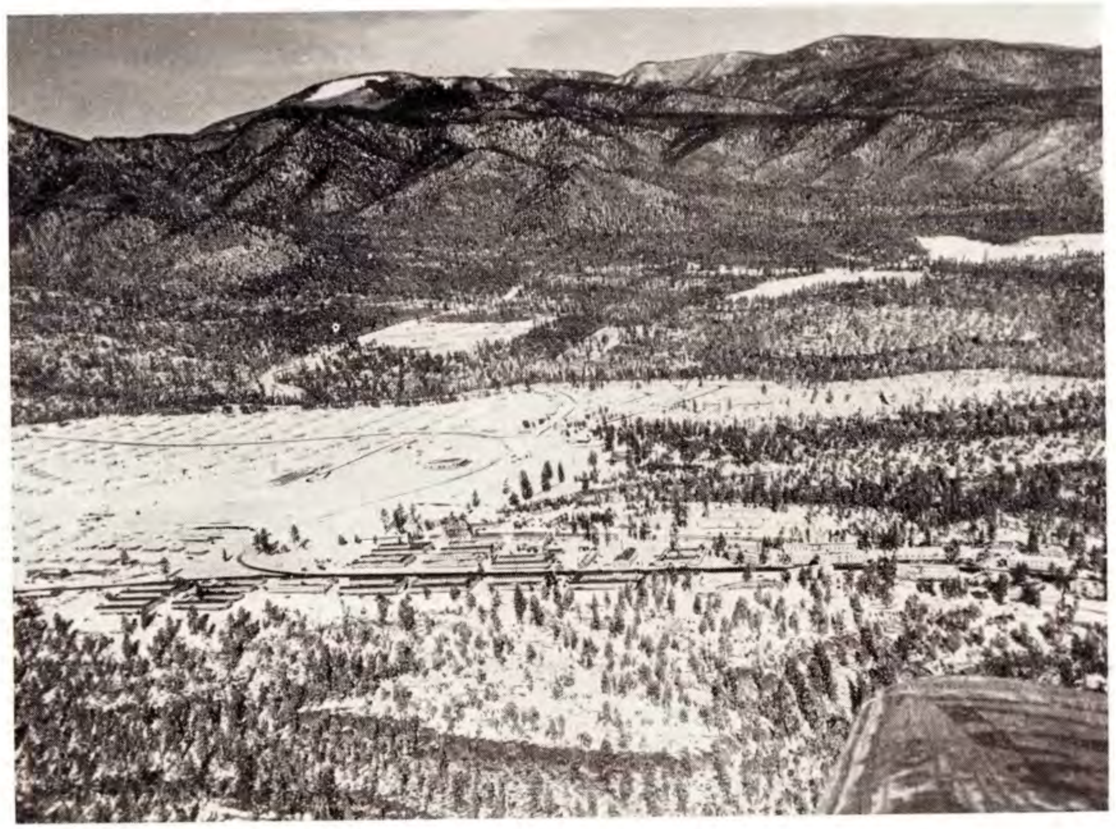
of the details of the bomb are secret. The government does not tell how they make the bomb work. All of the work on the actual making of a bomb is done at Los Alamos, New Mexico."

Howard picked up one of his newspaper clippings and handed it to Mr. Anderson. "Here's a story that really interests me!" he said. "It says here that they plan to put an atomic pile in a submarine. The pile will

atomic energy can be useful to man. Another example would be the rocket that we first talked about."

"Couldn't we use atomic energy to run automobiles, trains, and ships, too, Mr. Anderson?" questioned Barbara.

"We might use it on trains and ships, but an automobile would offer a different problem. The best way to explain it is by a diagram.* (See page 41)



Atomic Energy Plant At Los Alamos, New Mexico
(Courtesy Atomic Energy Commission)

make electricity which will run the motors. Since an atomic pile does not have to have a fire or anything that uses oxygen, the submarine can stay under the water for a long time."

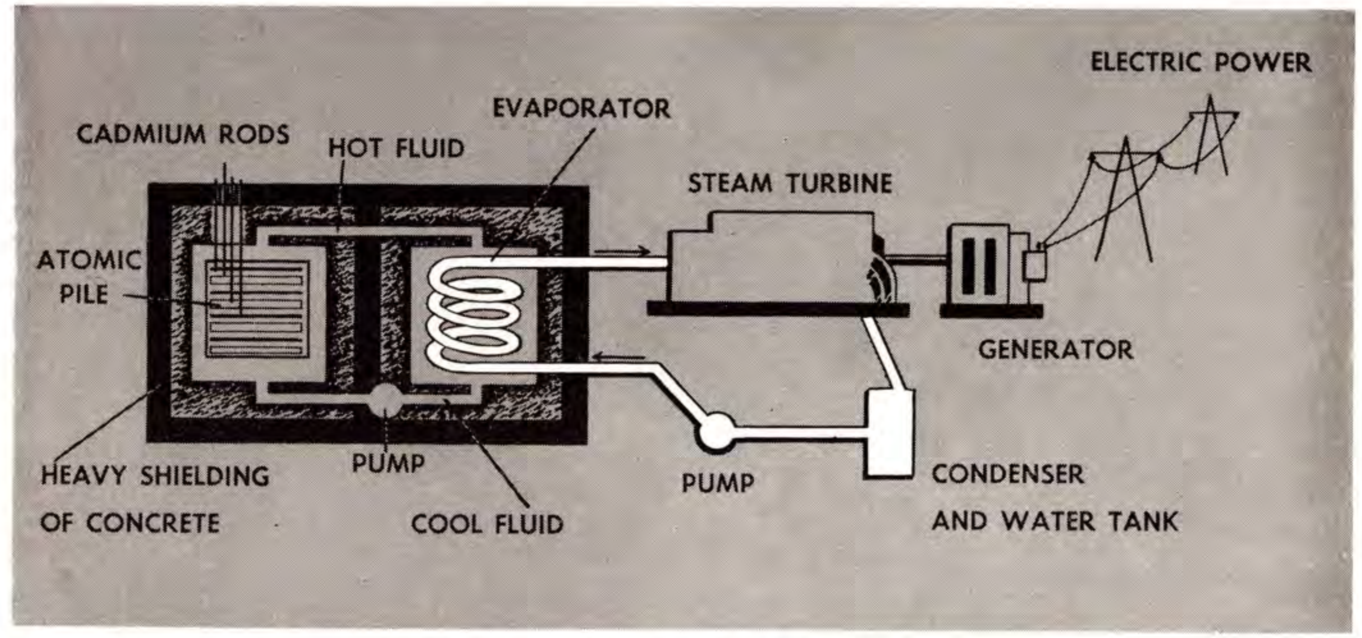
"How are the men in the submarine going to breathe? They would run out of oxygen!" asked Barbara.

"They have that all figured out, too, Barbara. From the electricity that the atomic piles make they will make artificial sunlight. There will be a greenhouse in the submarine. The plants will use the carbon dioxide that the men breathe out and give off oxygen," continued Howard. "But tell me, Mr. Anderson, how can an atomic pile make electricity?"

"You'll have to remember some of the things we've been talking about. The heat released from a chain reaction can reach a temperature of a million degrees if it's not controlled. However, with the use of cadmium rods, this heat can be controlled. It can be very valuable to us if we use it in the right way. The story of the submarine is a very good example of how

"First, locate the atomic pile. This atomic pile is just like the other piles that we talked about," explained Mr. Anderson. "It is just a heavy pile of graphite bricks surrounded by a concrete shield. Approximately 50 tons of concrete are needed for each atomic pile or furnace. There are openings in the furnace so that uranium or plutonium may be placed inside the furnace. When the uranium or plutonium is placed inside the pile, the cadmium rods are shoved all the way in. There is a pipe on the inside of the furnace that carries a gas. In the compartment next to the atomic pile we have water pipes. When the atomic furnace is turned on, heat is produced. The heat in turn makes this gas on the inside of the pile very hot. There is a pump that moves cold gas into the pile and the cold gas pushes the hot gas on out. This hot gas is then allowed to fall over the water pipes and give up some of its heat to the water. The gas is then picked up by a fan at the bottom of the compartment and sent into the pile to be heated again. Do you still follow me? Are both of you still with me?"

*A large picture may be found in *Life* Magazine—1948.



What An Atomic Energy Power Plant Might Look Like

"Yes," answered the children.

"When this hot gas strikes the water pipes, the water changes to steam," he went on. "Steam naturally rises because it is expanded and is lighter than water. The steam leaves the evaporator through a pipe and is carried to a turbine."

"What's a turbine?" asked Howard.

"A turbine looks very much like a windmill. The turbine has blades on it and when the steam hits these blades the turbine turns. The faster the steam comes, the faster the turbine will turn. There is a shaft that connects the center of the turbine to an electrical generator. When the turbine turns, the shaft will turn. Then the generator will turn and produce electricity."

"Is that generator just like the one on our car?" asked Barbara.

"Yes, only this one is much larger!"

"What happens to the steam after it leaves the turbine, Mr. Anderson?" questioned Howard.

"Another pipe takes the steam to a condenser where it is changed back to water. A pump then pumps the water back into the atomic pile to be changed to steam again."

"An atomic pile doesn't waste anything! It uses everything over and over again. How often do they have to put new uranium in the pile?" questioned Howard.

"There are so many atoms that have to be split that it would take several hundred years to use all the energy in 50 pounds of uranium. Remember these atoms are little fellows!"

"I guess we wouldn't be able to use the atomic pile in an automobile then because of the weight," commented Barbara.

"That's right," said Howard. "Wouldn't it be something if my brother had a 50-ton atomic pile on the back of his old jalopy. The car would be smashed flatter than a pancake!"

Mr. Anderson laughed and continued, "Electrical power produced from the atomic pile can be put to many uses. Another example would be an atomic pile placed in a ship. It would work exactly the same as the one in the submarine. Bigger and faster ships could be built. With these ships we could supply the people in war-devastated countries with food and machinery. Since World War II, the peoples in many foreign lands are having a hard time in recovering from the war. We should do everything we can to help them recover. These people are just like we are. They may have different colored skins and speak different languages, but they feel the same way about their country and lives. All of these people want to stay on their farms and keep their small businesses. I have wandered away from the subject of atomic energy, but atomic energy enters into that picture, too. Atomic energy is a problem of the world and we must all recognize it. I'm mighty glad that you two are taking such an interest in this subject. You're going to be the leaders in our country in a very few years.

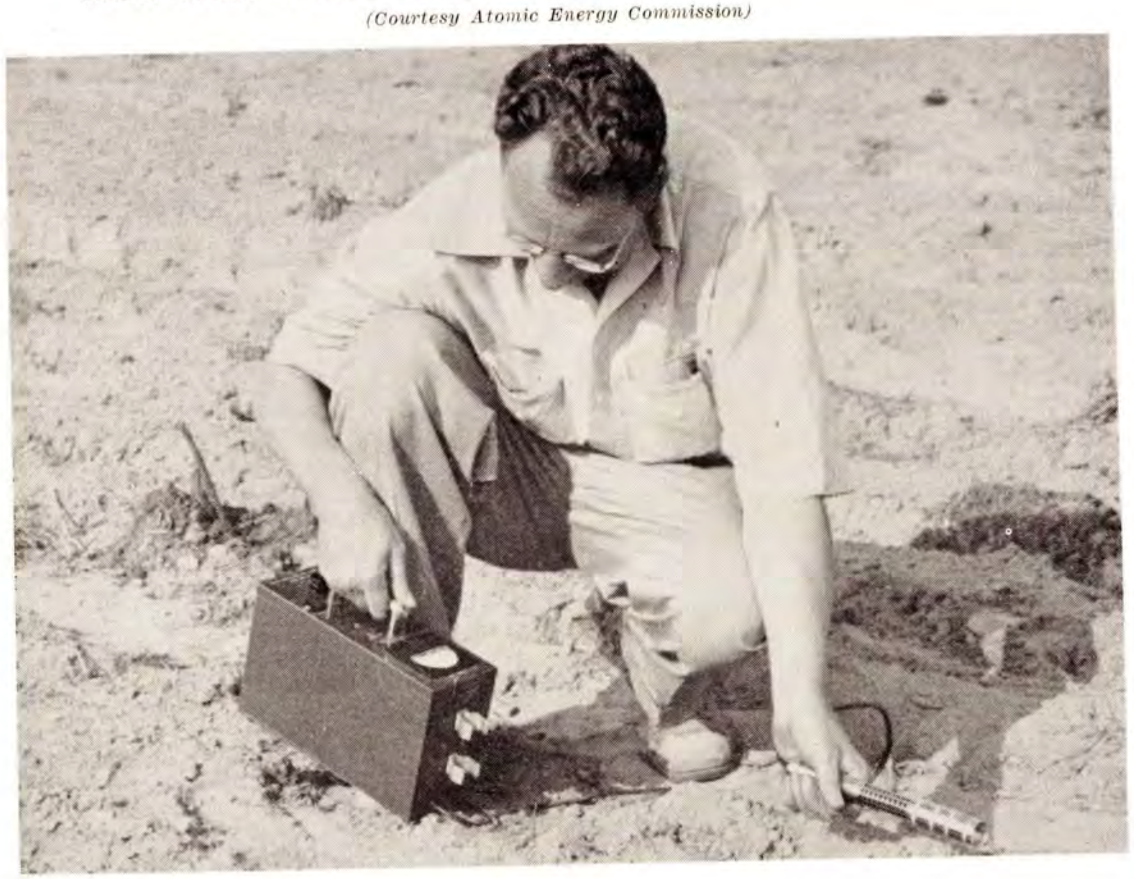
"The United States may not benefit as much from some uses of atomic energy as some countries. Electricity is a splendid example. We have a lot of waterpower in the United States from which we make electricity. Where we don't have water power, we use coal to heat water into steam. In that case, the steam is used to turn the turbine that helps make electricity.

"Because of atomic energy, many new cities may be born. We have a lot of resources in Alaska. There are mines that can only operate during the summer months. If an atomic pile were placed in these remote regions a lot of electric power could be produced. The pile could supply all the heat and light a factory could use in these faraway places. Here again, enough atomic fuel to last for a year could be transported in one airplane. There's a whale of a lot of power in a small amount of uranium!"

ABOVE: A Geiger counter is used to detect the presence of radioactive iodine in the thyroid

BELOW: Checking radioactive fertilizer in the soil

(Courtesy Atomic Energy Commission)



"Yes, I know, Mr. Anderson!" interrupted Howard, "I was reading in the book, *You and Atomic Energy*, that a half ton of uranium could produce enough power to supply a family of five people with enough electrical power to last over seven million years."

"Yes," added Mr. Anderson, "It's quite amazing what we can do with a very small amount of uranium or plutonium."

"There are other uses for the atomic pile beside supplying electrical power," continued Barbara. "I have an article here entitled, 'The Atom Turns Healer,' in which the writer talks about radioactive elements. Tell us how do radioactive elements work?"

"Uranium and radium are the only radioactive elements that we find in nature. Remember radioactivity can be detected by a Geiger counter. If we place iodine in an atomic pile the iodine will absorb some of the radioactive rays. When the radioactive iodine is taken out it may be injected into the body of a man or woman. The iodine is used by the thyroid gland in the throat. Many cases of cancer are found in the thyroid gland. The radioactive rays given off by the iodine will kill cancer growth in the thyroid. The United States has built a large hospital at Oak Ridge, Tennessee, for the purpose of research on cancer."

"Wouldn't it be wonderful if they could find a cure for cancer?" asked Barbara.

"Yes," answered Mr. Anderson. "Cancer is one of our most dreaded diseases. One matter must be determined, however. Are medical doctors going to be the only people to use radioactive elements?"

"Well," answered Howard, "here's a little clipping that tells about the atom being 'a farmer's hired hand'. It seems they are going to use the element phosphorus. All plants need phosphorus and it is supplied by fertilizer. They can study the plant with a Geiger counter and see where the fertilizer goes."

"I see. They've discovered that corn needs phosphorus only when it starts to grow," continued Mr. Anderson.

"When our farmers know this, they can tell how much fertilizer should be placed on a corn field. This would save fertilizer and produce better corn yields per acre. The men also discovered that potatoes need phosphorus all the time they are growing. Just think what this knowledge can do for nations that are overcrowded and underfed. Something like this might improve our world a lot."

"That little atom can do a lot, can't it? Something that we can't even see, can do all of that! Gosh!" Howard remarked.

"We've just talked about a few of the many different uses that we can make of atomic energy. It is one of the greatest discoveries that has ever been made by man. We can use it to produce electricity; provide power for trains, ships, and rockets; for study in medicine, and to help us find the secrets of our plant world. This is only the beginning. You kids are living during an era of remarkable progress. I'm certainly glad to have had these visits with you. And I hope I've been able to help you to understand a little more about the world you live in."

The children left feeling very grown up and much wiser! And they were far better prepared to follow the progress of the field of atomic energy and observe what new uses were made of it.

The Control of Atomic Energy

A few days later, Mr. Anderson saw Barbara and Howard coming slowly down the street. Since they were usually "on the run," it surprised him to see them walking so slowly and talking so earnestly together. When they came to his office door, he invited them to come in and tell him what was "on their minds."

"Well, Mr. Anderson," said Howard. "We're talking about the troubles our country is having with Russia. That's the headline news almost every day in the week."

"Howard and I are trying to figure out what the world is going to do with this atomic bomb," added Barbara.

"We know how powerful atomic energy is. We're wondering how it's going to be controlled so it won't be used in waging a war and killing millions of innocent people."

"Well, kids, I'm happy to tell you that the nations of the world are thinking about the very same problem. They're trying to work together to figure out a way of controlling the atomic bomb. There are very few people in the world who really want war, although there are, and always have been, 'aggressor' nations on the earth."

"But, Mr. Anderson, some nations are arguing most of the time. That isn't the way to solve our problem of controlling atomic energy," declared Howard.

"Howard, you've hit the nail right on the head. But I believe I can give you some information that will help you to see that although the nations are not immediately agreeing to the way in which atomic bombs should be controlled, they all do agree that they *must* be controlled.

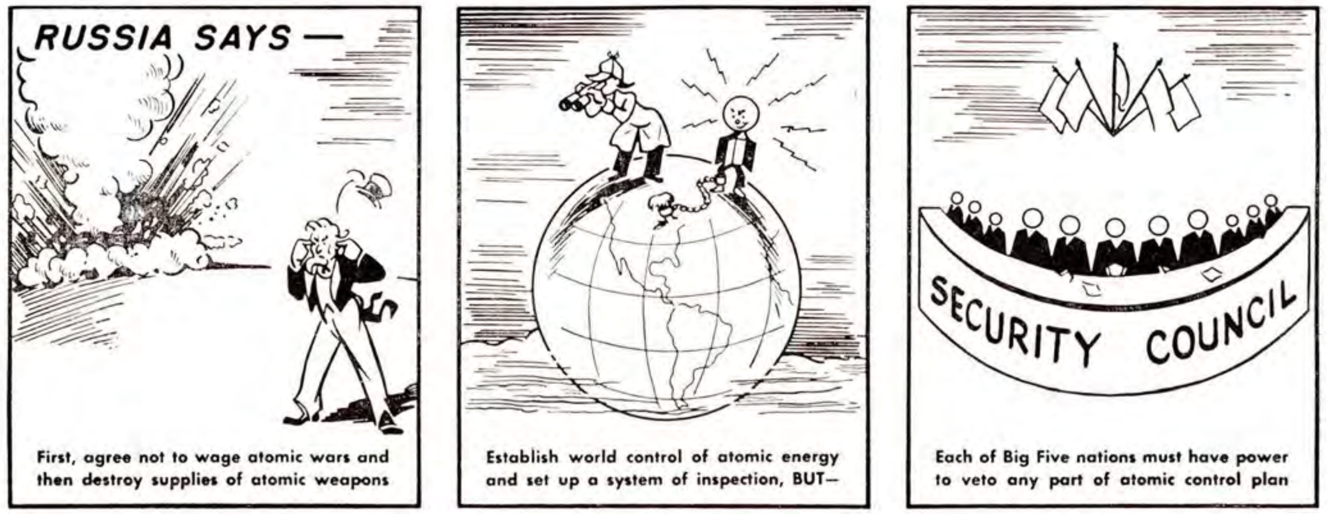
"The majority of the nations of the world have formed an international organization known as the United Nations. At the meetings of the United Nations, both Russia and the United States have presented plans for the control of the atomic bomb. These pictures illustrate clearly what these plans are. Here, take a look."

"Mr. Anderson, what is the Security Council?" asked Barbara.

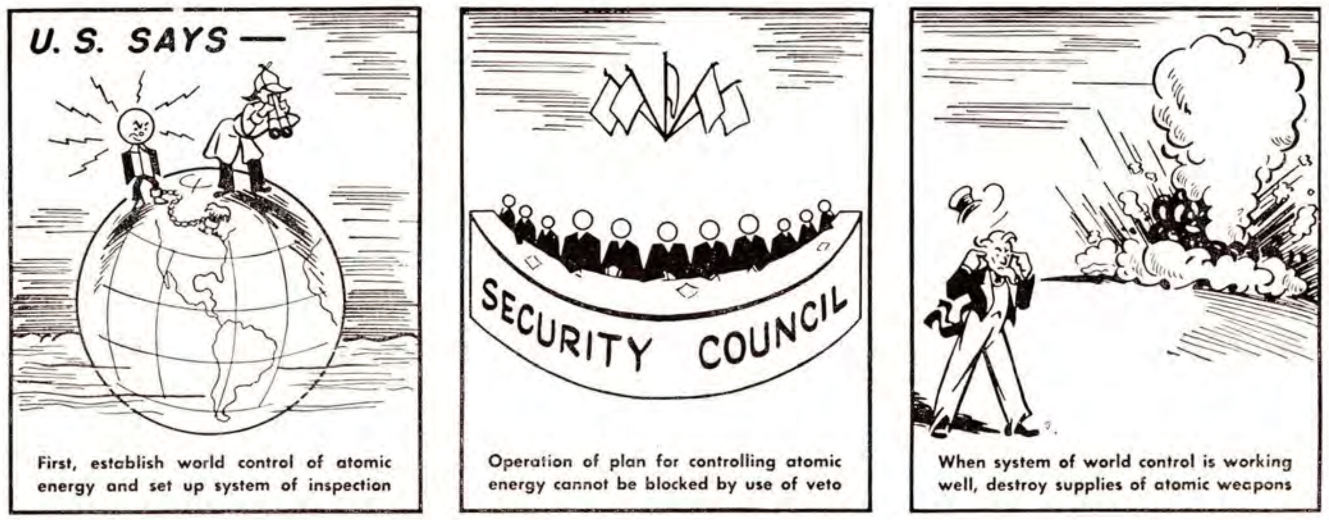
"The Security Council is that department of the United Nations which deals with crises, anywhere in the world, which are dangerous to the 'peace and security' of the world. Another part of UN—the Economic and Social Council—tries to *prevent* crises from arising. But the Security Council deals with those which already exist."

"Then," questioned Howard, "why don't these nations agree to settle the matter of atomic energy control right away. Don't they realize how important it is?"

"Yes, Howard, these countries are very much aware of the importance of controlling atomic energy. But they are unwilling to give up their own ideas. There must be some sort of compromise—but they are unyielding—and thus the final plan is deadlocked. The same thing happened away back when the United States was only 13 colonies. They had many an argument before all the colonies were willing to sign our constitution. There were so many disagreements that many people believed there never would be a United States.



From the *Junior Review*—October 10, 1949.
(Drawings by Kermit Johnson)



From the *Junior Review*—October 10, 1949.
(Drawings by Kermit Johnson)

"The same thing was true following World War I, when a League of Nations very similar to the United Nations of today was formed. The United States was not even willing to join this organization, and, without our strong support, it became very feeble and then failed. "So you see, Howard, even though you do not see progress on atomic energy control, there actually has been a great deal of improvement in the ability of nations to think about problems on an international basis. "Possibly you two would like to write to the United Nations and find out what this organization is doing right now to solve world problems. Children throughout the world are writing to the United Nations.

"The children of Nantes, France, have said, 'We work for the prosperity of the world and we try to see that no war shall break out'.

"There is another letter from a boy in the United States who says, 'Congratulations on your wonderful work this last four years in trying to make a free world for not *just* us. We hope you can hold everything and keep the peace until we get old enough to take over. So far you have done very well'.*

"These are just a few of the thousands of letters that have been received by the United Nations. These letters seem to prove that children who *think* and who see truth easily are quick to grasp the need of joining hands in a worldwide effort to make the United Nations work."

"Mr. Anderson, I believe you are right," said Howard very seriously. "Children all over the world want peace, and so if we all help each other to get enough food, clothing, and shelter, we *can* have a peaceful world. Perhaps through the wise use of atomic energy we can do just that."

"Thank you so much, again, Mr. Anderson, for all of your assistance. Let's go home and write a letter to the United Nations. Shall we, Howard?"

*Vitray, Laura. "The Children's Army of the United Nations," *United Nations World*, March, 1950. pp. 37-40.

SUGGESTIONS TO AID TEACHING
(Refer to corresponding superscripts in story)

1. Show the film *Nature of Energy*. Allow ample time for discussion and reshowing.
2. The children may take a map of the world and use colored pins to denote the location of the discoveries. Graphs may be made from this material on the map. A table of the elements appears later in this chapter.
3. The children may arrange a display of easily obtained elements on a table and test each by magnetism, weight, heat and action in water.
4. The children may doubt the fact that everything is made of elements. A list may be compiled and the children may take individual topics and track them down. The majority of living things are made of carbon, hydrogen, and oxygen.
5. At this point a map may be started to show the countries and men who helped develop our knowledge of the atom. Reports on the lives of the scientists are very interesting to the children.
6. As the names are mentioned in this part they can be recorded on the map suggested in No. 5.
7. If the children are not familiar with magnetism, a short time may be devoted to the study of magnets and magnetism.
8. Another example of the movement of electrons that can be used is static electricity. If it is possible to obtain a static electricity machine from the high school physics department, this can be helpful to clarify ideas about electricity.
9. Make certain the children are familiar with large numbers. The encyclopedia has a good illustration of a billion.
10. This is a good point to introduce the book, *How Big is Big*? Let children look at the book and discuss the last half of the book.
11. The idea of enlarging a regular photograph can be helpful here.
12. It is interesting to the children to note how some of the elements received their names. They were named after countries, people, planets, and plain names that the discoverers thought up.
13. Hydrogen is used in weather balloons and at one time was used in dirigibles, but hydrogen is explosive.
14. This offers a good opportunity to discuss the various weights and measures that we now have.
15. The pupils may ask how he knew he had done this. The teacher should explain differences between gases. Oxygen will burn and nitrogen will not.
16. The rays given off by radium are used in X-rays and also on watch dials so the dials may be seen at night.
17. A comparison may be made between the gold miners of 1849 and the uranium miners of 1949-50. The 1950 miners are equipped with Geiger counters rather than picks and shovels.
18. The gold would be in such minute quantities and it would be mixed with other elements. It would be unprofitable to make gold in this way.
19. Hahn and Strassman were able to identify the elements because of certain characteristics.
20. This experiment may be seen in frontispiece.
21. *You and Atomic Energy* gives a good explanation of how this might happen. The teacher may tell the children.
22. The University of Chicago was helping in the project. We now have many different colleges cooperating. In Iowa, the State College at Ames and the University at Iowa City are helping.
23. A demonstration of how a cadmium rod absorbs neutrons can be shown by taking a roll of clay and tossing small bits of rock at it. The rocks will stick to the clay.

TABLE OF THE ELEMENTS

Number of Protons	Name of Element	Symbol of Element	Weight of Element	Discoverer of Element	Where Discovered	When Discovered
1	Hydrogen	H	1	Cavendish	England	1766
2	Helium	He	4	Ramsay	Scotland	1898
3	Lithium	Li	6	Arfvedson	Sweden	1817
4	Beryllium	Be	9	Wöhler	Germany	1882
5	Boron	B	10	Davy	England	1808
6	Carbon	C	12			Ancient
7	Nitrogen	N	14	Rutherford	Scotland	1772
8	Oxygen	O	16	Priestley	England	1774
9	Fluorine	F	19	Moissan	France	1886
10	Neon	Ne	20	Ramsay	Great Britain	1898
11	Sodium	Na	22	de Monceau	France	1736
12	Magnesium	Mg	24	Black	Scotland	1755
13	Aluminum	Al	26	Wöhler	Germany	1827
14	Silicon	Si	28	Berzelius	Sweden	1824
15	Phosphorus	P	30	Brand	Germany	1669
16	Sulphur	S	32			Ancient
17	Chlorine	Cl	35	Scheele	Sweden	1774
18	Argon	A	39	Ramsay	Scotland	1894
19	Potassium	K	39	Davy	England	1807
20	Calcium	Ca	40	Davy	England	1808
21	Scandium	Sc	45	Nilson	Sweden	1879
22	Titanium	Ti	47	Gregor	England	1789
23	Vanadium	V	50	Sefstrom	Sweden	1831
24	Chromium	Cr	52	Vauquelin	France	1797
25	Manganese	Mn	54	Gahn	Sweden	1774
26	Iron	Fe	55			Ancient
27	Cobalt	Co	58	Brandt	Sweden	1735
28	Nickel	Ni	58	Cronstedt	Sweden	1754
29	Copper	Cu	63			Ancient
30	Zinc	Zn	65	Marggraf	Germany	1746
31	Gallium	Ga	69	Boisbaudran	France	1886
32	Germanium	Ge	72	Winkler	Germany	1886
33	Arsenic	As	74			Ancient
34	Selenium	Se	78	Berzelius	Sweden	1817
35	Bromine	Br	79	Balard	France	1826
36	Krypton	Kr	83	Ramsay	Great Britain	1898
37	Rubidium	Rb	85	Bunsen	Germany	1861
38	Strontium	Sr	87	Crawford	Scotland	1790
39	Yttrium	Y	88	Gadolin	Finland	1794
40	Zirconium	Zr	91	Klaproth	Germany	1789
41	Columbium	Cb	92	Hatchett	England	1801
42	Molybdenum	Mo	95	Scheele	Sweden	1778
43	Masurium	Ma	99	Noddack	Germany	1925
44	Ruthenium	Ru	101	Klaus	Russia	1844
45	Rhodium	Rh	102	Wollaston	England	1803
46	Palladium	Pd	106	Wollaston	England	1803
47	Silver	Ag	107			Ancient
48	Cadmium	Cd	112	Stromeyer	Germany	1817
49	Indium	In	114	Reich	Germany	1863
50	Tin	Sn	118			Ancient
51	Antimony	Sb	121			Ancient
52	Tellurium	Te	127	Muller	Rumania	1782
53	Iodine	I	126	Courtois	France	1811
54	Xenon	Xe	131	Ramsay	Great Britain	1898
55	Cesium	Cs	132	Kirchoff	Germany	1860
56	Barium	Ba	137	Davy	England	1808
57	Lanthanum	La	138	Mosander	Sweden	1839
58	Cerium	Ce	140	Hisinger	Sweden	1803
59	Praseodymium	Pr	140	Brauner	Czechoslovakia	1882
60	Neodymium	Nd	144	Brauner	Czechoslovakia	1882
61	Illinium	Il	147	Hopkins	United States	1926
62	Samarium	Sm	150	Boisbaudran	France	1879
63	Europium	Eu	152	Demarcay	France	1901
64	Gadolinium	Gd	156	Boisbaudran	France	1886
65	Terbium	Tb	159	Mosander	Sweden	1843
66	Dysprosium	Ds	162	Boisbaudran	France	1886
67	Holmium	Ho	164	Cleve	Sweden	1879
68	Erbium	Er	167	Mosander	Sweden	1843
69	Thulium	Tm	169	Cleve	Sweden	1879
70	Ytterbium	Yb	173	de Marignac	Switzerland	1878
71	Lutecium	Lu	174	Urbain	France	1907
72	Hafnium	Hf	178	Coster	Netherlands	1923
73	Tantalum	Ta	180	Ekeberg	Sweden	1802
74	Tungsten	W	183	Scheele	Sweden	1781
75	Rhenium	Re	186	Noddack	Germany	1925
76	Osmium	Os	190	Tennant	England	1803
77	Iridium	Ir	193	Tennant	England	1804
78	Platinum	Pt	195	Scaliger	Italy	1557
79	Gold	Au	197			Ancient
80	Mercury	Hg	200			Ancient
81	Thallium	Ti	204	Crookes	England	1895
82	Lead	Pb	207			Ancient
83	Bismuth	Bi	209	Geoffroy	France	1753
84	Polonium	Po	210	Curie	France	1898
85	Alabamine	Am	211	Allison	United States	1931
86	Radon	Rn	222	Dorn	Germany	1900
87	Virginium	Va	223	Allison	United States	1931
88	Radium	Ra	226	Curies	France	1898
89	Actinium	Ac	227	Debierne	France	1899
90	Thorium	Th	232	Berzelius	Sweden	1815
91	Protactinium	Pa	231	Hahn	Canada	1917
92	Uranium	U	238	Klaproth	Germany	1789
93	Neptunium	Np	239	McMillan	United States	1940
94	Plutonium	Pu	239	Seaborg	United States	1940
95	Americium	Am	241	Seaborg	United States	1945
96	Curium	Cm	242	Seaborg	United States	1945
97	Californium*					
98	Berkelium*					

*These are not official names as yet. According to a letter from Dr. Glenn T. Seaborg, University of California, a co-discoverer of these elements, the International Union of Chemistry has not had a meeting since these two elements were discovered. They will pass on the recommended names at their next meeting.

CHAPTER VII

A FIFTH GRADE STUDIES ATOMIC ENERGY

Fifth Grade, Campus School, Iowa State Teachers College

INTRODUCTION

On April 10, 1950, a fifth grade class in the Campus School, Iowa State Teachers College, began the study of a unit on atomic energy. The teacher was Mr. James Wailes, Supervisor of Student Teaching.

This was the second time Mr. Wailes had developed a unit on Atomic Energy with fifth grade pupils. In both instances, the units were carried on for the purpose of answering the question, "Can atomic energy understandings be taught satisfactorily at the fifth-grade level?" Thus, these units are to be considered entirely experimental in nature. *The committee chose the lowest possible grade level at which they thought the unit might warrant inclusion in the curriculum.* This unit might be more satisfactory if placed at sixth, seventh, or eighth grade levels. The success of the unit, however, is going to depend largely upon the teacher.

The first unit was taught without too much material actually in the children's hands. The second unit was taught with the stories presented in the previous chapter as a text. The children came from both rural and urban homes and in ability were a good cross section of any public school.

A diary of experiences was kept each day by Miss Margaret Day, Supervisor of Student Teaching. At the conclusion of each period a summarizing statement was written regarding the work of that day as it related to the study of atomic energy. As the unit progressed similar daily reports were made, thus developing into an actual diary of the work done during this atomic energy unit.

On the final day, Mr. Wailes prepared a summarizing lesson which was centered around certain key questions. Careful and detailed notes were taken of this discussion. These notes were edited in such a way as to give the essence of the discussion.

Several members of the committee which prepared this teachers' sourcebook visited the class on various days. It seemed evident that the teacher and most of the pupils were substantially interested in the subject. On a number of occasions the pupils revealed an unusually good grasp of the subject. At other times it was quite apparent that some of the children were "parroting" what they had heard or read.

The main purpose of the two units was not to make nuclear scientists out of fifth grade pupils, but to help them develop certain understandings about the release of atomic energy and the ways in which it may be put to work by society.

It seemed to the observers that the children preferred challenging classes to merely "easy" classes. Furthermore, it was apparent that children can be motivated to study and understand relatively difficult subject matter *when the subject matter is of current interest and significance*. In other words, the elementary school curriculum may well be influenced by that which is important in the world of today.

The following diary report of this fifth grade studying about atomic energy and its social implications is presented as a day-by-day record of what transpired.

From the diary and the summarizing lesson it can readily be seen that certain concepts have become part of the children's knowledge and understanding. Following the diary is a critical evaluation made by Miss Day and her pupils. The unit is not to be considered the "ideal," but it may aid an intermediate or upper grade teacher in setting up a similar unit.

BASIC CONCEPTS TO BE DEVELOPED

1. All matter is made up of about 100 different elements.
2. Atomic energy is one of several types of energy. It is the most recent form of energy made available to man—and by far the most intense.
3. Atoms are exceedingly small.
4. Each atom may be constructed somewhat like a tiny solar system.
5. Most atoms have a heavy center (nucleus) made of protons and neutrons. Electrons revolve about the nucleus at tremendous speeds.
6. The nucleus and the electrons in an atom are very small in comparison with the distance between them.
7. One element may be changed to another element by changing the structure of the nucleus of the atom.
8. Scientists are able to control the release of atomic energy during nuclear fission.
9. Scientists in other countries are highly competent, therefore, we do not have a monopoly on atomic energy. The problem of releasing atomic energy was not solved by American scientists alone—it was solved by the cooperative efforts of many scientists from many nations.
10. The United Nations is a world organization that may some day have the necessary power and wisdom to effectively control atomic energy.
11. It will be up to the children who are in our schools today to help solve the problems brought about by man's knowledge of how to release nuclear energy.
12. Atomic energy has many possibilities for making life better for us. It can bring about many advancements in such fields as medicine, agriculture, and power production.

DIARY OF EXPERIENCES

April 10

The unit began with a general discussion of atomic energy. A number of questions were asked by the children and these questions were listed on the blackboard. These questions were of a wide variety: Who discovered atoms? What do they use to make atomic energy besides atoms? What is atomic energy? Where does atomic energy come from? What good is atomic energy? Can we use atomic bombs for something different than war? How is an atom made? How big is an atom? The children and the teacher organized the questions into three categories. These categories were (1) How is the atom made? (2) How is the atom split? and (3) How is atomic energy used? Following this planning, the children started reading the first part of "Howard and Barbara Discover Atomic Energy." Following the directed reading, the teacher, assisted by the children, placed twenty easily obtained elements on the table. The children examined the elements quite closely to note any differences in weight and to discover what effect a magnet had on the various elements. The teacher attempted to burn all of the elements and also immersed them in water. The children by their own experimentation and observations noted differences in the elements.

April 11

This class session was a continuation of the work on the first main problem. The discussion centered around differences in elements that had been observed on Monday. The following differences were noted: they varied in weight, some would burn, some reacted to water, and some were attracted by a magnet. One pupil brought out the important fact that each element was either a liquid, a solid, or a gas.

The teacher asked for the types of energy with which the pupils were familiar. Some of the replies were: heat, electrical, and atomic energy. These types of energy were talked about briefly and the film *Nature of Energy* was shown. Following the film, the children talked about the different examples of energy that they had seen and what the differences were between the types of energy.

April 12

The teacher and pupils reviewed the work done on types of energy. The children concluded that the main difference between atomic energy and other types of energy was that atomic energy is the newest and the most powerful.

One of the pupils looked up the word *atom* in the encyclopedia and reported to the class. The report concerned the size of an atom. The source said it would take billions and billions of atoms to cover one square inch. Time was taken to discuss the meanings of large numbers that would be used in the study of atomic energy. Comparisons were made to clarify the meanings of large numbers. The children continued reading in the story and were encouraged to ask questions they had about the atom. Following this discussion, the teacher read to the class *How Big is Big?* Two copies of the book were placed on the reading table.

April 13

One of the children raised a question about liquids, solids, and gases. References were made to the pictures of elements that had been placed on the bulletin board. A copy of the *Table of Elements* was distributed. (A copy of this table may be seen at the end of the previous chapter.) In order to develop an understanding of the contributions of numerous countries to our knowledge of atoms and atomic energy, the discoverers of the elements were discussed. Several of the pupils selected certain scientists on which to make brief oral reports. One pupil asked if he might prepare a map of the world and use colored pins to indicate where each element was discovered. He did a very good job in placing the pins in the respective countries. This map was later used as a source of information for graph study in arithmetic.

The children then read about two of the three parts of the atom: the proton and the electron.

April 14

Discussion was centered around examples used on the blackboard to show the relative positions of the electron and proton in the atom. The third part of the atom—the neutron—was presented by the story. The children then continued to read about the structure of the atom. In the discussion the electron revolving around the nucleus was compared to the earth revolving around the sun. A differentiation was made between gravity and electrical attraction. The idea of space within the atom was presented with extensive use of blackboard diagrams. This proved to be a very difficult concept for the children to visualize.

April 17

The early portion of the period was spent in reviewing the work of the former week.

The arrangement of the elements in the table was discussed and the subject of atomic weights was introduced. In order that the children might have a better understanding of atomic weight, the teacher asked the children what some of the weights and measures were that they used each day. Some time was spent in the discussion of inches, pounds, miles, and other types of weights and measures.

April 18

The differences between elements, especially as related to atomic weights and structure, were again presented. The *Table of Elements* was again reviewed along with the makeup of the nucleus of the atom. The majority of the children felt that all of the questions that we had set up under this first main problem had been answered to their satisfaction. However, there were still two children who could not believe that everything was made of elements. Various items, such as hair, grass, rope, sky, rubber, plaster, plastic, and cardboard, were listed and the children each selected one item to report on. The balance of this period and a language period were used for collecting information and preparing reports.

April 19

Various pupils gave the reports that had been chosen at the end of the previous day's work. It was discovered that many things in the world are made of carbon, hydrogen, and oxygen.

Following the reports the teacher placed on a table a number of colored blocks—these blocks were used to represent the various combinations of atoms used to form certain elements. The children helped to arrange the blocks in different combinations to show that different forms might result. The majority of the pupils reached the generalization that everything is composed of elements and that each element is made of different combinations of atoms.

The discussion that followed was centered around the natural and artificial changes of elements. A pupil gave a report about Sir Ernest Rutherford, who had proved that atoms of one material can be changed to atoms of a different material.

April 20

The second main problem (see diary for first day) was brought up for discussion and the questions were reviewed before the children read the second part of the story *Splitting An Atom*. The children asked many questions about "chain reaction." The teacher illustrated what was meant by a chain reaction by using the blackboard. Charts on a bulletin board were also referred to.

Prior to this period three boys had set up the mouse trap experiment to show how a chain reaction works. One child said that it looked as though popcorn was being popped.

The differences between Uranium 238 and U235 were brought out. The children read about the construction of the atomic pile. The teacher then told of several interesting facts that he had read about the construction of the first atomic pile at Stagg Field, Chicago.

April 21

One pupil was asked to draw a picture of a chain reaction on the board and tell briefly how it worked. This served as a review of the previous day's work.
The atomic pile was studied quite thoroughly. Diagrams were drawn on the board and a large picture on the bulletin board was used for illustration.

April 24

The first half of the period was spent in answering the children's questions about the atomic pile. Several hazy concepts related to the "splitting of the atom" were clarified by the discussion.

The children then read "Barbara and Howard Discover Atomic Energy" to learn about the uses of atomic energy, especially in the making of electrical power. The balance of the period was spent in talking about how electrical power might be put to work to improve world conditions.

April 25

The children brought in clippings about the recent explosion at the University of California atomic plant. Time was devoted to reports and discussions of the material that they had brought to class.

A comparison was made between the United States and other parts of the world as far as resources for making electricity were concerned. The possibilities of atomic energy plants in various parts of the world were discussed. The locations of known uranium deposits were pointed out on the wall map.

The use of the atomic pile for transportation was read and talked about. It was decided that atomic energy power plants were feasible in large ships, submarines, and trains, but not automobiles because of the weight involved.

April 26

The children read "Barbara and Howard Discover Atomic Energy" in order to discover additional uses of atomic energy. They asked questions that had been prompted by the story. The balance of the period was spent in a discussion which included the topics: (1) various diseases and how they are spread, (2) the possible uses of radioactive elements in studying and curing disease, (3) the uses of atomic energy in agriculture. Many references were made to conditions in overcrowded countries and to underfed peoples.

April 27

The discussion of the previous day's reading was continued. The discussion was referred back to our original set of questions to make certain that all the children's questions had been answered.

Then the pamphlet *Inside The Atom* was read as a form of summary for the unit. The children enjoyed this illustrated presentation and seemed to understand the reading very well.

April 28: Diary Report of Summarizing Lesson

INTRODUCTORY STATEMENT: The summarizing lesson that follows was written by Miss Margaret Day, the regular teacher of the class with which this experimental unit was conducted. As was true with the brief reports of the preceding lessons, the notes on the summarizing lesson are not verbatim. They do, however, give the essence of the class discussion. The questions around which the lesson was organized are listed consecutively. It is obvious that the brief responses given by the children do not reflect their degree of understanding. It was the intent of the teacher to cover the high spots of the three weeks' unit, rather than to elaborate on specific parts (which had been given detailed treatment in previous lessons). In the majority of cases the general questions were those raised by the children at the beginning of the unit.

Mr. Wailes: Our purpose today is to summarize the most important things we have learned about atomic energy. During the past three weeks we have talked about the structure of the atom, releasing of atomic energy, and the uses of atomic energy.

I have prepared a number of questions for today's discussion. If we are able to answer the questions and know the "whys" of our answers we can be sure we have learned a lot about atomic energy. (Note: all *major questions* prepared by Mr. Wailes are written in capital letters.)

Mr. Wailes: WHAT ARE THE FORMS OF ENERGY THAT WE DISCUSSED?

Don: Moving. Muscular. And those balls that we saw in the movie were stored energy.

Priscilla: Atomic.

Nancy: Chemical.

Bob: Heat.

Jerry: Radio.

Bob: No, that was radiant. Light is radiant energy.

Bobbette: Electrical energy.

Mr. Wailes: HOW DOES ATOMIC OR NUCLEAR ENERGY DIFFER FROM THESE OTHER FORMS?

Priscilla: They are not the same types and they are not used the same way.

Nancy: More powerful.

Bob: It is used for both good and bad.

John H.: Several things—the way it is made.

Bob: Atomic energy is newer.

John H.: We can control it.

Jerry: It is more strong—it can lift things, pull a car, and that submarine.

Bob: You can't use it in a car because of the weight.

Mr. Wailes: What do you mean by weight, Bob?

Bob: You would have to have an atomic pile and the concrete alone would smash a car.

Nancy: The atomic pile does not need oxygen.

Mr. Wailes: Why is that?

Nancy: The atoms just split and nothing burns inside the pile.

John L: They use different things to make it: concrete, graphite, cadmium rods.

Mr. Wailes: WHAT ELEMENTS DO WE USE TO MAKE ATOMIC ENERGY?

Tamara: Uranium and radium.

Mr. Wailes: Do we use radium?

Bobbette: Not radium, but something that starts with "p."

Jerry: That's plutonium!

Mr. Wailes: Where do we get plutonium?

Jerry: From the word Pluto. That's where we get its name.

Bob: Cement, graphite and cadmium.

Mr. Wailes: That is what we have to use, isn't it, Bob?

Jerry: The atomic pile uses the things Bob said.

John H.: U238 is needed to make plutonium. A neutron is "plastered" to the nucleus of U238 and it changes its weight.

Mr. Wailes: Plutonium is a man-made element. We don't find it anywhere in nature!

Mr. Wailes: WHAT ARE SOME OF THE ELEMENTS THAT WE DO FIND IN NATURE?

John L.: Silver, gold, lead.

Don: Uranium, iodine.

Tamara: Radium.

Jerry: Krypton, barium.

Priscilla: Iron.

Fritz: I don't know.

Nancy: Copper.

Bob: Lead and sulphur.

Jerry: Oxygen, nitrogen, hydrogen, helium, neon, the one named like Germany, Plutonium, Curium.

Bob: Oh, he named the gases—I didn't think of them.

Bobbette: Mercury.

Bob: Cadmium, graphite.

Bobbette: Graphite was not on the sheet.

Mr. Wailes: Graphite is a form of carbon. You're right, Bobbette, graphite was not listed on the table.

Nancy: The one named after America.

Mr. Wailes: Americium.

John H.: Plutonium.

Don: Tungsten.

Mr. Wailes: That is enough. We are doing a lot of good thinking. Let's continue thinking about elements for a few more minutes.

Mr. Wailes: WHAT ARE SOME OF THE WAYS WE CAN TELL ELEMENTS APART?

John L.: Some of them can be picked up with a magnet, and others cannot.

John H.: Protons, neutrons and weight.

Priscilla: Looks.

Bob: Atomic number.

Mr. Wailes: Could we tell a difference by looking at its atomic number in the table?

Bob: I don't believe we could.

Mr. Wailes: Why couldn't we, Bob?

Bob: If we looked at the number, we would know it had a different number of protons. I guess we could.

Mr. Wailes: Why could you tell a difference with a Geiger counter?

Jerry: The counter would pick up the radioactive rays and make that buzzing sound.

Priscilla: Weight is another way we can tell the difference.

Jerry: The way it reacts; chain reaction is another difference.

Bob: The way it reacts to water. And melting point is another.

Jerry: Some of them would burn.

Mr. Wailes: IN WHAT WAYS ARE ELEMENTS THE SAME?

John H.: The same color.

Nancy: No, gold is different colored than mercury.

John L.: They are all elements.

Priscilla: They are used in the same things.

Mr. Wailes: Do you mean they are made of the same things?

Priscilla: Yes.

Bobbette: Atomic structure. They are all made of atoms.

Mr. Wailes: Why wouldn't they all be exactly alike?

Bobbette: Because the atoms are different elements.

Priscilla: That is what I meant.

John H.: They all have an atomic weight.

Jerry: You could pick up most of the elements with a magnet.

John H.: Not all of them, just a few. Can you pick up hydrogen with a magnet?

Jerry: No! Because hydrogen is a gas.

John H.: Okay, then.

Priscilla: Elements are all alike also because they are made of neutrons and protons.

John H.: An atomic structure of the element could not be changed. But in the hydrogen bomb they change hydrogen to helium. They will have to change the definition, won't they?

Mr. Wailes: John Dalton, in 1808, said the atomic structure couldn't be changed, but we have done it. Yes, the definition will have to be changed so it will say we can change one element to another by changing the atomic structure.

Nancy: All elements are made of atoms.

Mr. Wailes: We have had two people say all elements are made of atoms.

Mr. Wailes: WHAT IS THE ATOM MADE OF?

Carol: Protons are in the center.

Jerry: And neutrons and electrons, and the nucleus, too.

John H.: The nucleus is made of protons and neutrons. The electrons revolve around the outside.

Mr. Wailes: WHAT DOES AN ATOM LOOK LIKE?

John H.: The neutron and proton are in the middle, but not all have neutrons. Hydrogen doesn't. Electrons are on the outside.

Bobbette: They look like the earth revolving around the sun. The sun represents the nucleus.

Bobbette: They are revolving and rotating too, aren't they?

Mr. Wailes: Yes, Bobbette, scientists believe that to be the case.

Bob: There is a lot of empty space inside the atom between the electron and the nucleus.

Mr. Wailes: We have been using some large words. Who can tell me what an electron is?

Tamara: It goes around the nucleus of the atom.

Nancy: It is the moving part of electricity. It moves along a wire when electricity flows.

Mr. Wailes: What is another example?

Nancy: Lightning. The electrons high up in a cloud are attracted by the positive charges in the bottom part.

Priscilla: That picture we had on the bulletin board.

Mr. Wailes: What picture was that?
Priscilla: The one with the atoms of different elements.

John H.: Current on a wire is another example. The electrons don't weigh much.

Mr. Wailes: Fine! What do we mean by a proton?

John H.: It is in the nucleus of the atom. The proton has most of the weight of the atom.

Nancy: The part of electricity that does not move.

Bob: Part of the nucleus.

John H.: I gave that one, Bob!

John L.: We had a plus mark for it.

Bob: It is positive.

Mr. Wailes: We forgot to include that about the electron.

Bob: The electron is a negative charge of electricity. We used a minus mark for the electron.

Mr. Wailes: We're moving right along now. What is a neutron?

Tamara: Is it a moving part? When we split an atom, the neutrons go on to split other atoms.

John H.: Not all atoms have neutrons in the nucleus. Hydrogen doesn't!

Bob: The neutrons keep the chain reaction going.

Bobbette: It is a neutral charge of electricity.

Bob: That's right; it is neither positive nor negative.

Mr. Wailes: What is the neutron made of?

Bobbette: The neutron is made of one proton and one electron.

Mr. Wailes: Fine, Bobbette! Why would they stick together?

Bobbette: They are opposite charges so they will attract each other.

Mr. Wailes: Where is most of the weight found in the atom?

John L.: In the center or the nucleus.

Priscilla: On the scale. I mean the table we have.

Mr. Wailes: But in what part of the atom do we find the weight?

John H.: The protons and neutrons have weight. The electrons weigh very little. The nucleus.

Mr. Wailes: WHAT HOLDS THE ATOM TOGETHER?

Tamara: Attraction, sort of like gravity.

Nancy: Electrical attraction.

Mr. Wailes: What do we mean by electrical attraction?

Bobbette: Like the sun revolving around the earth. The sun's gravity keeps us from flying off into space. The same is true in an atom, only the attraction between the opposite charges of electricity holds the electron.

Mr. Wailes: What opposite charges?

John H.: The electron outside and proton on the inside. Just like the N and S poles of a magnet. The opposite charges attract.

Bobbette: Then the speed of the electron keeps it from being pulled into the nucleus. Just like the earth pulling away from the sun.

Mr. Wailes: Good! Let's come back to elements now for a short time.

Mr. Wailes: WHAT ARE THE DIFFERENCES BETWEEN HELIUM, HYDROGEN, MERCURY, GOLD, AND URANIUM?

John H.: You can split uranium. They change hydrogen to helium in a hydrogen bomb. They cannot split gold, but they did make gold in a cyclotron.

Nancy: Helium and hydrogen are gases. We can pour mercury, and uranium is a solid.

Bob: Uranium is radioactive.

Bobbette: Different color, different weight.

Tamara: Elements are either liquid, solids or gases.

Mr. Wailes: Let's go back to John's statement. How can one element be changed to another?

Priscilla: Mixing them together.

Don: Using a cyclotron.

John H.: They have betatrons and synchrotrons now to blast elements. That is what it said in one of those magazines.

Mr. Wailes: The betatrons and synchrotrons are other forms of atom smashers.

Nancy: In an atomic pile they change uranium to plutonium. Chain reaction does that.

Bobbett: When uranium is split they get two elements; I forget the names.

Jerry: Barium and krypton.

John H.: The cyclotron uses a neutron bullet and it is shot at an element. If the neutron hits and sticks there is a new element because the weight is changed.

Mr. Wailes: It is not necessarily a neutron, John, but it has to be some charged particle. With the charged particle we can change one element to another element by changing the atomic structure.

Mr. Wailes: Now, what do we mean by radioactivity?

John L.: Those rays that come off radium and uranium. Plut— that one made from uranium, too.

Priscilla: Over a long period of time the rays flying off make a new element. It loses some protons so it doesn't weigh as much.

John H.: These rays can be picked up by a Geiger counter.

Bob: They are radiant energy!

Jerry: The rays are harmful to man.

Carol: But some of the rays are also useful because we use them in an X-ray machine.

John H: They go through almost everything except lead.

Carol: They may kill cancer, too!

Mr. Wailes: Radioactivity then may be harmful or helpful. Uranium is one of the radioactive elements.

Mr. Wailes: IN THE CASE OF URANIUM, WHAT HAPPENS WHEN THE NUCLEUS IS SPLIT?

John H.: It gives off neutrons.

Tamara: It will turn to lead after a long time.

Mr. Wailes: Does that happen in the splitting, Tammy?

Tamara: No, that is radioactivity! Barium and that gas like neon is given off when it splits.

Priscilla: The neutrons that fly off may start a chain reaction. If there is enough uranium it will.

Nancy: Atomic energy is released. That is where we get atomic energy. Barium metal and krypton gas are formed too.

Mr. Wailes: We have two elements formed. Priscilla mentioned a chain reaction.

Mr. Wailes: WHAT IS A CHAIN REACTION?

Bobbette: That happens after an atom is split.

Priscilla: The atom splits and neutrons shoot out and hit other atoms and that just keeps up until it runs out of atoms.

Bob: Couldn't we start a chain reaction with any kind of atom?

Mr. Wailes: No, remember uranium 235 and Plutonium are the ones that will most easily split. They are unstable elements. As far as I know, we cannot split the stable elements.

John H.: In a hydrogen bomb they don't split an atom; they shove them together. The hydrogen makes helium. That uranium chain reaction keeps getting bigger and bigger because more neutrons are released each time an atom splits. It really splits a mess of them in a hurry.

Mr. Wailes: BY WHAT TWO KINDS OF CHAIN REACTION DO WE RELEASE ATOMIC ENERGY?

John L.: The atomic bomb.

Bobbette: The atomic pile.

Mr. Wailes: What is the difference?

Jerry: The bomb explodes, but an atomic pile doesn't.

Bob: We can control the heat in an atomic pile, but not the bomb.

Mr. Wailes: How do scientists control atomic energy in the atomic pile?

Carol: Cadmium rods.

Mr. Wailes: Why would cadmium rods control it?

Carol: The cadmium rods absorb the neutrons like mud absorbs rocks when you throw them at the mud.

Nancy: Put less uranium in. It wouldn't last as long, would it?

Mr. Wailes: That's right, Nancy, but that is not how we control it.

John L.: Can't they control it only when it is in an atomic pile?

Mr. Wailes: Right, John!

John H.: Graphite bricks slow the neutrons down in the atomic pile.

Don: The uranium gives off radioactive rays when you have it started.

Jerry: The cadmium rods absorb some of the neutrons so it doesn't split as many atoms.

John H.: The only way it can be controlled is to use an atomic pile.

Mr. Wailes: We all seem to have a good idea about the atom and how we obtain atomic energy. Let's move on.

Mr. Wailes: WHEN DID WE FIRST DISCOVER ATOMS AND ATOMIC ENERGY?

Jerry: Atoms were named by Democritus in 300 B.C. Atomic energy was discovered by Hahn, Meitner, Bohr, Rutherford, and a lot of others.

Mr. Wailes: Where were these men from?

Jerry: Greece, Germany, England, Denmark, and some were from the United States.

Bobbette: B e c something or other and Madam Curie from France discovered radioactivity.

Mr. Wailes: Becquerel.

Mr. Wailes: All of these men are from different countries. Does that mean anything to you?

Nancy: It means all of the countries cooperated to make atomic energy.

Jerry: Russia didn't. They shot down one of our airplanes.

Priscilla: The scientists told each other and helped each other out. I think that is good.

Mr. Wailes: Is it a good idea for peoples of different countries to work together on something like atomic energy?

Priscilla: Yes, they can get more done for everybody's benefit.

Nancy: They can try more experiments. If there is more than one person it is better.

Jerry: Oh, some people just want to be the big heroes all the time, and they don't want to help each other.

John: All of the men had different ideas. By working together they made a chain reaction. It is a lot better when everyone cooperates.

Mr. Wailes: Something as big as this took a lot of work. Now that we have it, what are we going to do with it?

Mr. Wailes: WHAT ARE SOME OF THE THINGS WE CAN USE ATOMIC ENERGY FOR? HOW CAN IT MAKE LIFE BETTER FOR US?

John L.: Powering a submarine.

Don: Atomic piles.

Mr. Wailes: Why will atomic piles help us?

Priscilla: Make electricity.

Mr. Wailes: How?

John H.: A lot of heat can make steam and the steam can generate electricity.

Nancy: Big passenger boats could get power from an atomic pile.

Bob: They might be able!

Jerry: Rockets and cars.

John H.: Not cars, Jerry, the atomic pile would weigh too much.

Carol: Trains.

Mr. Wailes: All of the things we have mentioned would come under what heading?

Bob: Transportation.

Bobbette: Cure for diseases would be another use of atomic energy—the radioactive rays might kill cancer.

Jerry: My uncle had cancer.

Bob: That isn't atomic energy; that is radioactivity.

Mr. Wailes: How do we make iodine radioactive, Bob?

Bob: Put it in an atomic pile?

Mr. Wailes: Couldn't we say then that the radioactive elements used in medicine come from atomic energy. We have to use the pile where a chain reaction is going on to get these radioactive elements.

Bob: All right, I will let that pass.

Priscilla: Would it help polio?

Mr. Wailes: I do not know. They haven't discovered anything yet.

Priscilla: It would help though! When people get polio they are put in iron lungs. The lungs are run by electricity. The atomic pile could make electricity.

Mr. Wailes: Correct, Priscilla. It's a merry-go-round.

John L.: Would it cure heart disease?

Mr. Wailes: It might help someday, John. There are many different scientists in all parts of the world working with radioactive elements in studying different diseases.

John H.: They have radioactive fertilizer that they test the crops with. The scientists think they will be able to understand a lot more about plants. That could give our world better crops.

Mr. Wailes: WHAT DO YOU THINK ABOUT ATOMIC ENERGY?

Priscilla: It can be a big help in our world.

Mr. Wailes: Why?

John L.: It can cure disease.

Bob: Might make the world better.

Mr. Wailes: How?

Bob: By curing a lot of diseases.

Nancy: We can make many different uses of atomic energy mainly making electricity.

Bobbette: It is wonderful stuff.

Carol: They might find many more uses of atomic energy.

Bob: It can make our transportation much faster.

Mr. Wailes: We have just mentioned a few of the many different possibilities. Do you think it is here to stay?

EVERYONE: YES ! ! !

EVALUATION OF THE UNIT (By Miss Margaret Day, Fifth Grade Supervisor)

Before this unit began some interest in the subject of atomic energy had already been generated by such media as the radio, children's comic books, newspaper headlines, and discussion in the children's social groups. Most of the children displayed continued interest during the course of the unit. There were fluctuations in the level of interest shown, but as a general rule interest increased as the children became more familiar with the subject.

Probably the most important criterion for evaluating the success of this atomic energy unit is the degree of understanding developed. In the opinion of this observer even the scientific aspects of atomic energy were understood much more clearly by the children than was anticipated at the beginning of the unit. Their ability to discuss the subject with at least beginning understandings; their ability to use scientific terminology correctly (see Appendix II); and their modest success with written examinations on the subject all present evidence that many fifth grade children can achieve worthwhile understandings in a study of atomic energy and its implications. In fact, several of the parents told this observer that friends who are physicists were amazed at the accuracy and extent of the children's knowledge.

On the other hand, it is probably true that their concept of the actual structure of the atom, how it fissions, etc., is quite limited and will be much more easily developed at a more mature age. Their understandings of the peacetime uses of atomic energy, however, were developed to a highly satisfactory degree.

The attitude and emotional tone which the children developed toward atomic energy is of great importance. One might well ask, "Did the study of this unit make valuable contributions to the right kind of attitudes?" In the opinion of this observer the answer is a decided "yes." As a case in point, one boy said to his mother, "Before we studied atomic energy I was afraid that we would all be blown up by the bomb. Now I know that there are many fine things that atomic energy may do for us and other people in the world."

Probably the greatest criticism of this unit lies in the fact that most of the discussion was carried on by the more intelligent children, although some of the slower learning children would occasionally bring questions to class based upon radio reports and newspaper articles. It seemed, too, as though the girls were disinterested on a number of occasions, especially when the scientific aspects of atomic energy were being studied. However, many of the parents told this observer that their daughters discussed the subject frequently and with interest while at home.

In general, the parents expressed great interest in the study and were eager to have an opportunity to read the stories about atomic energy. It was felt by the observer that this unit developed desirable attitudes between the school and the parents.

Recommendations and Comments by the Children:

1. That the unit be taught in the fifth grade because they could understand it. "The unit could be introduced in the later grades, but the children there would only learn what we have already learned, and when we are in the 6, 7, and 8 grades we can learn much more, because we have a good foundation."
2. A few of the better pupils suggested that the story be altered so that Howard, Barbara, and Mr. Anderson would not be characters in this story. They felt they would rather have conversation with scientists like Dr. Bohr and Dr. Meitner doing the talking. Many of the children objected to this change, however, and said that the conversation between Mr. Anderson and the twins helped them to understand the subject better. (It should be realized also that the story was only in mimeograph form with no illustrations. Since that time, the story has been rather thoroughly edited and a number of illustrations added.)
3. One pupil said, "My mother says that since we are in the atomic age, we should know something about it. I think so, too."
4. Several children suggested that radio and newspaper items concerning atomic energy became more interesting after they "knew something about the subject."
5. The class seemed to feel that this work in atomic energy would help them to better understand other studies in science.
6. One of the fifth grade boys heard a radio broadcast in which a university professor reported that many children whom he had interviewed expressed fear of the atomic bomb. The boy's comment in response to the broadcast was, "We aren't afraid of atomic bombs—we know that there are lots of good things about atomic energy."

Probably one of the most significant things that this observer can say about the unit is that she learned a great deal about atomic energy herself merely by listening to the class discussions. This understanding has developed a greater interest in the subject.

If a teacher has adequate interest and understanding of the subject herself it seems likely that a unit on atomic energy has possibilities during the second semester of the fifth grade, or in the sixth grade. Certainly the subject deserves every consideration as a part of the junior high school curriculum.

CHAPTER VIII

USEFUL ATOMIC ENERGY INFORMATION FOR THE TEACHER

Man has searched for many years for greater and greater sources of energy. Dynamite, coal, gasoline and many chemicals have given him access to limited sources of energy and yet he has known that there are even greater sources of energy—sources which would stagger the imagination if they could be made available. For example, for some time the scientist has known that something is happening in the sun to release a tremendous supply of energy. This energy is given off in the form of heat, light, and other radiations of somewhat lesser importance. Within the twentieth century scientists have found out that the energy of the sun comes from atomic reactions, or more precisely, nuclear reactions of some kind. Today these nuclear reactions are believed to be nuclear fusion.

To clarify the term nuclear fusion it is necessary to explain what this world is made of in the light of twentieth century developments. There are approximately 100 elements which unite in various numbers and various ways to form all plant, animal, and non-living matter in the world. These elements are such things as hydrogen, oxygen, gold, copper, uranium, carbon, sodium, and helium, to mention only a few of the more familiar ones. When different atoms of these elements unite they form compounds. One such compound is water, a combination of two particles of hydrogen and one particle of oxygen. (The particles of an element are called atoms.) Table salt is another compound. It is made up of an atom of sodium and an atom of chlorine. Most of the things we see about us are compounds. Only occasionally do we find an element in its pure state. Gold and copper are some of the more common examples of metals found in pure state. Of course oxygen in the air is in a free state, that is, it is not united with any other element to form a compound.

The elements are made up of atoms of almost inconceivably small dimensions. At the atom's center there is a speck which is called its "nucleus." Whirling around the nucleus are other tiny electrical specks called electrons. It is believed that they revolve around the nucleus much as planets revolve around the sun.

The nucleus of each element is essentially made of protons and neutrons. Protons are little bits of matter, each of which carries a positive charge. Neutrons are much the same as protons only they are "neutral," i.e., they have no electrical charge.

The electron is a particle carrying a negative charge of electricity, in fact, the smallest charge of electricity known today. The number of electrons circulating around the nucleus of an atom is the same as the number of protons in the nucleus.

The weight of the atom is almost entirely centered in the nucleus. In fact the proton is approximately 1,840 times heavier than the electron. Since hydrogen has only one proton in its nucleus, and hence only one electron circulating around it, it has an atomic weight of 1 *and its atomic number is 1.* Helium has two protons and two neutrons in its nucleus, hence it has an atomic weight of 4, but an atomic number of 2. The atomic number of an element is always equivalent to the number of protons contained in the nucleus. In like manner, the atomic number of an element is always equivalent to the number of electrons in the orbits. Thus, it is evident that the number of protons in the nucleus of an atom is always equal to the number of electrons circulating in orbits about the nucleus. The atomic weight of an element is equivalent to the combined number of protons and neutrons in the nucleus.

Since uranium is such an important element in the production of atomic energy, it will be helpful to know more about its structure. In the first place, uranium is not a single substance. Three isotopes of uranium occur in nature. All isotopes of an element have the same atomic number, which in the case of uranium is 92. This means that there are 92 protons in the nucleus. U-235, however, has 142 neutrons; U-235 has 143 neutrons and U-238 has 146 neutrons. It has been found that U-235 is the most easily fissioned isotope of the three. It will split and release energy as a result of capturing a slow-speed neutron. The U-238 isotope can be split only by a high-speed neutron.

Scientists have a way of *splitting* (fissioning) the nucleus of an atom. Atom splitting means that the nucleus of the atom is broken apart. It is really a nuclear fission—something which is not done in the process of ordinary chemical reactions.

Tremendous amounts of energy hold the nuclear particles together and when the nucleus of an atom splits much of this energy is released. The nuclear parts (fragments) which result undergo a re-arrangement and become atoms of lower atomic number and weight. For instance, when atoms of uranium-235 are split, one to three neutrons are ejected from each atom. The result is that two new elements, barium and krypton, are formed. Barium has an atomic number of 56 and an atomic weight of 137. This means that it has in its nucleus 56 protons and 81 neutrons. Krypton has an atomic number of 36 and an atomic weight of 83. This means that it has in its nucleus 36 protons and 47 neutrons.

Where does the great quantity of energy come from when a bomb is exploded? In order to answer this question it is necessary to understand that when certain rearrangements of the nucleus of an atom occur, such as in nuclear fission, there is a tremendous release of energy which previously has been holding the nucleus together. This energy appears chiefly as heat. Energy can be measured in electron-volts. We do not need to know exactly what an electron-volt is. It is sufficient for our purposes to know that when an atom of carbon burns in the air it releases 4 electron-volts. This energy appears chiefly as heat and very soon distributes itself through the surrounding atmosphere with little noticeable effect. The energy released by a uranium nucleus when split is in the neighborhood of 200 million electron-volts. Therefore, the energy released by splitting the uranium atom is 50 million times greater than that released by burning an atom of carbon. Burning carbon is a very common thing even for elementary school children. However, it staggers the imagination to think of a release of

energy 50 million times greater than the energy released by burning one atom of carbon.

If it were possible to get millions of uranium atoms to release their nuclear energy simultaneously there would be a tremendous amount of energy which would appear as heat, light and other radiations and result in what is commonly called an explosion. This simultaneous release of the energy contained in the nuclei of a few pounds of uranium-235 was achieved by scientists during World War II and resulted in explosion of the atomic bomb. How was this achieved? Scientists reasoned that if it was possible to make the nucleus of an atom of uranium split it might be possible to arrange things so that the result of splitting one nucleus would result in splitting two or more other nuclei. These latter split four or more other nuclei and these split eight or more others and so on without end. This process can be briefly explained as follows: When a uranium nucleus is split it will release two or more neutrons having tremendous speed. These neutrons will strike the nucleus of two or more other atoms which in turn will each release two or more neutrons with tremendous speed. If things are properly arranged this process takes only the merest fraction of a second before so many nuclei have been split and so much energy has been released that a great explosion occurs. This is the principle of the atomic bomb.

Now scientists can control the process of nuclear fission by properly arranging the uranium in a pile of graphite (the lead in a pencil is made of graphite). This arrangement of uranium and graphite is called an atomic pile or reactor. In this reactor it is possible to control the release of energy so that the energy can be used for producing power or for producing other elements which can be used by doctors, plant pathologists, horticulturists and other professional people to study the effects of radioactive elements on plant and animal life. These radioactive elements have already helped in the study of how plants and animals assimilate food, in the treatment of cancer, and in many other uses beneficial to man.

The process of splitting the nucleus of an atom into two or more smaller pieces is called nuclear fission. The inverse process of putting the nuclei of two or more atoms together to produce an atom having a larger nucleus is called nuclear fusion. The sun gets its energy from nuclear fusion. Atoms of hydrogen unite to make atoms of helium releasing a great quantity of energy in the form of light and heat. Prior to the World War II this process could take place only in hot stellar bodies such as the sun. Since World War II it is believed possible to split atoms to produce temperatures hot enough to enable nuclear fusion to take place, in particular to allow four atoms of hydrogen to unite to make an atom of helium. The result is a release of energy even greater than that released when a large atom such as uranium-235 is split.

The method for producing a hydrogen bomb is now quite evident. A small atomic bomb made of uranium-235 or plutonium can be used as a trigger for exploding a quantity of heavy hydrogen. The disintegration of the uranium will produce such high temperatures that it will enable the hydrogen to fuse into helium with the consequent release of immense quantities of energy. There may be no limit to the size of the explosion that can be obtained with the hydrogen bomb. The more heavy hydrogen made available in the bomb the greater may be the explosion. This is not true of the atomic bomb. There is a real upper limit to the amount of energy that can be released through the fission process because it is not possible to put more than a certain amount of uranium-235 or plutonium in the bomb. If too much uranium or plutonium is placed in the bomb it may explode automatically. However, it is probably true that the upper limit of the bomb could be raised by making more chambers in which to place the uranium or plutonium. In other words it is theoretically possible to have a battery of atomic bombs.

There is yet another difference between atomic energy as obtained by fusing hydrogen and atomic energy obtained by fissioning uranium. The energy released by fusing hydrogen to make helium cannot be controlled at the present time. It has already been pointed out that by means of a graphite pile it is possible to control the energy released by the splitting of a quantity of uranium atoms. Thus, at the present writing, the only possible use of the hydrogen fusion process is to produce explosions—explosions of such size that they would have few possible peacetime uses. The energy obtainable from splitting the uranium atoms can be put to beneficial use because it is a process that can be controlled. (Operated at various energy levels.)

The fact that the release of energy produced by nuclear fusion cannot be controlled may put our future, in this atomic age, in a more precarious position than it was when the atomic bomb was first produced. We may be able to produce great quantities of energy that could do work which is beneficial to mankind. Furthermore, we may be able to learn many of the innermost secrets of nature but all of this will be to no good purpose unless we learn how to control this knowledge for constructive purposes only. It is the task of the schools everywhere to develop those attitudes towards science and toward one's fellowmen which will make sure that atomic energy will be released only in such ways as will result in a better life for all mankind.

ILLUSTRATIVE INFORMATION ABOUT ATOMIC ENERGY*

1. Atomic energy is the basic energy of the universe.
2. Ordinary chemical reactions affect the *arrangement* of the atoms but not their identity; atomic reactions change the identity of the atoms.
3. The sun loses by radiation 4 million tons of its mass every second, yet its total material is so great that it can run steadily for millions and millions of years.
4. The transmutation of hydrogen (the lightest element) into helium (the next lightest) with the coincident transformation of a small increment of the mass involved into radiation, is what happens in the hot interior of stars built in the solar model.
5. In the sun's interior, where hydrogen builds into helium, the temperature is more than 20,000,000 degrees centigrade. The surface temperature is only 6,000 degrees centigrade. Our existence is possi-

*These illustrative facts are included chiefly for the purposes of (1) emphasizing the unusual magnitudes which need to be considered when dealing with the quantitative aspects of atomic energy, and (2) pointing out that we are at the gate-way to a new world, a world of nearly unlimited power.

In most instances, it should be recognized that these "facts" are only approximations and that entirely accurate figures probably will never be obtained. In preparing this list, the committee has used authoritative sources, but has not quoted verbatim.

ble only because the outer atmosphere of the sun serves as a screen and a radiation softener.

6. Our earth, because of its great distance from the sun (92,000,000 miles), blocks only about one part in two billion of the outpouring radiation from the sun.

7. The cyclotron at the University of California weighs approximately 4,000 tons. The 10 foot wall of concrete surrounding this cyclotron is protection against the high energy radiations.

8. An ounce of hydrogen (the lightest element) contains about 20 million billion billion atoms.

9. An atom is so small that a hundred billion billion (100,000,000,000,000,000,000) are contained in the head of a pin.

10. Each day your body takes in nearly a billion billion billion new atoms. (1,000,000,000,000,000,000,000,000,000) (Or $1x10^{27}$)

11. The average person contains about 10 billion billion billion atoms. (10,000,000,000,000,000,000,000,000,000) (Scientists write this number as $1x10^{28}$.)

12. Atoms are so small that it would take the entire population of the earth 10,000 years to count the number of atoms in one drop of water. Before making this count, each of us would have to shrink to one-billionth (1/1,000,000,000) of an inch in height to see what we were counting.

13. The diameter of the nucleus of an atom is 1/2,500,000,000,000th of an inch.

14. If the nucleus of a hydrogen atom could be enlarged to the size of a pin head, the atom itself, if enlarged correspondingly, would be about 30 stories high.

15. The nucleus—the object of study in nuclear science—is about 1/10,000 as large as the atom. If an atom were expanded to the size of a concert hall, its central nucleus would be smaller than a fly; thus it is obvious that the atom is largely space. The nucleus constitutes nearly all of the mass of the atom, and consequently, the mass of all things. A piece of solid nucleus material the size of a marble would weigh more than 400,000,000,000 pounds.

16. More than 99 per cent of that part of an atom which isn't space is contained in the nucleus.

17. Your automobile is about 1 million times as powerful as a fly (atomic power is a similar improvement over gasoline).

18. Each fission of a uranium atom releases energy millions of times greater than that released by a single molecule in a chemical reaction.

19. For the same weight of material the energy released from the nucleus of an atom is roughly a million or more times greater than that from chemical change.

20. When electrons stream through a wire they create an electric current. About 6 billion billion pass through a 100-watt electric light each second.

21. One atom in itself is not powerful—even though when it splits it yields something like 200,000,000 electron-volts. It would take 1,000,000,000,000,000,000 electron-volts to raise a pencil from the floor to the top of your desk. In other words, you need the energy from 5,000,000,000 uranium atoms to do it for you. "So an atom isn't powerful at all by itself. The beauty of atoms is that it is so easy to get a crowd of them. In one pound of uranium there are 1,160,000,000,000,000,000,000,000 atoms . . . if all these big numbers have made you dizzy, this is all they are meant to point out—one atom isn't very mighty, as humans measure might. But a pound, or an ounce, or a mere smidgeon of uranium has so many atoms that it packs a wicked wallop."

22. If all the mass of one pound of coal were directly converted into energy, it would probably equal the energy released in burning 1 1/3 million tons of coal.

23. The combustion of one pound of coal can raise the temperature of 700 pounds of water by 18° Fahrenheit. But "combustion" of one pound of uranium would produce an equal temperature rise in 2 billion pounds of water.

24. One ounce of matter is equivalent in energy to the output for a month of the great power plant at Boulder Dam.

25. Einstein's famous formula which showed the relationship between matter and energy is $E=MC^2$. "E" stands for energy; "M" for mass; and "C" for the velocity of light. It is most important to note that C represents a huge number—186,000 miles per second. When multiplied by itself, as C^2, this number becomes 34,596,000,000. This means that when an incredibly small amount of matter is annihilated, an enormous amount of energy is produced.

26. The "shell" of an atom is only about 1/250,000,000 of an inch in diameter.

27. A typical isotope shipment (carbon 14) from Oak Ridge is 1/300 of an ounce of barium carbonate. In that shipment, 37 million atoms are disintegrating every second. If that small quantity of barium carbonate were equally distributed among a million rats, a Geiger counter could detect radioactivity in each rat.

28. One proton has about 1,800 times as much mass as an electron.

29. Among the 98 elements now known there are over 800 known isotopes. For example, carbon has five known isotopes; two are both stable and natural, and three are radioactive and man-made.

30. Two giant proton-synchrotrons (atom smashers) to be built at the University of California, Berkeley, and the Brookhaven Laboratory, Long Island, will have diameters of approximately 75' and 110' respectively.

31. The Brookhaven Atomic Reactor is a pile of some 60,000 graphite blocks—the graphite is like the lead in a pencil. There are 2,600 different sizes and shapes of these pieces of graphite. Putting them together was like assembling a giant puzzle.

32. It is not unusual for a single bolt in one of the magnets of a cyclotron to weigh over 400 pounds.

33. Why is the atomic powered automobile not an immediate possibility? Because the weight and size of the atomic reactor needed to power it would be too great. According to one estimate this atomic automobile would weigh 175 tons and have thirty-six wheels.

34. Radium seems to be an almost limitless reservoir of energy. One authority claims that it is 1½ million times more radioactive than uranium.

35. A tablespoon of uranium contains potentially the same amount of energy as 750 tons of coal.

36. An ounce of uranium (the heaviest natural atom) contains about 100 thousand billion billion atoms. (100,000,000,000,000,000,000,000,000)

37. Some atomic instruments are so sensitive that they can detect extremely small amounts of radioactive elements sometimes as little as a billionth of an ounce.

WHAT THE FUTURE MAY HOLD FOR MANKIND

1. In the future we may derive our main source of energy from the atomic nucleus. When this time comes, energy for man's use will be plentiful and cheap.

2. The production of electrical energy from the atomic nucleus will almost certainly come.

3. Through the use of atomic energy food may be cheap and abundant throughout the world.

4. Metals of lightness and incredible strength will be produced. Metals of great value, such as gold, may be produced artificially.

5. Heart disease, cancer and contagious diseases can be more readily studied through the use of radioactive isotopes and may eventually be brought under control.

6. Because radioactive isotopes aid in the study of diseases, the life span of man will undoubtedly be increased considerably.

7. Causes of arthritis may be discovered. Calcification of joints and disintegration of tissues may be controlled or even eliminated.

8. Thyroid growth is already being conquered by radioactive iodine. Blood disorders of rare but fatal types are succumbing to radioactive phosphorus.

9. It may be possible through the use of radioactive isotopes to break through the wall of ignorance that has always restricted us in understanding the fundamental processes of life.

10. Industries in cities will probably use atomic energy as a source of power. Thus the black pall of smoke over our cities will be lifted with a general improvement in both cleanliness and health.

11. Factories may derive their power from the nucleus of the atom. There may be power to run factories even in those countries that have no coal or water power.

12. Ships, trains and airplanes may be propelled by energy derived from nuclear sources.

13. Atomic power for ships, and perhaps for locomotives, may become a reality within the next decade. It is not likely that power for automobiles and airplanes will be developed so soon because of the weight of the shielding materials required to protect individuals operating the mechanism.

14. Aircraft with supersonic speeds flying at stratospheric altitudes are probably within reach of a few years' developments.

15. Some desert lands may be made productive.

16. It is possible to produce radioactive carbon which helps to unravel the mysteries of photosynthesis (the process by which plants store up energy from the sun).

17. Radioactive carbon will aid us to understand how lime is utilized from the soil.

18. There probably will be much more leisure time for all and a great increase in recreational opportunities.

19. Human relations may reach new highs. People everywhere may become more cooperative assuming friendly attitudes toward those who live in other nations.

CHAPTER IX

CITIZENSHIP IN AN ATOMIC AGE

INTRODUCTION

Modern civilization demands a high quality of citizenship. Each technological advancement and each scientific discovery introduces to the social order factors which require changes in our relationships with other peoples and groups. Improved means of communication and transportation have eliminated distance and have made the world into one interdependent neighborhood.

Along with the advance in technology, civilization has gradually evolved higher standards of ethical and moral conduct. Recognition that principles of righteousness and justice must be applied universally if mankind is to have a happy and secure social order had its earliest roots in Ancient civilizations. Slow but continuous progress has followed during succeeding centuries. Today citizenship standards must rise to a higher level than ever before if recent scientific discoveries are to prove beneficial rather than fatal to modern civilization. Mankind has successfully met the challenge in ages past. Sincere belief in the essential goodness of human personality gives democratic nations an optimistic outlook concerning the possibility of solving the new problems introduced by present day understanding of atomic energy.

The preceding pages have outlined goals and learning activities in the teaching of atomic energy as well as some of the scientific and social concepts which the elementary school child should develop. The need for certain citizenship traits is both stated and implied in the preceding sections. A summary of essential citizenship traits which should be fostered during the study of atomic energy and its social implications comprises the concluding section of this booklet. No attempt is made to list the traits in the order of their importance, nor to classify them into concepts, skills, and attitudes. The summary of citizenship traits is intended as a convenient check list which the teacher might use in determining the progress which her pupils are making in integrating and applying information about atomic energy in socially desirable patterns of actions.

QUALITIES AND ACHIEVEMENTS OF THE GOOD ELEMENTARY SCHOOL CITIZEN

1. He respects human personality. Human values are placed above any other values.
2. He reacts to people of all races, creeds, and sects in terms of the individual personality traits of each member rather than in terms of unscientific characteristics popularly attributed to various groups.
3. He desires and is willing to work for the application of principles of justice and fairness for all people in the world. Denial of justice and fairness to any individual or group is a threat to justice and fairness for all.
4. He recognizes his personal responsibility for helping to solve the problems which confront groups of which he is a member.
5. He understands that man's increasing ability to create machines and sources of power means that man also should learn how to use them for good purposes rather than for destructive purposes. Increasing knowledge requires increasing sense of responsibility.
6. He is learning to respect people who think out ways for making life more secure and comfortable for all. He is learning to respect intellectual achievement.
7. He realizes that all individuals tend to adopt or accept the prejudices and biases of their own social group. The intelligent citizen tries to be aware of his prejudices and does not permit them to interfere with his reasoned consideration of a problem.
8. He recognizes the importance of cooperative activity in a complex industrial world. He, therefore, tries to develop the ability to cooperate with others.
9. He realizes that the world has faced serious problems before but that intelligent planning has resulted in a reasonably satisfactory solution to many problems.
10. He appreciates the value of creativity in all kinds of work. He tries to develop his own resourcefulness.
11. He has faith in people and in the fact that people readily develop cooperation, kindness, and world brotherhood if these qualities are permitted opportunity for growth.
12. He begins to realize that his own freedom is obtained through spontaneous and free cooperation with groups who are interested in maintaining justice and freedom for all people in the world.
13. He has a sincere appreciation for the great contributions of people of the past upon whose work modern civilization is built.
14. He has learned the satisfactions which come from performing socially useful service for others.
15. He recognizes the fact that all people everywhere have the same basic need for security, for recognition and successful experiences, for engaging in creative activities, and for finding belongingness and status in the social order of which each is a part. These can be considered universal values.
16. He respects all forms of useful labor and appreciates the role of all workers in a complex industrial society.
17. He realizes that modern means of communication and transportation vastly increase the need for friendly relationships among people and nations as no group is able to isolate itself from the rest of the world.
18. He recognizes that all races are physically and mentally equal and that the differences which exist among them have evolved during a long period of adaptation to environmental differences. Differences in skin color and in habits of living are superficial.

19. He obtains security from the study of the past which reveals to him that civilization has progressed as larger and larger groups of people have found it possible to live happily under a just and fair system of government. The evolving of a world political unit which offers protection to all groups appears as a logical forward step in the political advancement of mankind.
20. He realizes that oppression, want, and insecurity foment aggression. No part of the world is safe while oppression, want, and insecurity are found in certain areas of the world.
21. He is becoming aware of the unscientific practice of scapegoating in order to relieve the group from responsibility for some undesirable condition which prevails.
22. He appreciates the need for ability to communicate his ideas clearly in either oral or written form.
23. He is alert to the value of acquiring new words which will enable him to communicate his ideas effectively. At the present time many of his new words may relate to atomic energy and its impact upon society.
24. He develops skill in the reading of charts, diagrams, and maps. He appreciates that these devices are excellent media for transmitting certain types of information to others.
25. He uses logical steps in solving his problems. He tries to define his problem accurately, to find facts which contribute to the understanding of his problem, to think through possible means for solving the problem, and to judge the wisdom of various possible solutions to the problem.
26. He analyzes data and opinions to determine whether these are designed to sway his emotions or whether they make an appeal to his reason. He is familiar with commonly used propaganda techniques such as name-calling and testimonials.
27. He evaluates ideas which are presented through movies, press, and radio. He is slow to accept hearsay, and seeks the authority for statements and opinions which are expressed.
28. He places himself in the role of inquirer rather than that of advocate for a course of action until he has had the opportunity to gather facts and form a reasonable opinion on the question at hand.
29. He stimulates the free interchange of ideas among peoples and groups in the firm belief that erroneous ideas will not long persist if they are open to free discussion.
30. He respects honest differences of opinion and is willing that other opinions than his own be considered by the group.
31. He recognizes that apathy concerning world problems is a serious drawback to the solution of these problems in the modern world.
32. He realizes that most problems in which conflicting interests exist must be solved through working together for a new and better solution. The individual is therefore willing to discard his own wishes in order that the welfare of the group shall be served.
33. He appreciates the importance of perseverence and industry in the discovery of scientific information. He respects industry and perseverence in others and in himself.
34. He recognizes the importance of scientific research in finding solutions to problems of disease and want in the modern world.
35. He appreciates the place which science has played in the progress of mankind. He is optimistic concerning what the future holds in store.
36. He keeps himself sufficiently well informed concerning developments in the use of atomic energy that he is not frightened by unreasonable rumors which arise concerning atomic development.
37. He understands that natural laws operate in the physical world and that through scientific research man can understand some of these laws.
38. He realizes that man's understanding of laws which operate in the physical world give him some ability to control factors in his environment for his own advantage. He can predict with some accuracy the results of some of his actions.
39. He possesses a feeling of security which comes through his knowledge that stable laws operate in the physical world.
40. He appreciates the fact that science is concerned merely with the discovery of facts and truths. Man is free to determine whether he will use new information for the advancement or for the destruction of society.
41. He appreciates the fact that all scientific knowledge is international. Scientific method is used throughout the world. New scientific discoveries quickly become known to leading scientists throughout the world.
42. He appreciates the importance of energy in modern civilization and understands that the discovery of this new source of energy is an event of great significance.
43. He realizes that intelligent plans must be made for making necessary social adjustments as a result of new inventions and discoveries.
44. He is concerned about the conservation of all resources, human and physical, in order that a higher standard of living may be attained by all peoples of the world.
45. He possesses intellectual curiosity, or a desire to find out more about his physical and social environment and to keep informed about new scientific discoveries and inventions.
46. He realizes that through the use of scientific research mankind may solve the age-old problem of securing adequate sources of energy. Much human energy and ingenuity could then be released and used for the advancement of civilization to higher levels.
47. He realizes that atomic energy is not new in the universe, but that man's understanding of it is new.

48. He expects rapid progress in scientific development in the area of atomic energy because of the broad background of research from the past which can be drawn upon to advance new discoveries.

49. He realizes that atomic energy is immeasurably more powerful as a destructive agent than any invention which man has previously improvised.

50. He realizes that no place on the earth can be considered secure from atomic attack. The need for world control of atomic energy is therefore apparent.

51. He knows that small, poor nations as well as large, wealthy nations will shortly have available the use of atomic energy for warfare. Wealth is therefore, much less important than it previously was in insuring security.

52. He realizes that the nations which are highly industrialized and in which large cities are found are especially vulnerable to atomic attack.

53. He has faith in the ability of human beings to rise to greater ethical heights than they have at present attained, just as man has reached greater heights than he had previously attained in his understanding of natural laws which operate in the universe.

54. He realizes that great thinkers of the world have given man elevated concepts of ethical conduct, which, if applied to daily living by all peoples of the world, would insure a secure and happy world social order.

55. He realizes that advancements in ethical thought are equally important with advancements in scientific information.

56. He participates actively in projects which foster world understanding and good will.

57. He holds an attitude of good will toward others.

WHAT SHALL WE DO ABOUT THESE QUALITIES?

How can this list of qualities and achievements be used by a teacher or a school system? These qualities are not empty statements of high sounding ideas. They are applicable to the children in each teacher's class. It is sometimes difficult, however, for an individual teacher to be sure that she is making correct interpretation and application. Therefore, the following suggestions for implementing these citizenship traits are made:

1. Have a series of staff meetings for consideration of citizenship in an atomic age. Bring in parents both for their ideas and for promoting action in home and community.

2. At the first meeting you may wish to read aloud a number of the items getting different peoples' interpretations. Ask all members of the group to read the other items individually and note the ones which seem confusing or about which they have questions.

3. At another meeting discuss those items which present problems, clearing up any misunderstandings, and changing or eliminating those which the group does not approve. Probably more value will come from the development of a local list of citizenship traits than from the study of an already prepared list.

4. Conferences with parents or other teachers might be devoted to an examination of specific illustrations of pupils who seem to possess the desired qualities or those who show a noticeable lack of them.

5. Another meeting might be devoted to making plans for developing these qualities of citizenship, using suggestions made elsewhere in this source book and also new ideas growing out of the particular school situation with which this group is concerned.

6. Each teacher may find it valuable to check the attitudes of pupils and the spirit of her classroom against this list—or the modified list which may be developed locally.

Children will not study this list of citizenship traits as such. They are, however, able to understand many of the ideas involved and to discuss them at the level of their own maturity. The most important measure of the value of this list of traits will be found in the way children live day by day.

APPENDIX I

POINTS OF VIEW OF SELECTED EDUCATIONAL AUTHORITIES

INTRODUCTION

At an early stage in the planning of this report letters were written to a number of leading authorities in various educational areas. Many of them were specialists in elementary school science or elementary education in general. These specialists were invited to express their opinions regarding the advisability of studying atomic energy and its related social implications at the elementary school level.

The following generalizations have been drawn from a study of the opinions expressed:

1. There was a majority agreement regarding the importance of the subject.

2. There was also rather general agreement that atomic energy and its social implications should be taught at the elementary school level *if content and activities appropriate to the maturity level of children could be found.*

3. There was a rather general agreement that an effort to discover appropriate content and activities should be made.

4. Some of the authorities felt that atomic energy and its social implications might be successfully taught at the elementary school level, while others seemed to be dubious about the possibilities. A small number appeared extremely skeptical regarding the project, but, at the same time, were willing "to be convinced."

5. The committee felt that the large majority of these authorities would be interested in a publication which presented a number of possibilities and ideas in the area of atomic energy instruction—even though it were recognized that individual school systems and classrooms might be able to use only a limited number of the suggestions in their own local situations.

6. It seemed to be either directly expressed or inferred that we should "view atomic energy in the larger framework of child development and in terms of the kind of boys and girls that are needed in a democracy."

OPINIONS OF SPECIALISTS

With the permission of the authorities represented, the following replies are presented here. In a few instances they have been edited slightly in order to utilize those sections of the response letters which applied to the problem at hand.

"Those of us engaged in the teaching of children or in the training of teachers for these children, are finding ourselves hard pressed to adjust and change our teaching to coincide with the rapidly changing and accelerating elements of our environment. Even if we were able to keep up, it would not be enough. The advent of the atomic age has thrust new demands and responsibilities upon every man, woman, and child. We can no longer just keep up; we must attempt to anticipate. One of the ways in which we can carry out 'anticipation' is to give to the children now in our elementary schools, equipment in the way of knowledges, skills, and attitudes, which will aid them to continuously orient themselves to this always changing world. Does this infer the study of atomic energy? I think it does! Some orientation in regard to our relationship to and responsibility for atomic energy may be derived from the following article entitled *Adam to Atom:**

> Since the dawn of history, man has attempted to push back the veil that hides the key to knowledge. Since the time of Adam, man has spread himself over the earth into tribes, clans, and nations. Since the time of Adam, man has used the tools and products of science to improve his living or as weapons to fight the neighboring clan or nation.
>
> Early man, often used pieces of stone to build a fireplace on which to cook his meal; or when confronted with danger chose the nearest stone to use as a weapon. Science can explain the formation of the stone on the basis of wind and water erosion, or by the freezing of water and the subsequent expansion. Science is also able to tell us the chemical composition of the stone, and classify it as sandstone, granite, or marble.
>
> Science is simply an explanation of what is. Science infers no good or evil. A stone may be used as a fireplace or as a weapon with which to kill. Science does not determine the use to which man may put the stone. Only man can determine whether the use will be of benefit to mankind.
>
> The past few years have witnessed an acceleration in the products of science, such as the atom bomb. Even though the atom bomb possesses terrific potentialities as a weapon of war as compared to a stone, the fact remains that both may be used as weapons of war or for the benefit of mankind. Science has contributed many weapons of war, but war is not the sole responsibility of science. That responsibility rests on every citizen. Science is neither good nor bad—it is what man does with science or its products that may be good or bad.
>
> Some may call this an age of gadgets produced by science, but one of the chief contributions of science has been a method of thought inferior to none—the scientific method. If the method of science were applied to the problems confronting man in world politics, education, and leadership, man would be able to use the products of science to improve social and economic progress. We need only quote Benjamin Franklin to substantiate the above statement: 'The rapid progress true science now makes, occasions my regretting

*Anderson, Kenneth E., "Adam to Atom," *School Science and Mathematics*, May, 1948.

that I was born so soon. It is impossible to imagine the height to which may be carried, in a thousand years, the power of man over matter. O that moral science were in a fair way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn what they now improperly call humanity'.

Yes, man has progressed from Adam to atom. Shall it be from Adam to atom to peace? Shall it be from Adam to atom to chaos? Only man can determine the direction we now take.

"What implications does this article have for education of elementary school children? Man is curious about his environment. Let us therefore encourage genuine curiosity in children. They hear about atomic energy. They talk about atomic energy. They may live or die by atomic energy, so they need to know about atomic energy. The schools are responsible for imparting to children an understanding of the nature of this new energy and the consequences of its uses. Science can explain the technical applications of new concepts through which our material world becomes a better place in which to live—a better place to live *if* the new developments are used to benefit mankind. A tremendous responsibility is placed upon our future men and women. They must be made ready to meet this responsibility: they must learn to apply effective methods to the solution of problems, and they must choose to use the productions of science for good.

"How can this preparation be best accomplished? In the elementary school children can be given an understanding of the broad concepts or 'big ideas' of science, a scientific method of thinking commensurate with their level of maturity, and some insight into and realization of the relationship of science to society. Can our teachers do it? Not until they themselves are educated in this philosophy. Science in the elementary school can no longer be conceived as nature study with additional units on machines and magnets. Our science program on the elementary level must be sequential, and organized not so much around the typical questions of 'What is it?' 'When?' 'Where?' 'How?' 'Why?' and 'Who?' as around an approach of 'How can I find out?' Atomic energy must not become the focal point in the elementary science program, however. An understanding of it must grow out of a broader understanding of the whole field of science, a curiosity concerning the immediate environment and the operations of science upon it. If we take this approach to the study of atomic energy in the elementary school, it seems to me we should help our children to acquire a more thorough understanding of their world, and confidence in its future."

Kenneth E. Anderson
School of Education
The University of Kansas
Lawrence, Kansas

"As far as an understanding of the science underlying the liberation of atomic energy, I doubt if there is anything we can do. As you know the concept of 'energy' is very difficult to teach. We do teach the nature of burning in which heat energy is liberated. Burning is an example of a chain reaction which can be easily understood. About as far as we can go is to get across the idea that liberation of atomic energy is a chain reaction which results in the liberation of energy of an entirely different order than any chemical change. A comparison of the energy generated from the burning of one pound of coal with that generated when a pound of matter is converted to energy would give some idea of this. Then the relative destructive effects of a given quantity of explosives with that of the atomic bomb could be presented. The essential idea to get across would be that in atomic energy we have a source of energy which is inconceivably greater than any source of energy we have hitherto used; that the development of this source of energy will bring great changes in our world—so great, that at present we can hardly predict them. We could also discuss the ways in which atomic energy will probably affect us. We should play up the peaceful uses in the production of radioactive isotopes which we can use to discover chemical processes in living things and in the discovery of disease. I doubt that I would try to develop a unit on atomic energy. I would bring it in under a general unit on energy and thereafter in every unit in which its use may have implications."

Wilbur L. Beauchamp
Associate Professor of Teaching of Science
The University of Chicago
Chicago 37, Illinois

"Your letter is most provocative, and I am glad your committee is giving thought to the place of atomic energy in the elementary school. It seems to me your total proposed outline is excellent. And, I like your own interpretation of the place in the elementary school of atomic energy considerations as explained in a closing paragraph of your letter.

"I think we need to keep in mind that the children in our schools are living in a world in which a great deal of discussion is going on about atomic energy and its implications for good and bad. Much of what they hear may be inaccurate information, opinions based on prejudices and highly charged emotions, and misunderstandings due to a real lack of information on the part of their associates, young and old. Thus, they are forming opinions of their own about atomic energy whether or not we deal with the topic in school. To me it follows that we have some obligation to try to help children clarify their understandings on problems in this area just as we have a responsibility in school to help them with other immediate and pressing problems. It does not follow, however, that a multitude of technical and scientific facts on the subject need to be learned by children in the elementary school. Rather, it seems to me, there should be more emphasis in the elementary school on working out solutions to many problems of significance to the children. Children need opportunities to solve problems if we really want them to be able to solve problems. An emphasis which makes possible and urges children to do group thinking and planning on a variety of important problems is, in my opinion, as good a preparation as any other for living in an atomic age."

Paul E. Blackwood
Specialist for Elementary Science
Office of Education
Washington 25, D. C.

"It is a pleasure to have your letter of March 31 and to have the opportunity of examining your draft publication, *Preparing Elementary Pupils for the Era of Atomic Energy*.

"Your document is naturally one of great interest to all education and to many individuals here in the office of Education. I have taken the liberty therefore of showing it to Dr. Glenn Blough and Dr. Paul Blackwood who are Specialists in Elementary Science. They may write to you directly.

"Again, please accept my thanks for permitting me to see this '. . . brave new document which may do so much to help the students bring forth a truly brave new world'.

"In an overall personal judgment I liked the document and believe that you and your committee are to be congratulated for a difficult job very well done."

Floyde E. Brooker, Chief
Federal Security Agency
Office of Education
Washington 25, D. C.

"In my earlier note I tried to convey the undecided attitude of most school people with whom I had talked and the lack of agreement. My personal view has developed little since that reply to your question. There is much and immediate need for attention to science in our elementary and higher schools in this time of partial science and potential barbarism. This age is yet to be proved the Atomic Age. Much of science essential for education in a democracy hardly falls within the group of studies usually viewed as atomic science, although clearer insight in many fields is unfolding as a result of nuclear studies. The lure of atomic headlines seems to be inspiring an attempt to energize school life with atomic studies or with 'The Bomb' alone. Much science is molding our lives that does not fall within the atomic category. Let us not permit 'atomic energy' to monopolize the time for science in our schools to the exclusion of other important science information and influence. There may be danger that the bomb will blast much other important science temporarily from the curriculum. By all means include atomic energy in our science education at elementary and higher levels, but with due respect for the importance of other fields.

"And let us not think that atomic studies by scientists or by elementary school pupils will reform the political and economic life of the earth or lessen 'man's inhumanity to man'."

Franklin P. Carroll
Frankford High School
Philadelphia 24, Pa.

"We must consider that atomic energy is one of many forms of energy that have been discovered by man at various times of his history. These forms of energy have brought about elements of progression and retrogression. The majority of discoveries and inventions that man has made have been utilized for good as well as for evil. For this reason atomic energy should not be set apart in the elementary school curriculum into a separate category. It should become a part of the larger program of the elementary school curriculum and should be viewed in terms of science and social living in childhood education.

"As I wrote you earlier, we should attempt to view atomic energy in the larger framework of child development, and in the terms of the kind of boys and girls that are needed in a democracy.

"We are living in a period of paradoxical conditions. Through science man has made discoveries about the nature of the universe which can be useful in developing a higher standard of living; better health, more conveniences, finer recreation. Yet, many of these discoveries provide man with new means for human destruction. The boys and girls in our classrooms will live in a time of important decisions—decisions as to whether science is to be used predominantly for good or for evil. It is essential to the very survival of our democracy and our civilization that the next generation be intelligent concerning the potentialities of science.

"Through the teaching of science, we can gradually assist in developing a dynamic democracy. Children must develop a poised, well-balanced, and yet realistic outlook upon the modern world. They must learn that by working resourcefully and intelligently with the materials, forces, and patterns of the universe they can create their own world. In this way science can be utilized in developing a dynamic democracy.

"It is against such a background of child development and social values that I would see atomic energy. In addition, this means that the evaluation of such instruction should be in terms of the development of resourceful behavior."

Gerald S. Craig
Professor of Natural Sciences
Teachers College
Columbia University
New York 27, N. Y.

"The development of instructional materials on atomic energy for the elementary level seems a rather ambitious undertaking. Perhaps sixth, seventh, and eighth grade pupils may read newspaper and popular science articles about the problems of atomic energy and its use. Children hear the term electron so much today that I believe we should use it regularly in the intermediate grades in studying electricity. The nucleus of the atom is another matter. However, I see no reason why children cannot talk about atoms and gain a very limited understanding of atomic structure. They can learn that the nucleus is held together with tremendous forces and can gain a little idea of what the release of atomic energy means. They would thus be much more interested in reading the rapidly increasing supply of popular articles on atomic energy, its developments, potentialities, and implications."

W. C. Croxton, Chairman
Division of Mathematics and Science
State Teachers College
St. Cloud, Minnesota

"I have just finished reading your very detailed and excellent booklet, *Preparing Elementary Pupils for the Era of Atomic Energy*. I believe that you and the committee have completed a very worthwhile task, the results of which will be useful and appreciated by a number of teachers who are attempting to incorporate atomic energy into their school programs."

Donald G. Decker
Chairman, Division of Sciences
Colorado State College
Greeley, Colorado

"It is my feeling that there is no aspect of atomic energy that should be handled in the elementary school, although much can be done at the junior high school level. However, most of the work in this field should be reserved for the high school and college."

George W. Frasier
President Emeritus
Colorado State College
Greeley, Colorado

"Your letter of February 4, 1950, on the subject of *The Iowa Plan for the Study of Atomic Energy* reveals a very significant step forward in this phase of curriculum. I am glad to note that Iowa has taken such an interest in a field which unfortunately is being neglected. As I look over the table of contents for the elementary school phase, I am interested to note the well-rounded treatment which you are providing. Since you ask me for comments or questions about particular phases of your proposal, I would like to question *Characteristics of Elementary School Citizens in the Atomic Age*. To me, the title itself does not reveal the pertinence of this subject for the publication. Perhaps I am not aware of what you have intended.

"Another question I have concerns the basic assumption which has the following sentence: 'This information should at least reach the level of that acquired by the intelligent layman'. It seems to me that elementary teachers need to be more conversant than the intelligent layman about atomic energy. I don't mean that they should be specialists in nuclear physics, but it seems to me that they will need to have a stronger background in the content and the vocabulary of atomic energy than would the ordinary intelligent layman. I would also add another basic assumption which would read as follows: 'The emphasis must be upon an optimistic, constructive view of the atomic age—not a fearful, pessimistic treatment concerned mainly with atomic bomb destruction.' I would also suggest another objective under the category of Attitudes, which might read as follows: 'Scientific progress results from the contributions of many scientists from many different lands.'

"I hope that the above comments will be of some use, and I am anxious to keep in touch with you about the progress of the publication."

B. Frank Gillette
Assistant Professor
of Education
Stanford University
Stanford, California

"I have received your letter of February 4 and was very much interested in the encouraging progress you are making in connection with the preparation of the pamphlet entitled *The Iowa Plan for the Study of Atomic Energy*. I shall look forward to receiving the finished product.

"I must state at this time that I am not an elementary school authority, and I question the weight of my opinion on matters connected with the elementary school curriculum. However, I will venture that atomic energy education can and should start at the elementary level and that there have been satisfying results in that direction already in some sections of the country. I suppose you are aware of what the school children in Providence, Rhode Island, have done. There, a teacher, who had attended the atomic energy workshop at the Rhode Island College of Education, introduced atomic energy into her second grade class. As a result of some talks and classroom discussion on atomic energy, the students wrote essays, photostat copies of which I am enclosing. This would appear to be evidence that atomic energy education is for nearly all age levels and that the teacher *can* begin with simple instructional methods in the very early grades and the pupils *can* understand and comprehend.

"It seems to me that these young children, receiving such early instruction in atomic energy, are going to benefit from a continuing and increasing familiarity with the subject, and when they mature as high school students and later as adults, they will have a firmer grasp of the problems which are bound to confront them in the years ahead.

"I suppose you are aware of what Dr. Clifford Coles of the Keene Teachers College at Keene, New Hampshire, has done. He made a tape recording of a class in atomic energy at the sixth grade level. It is worth hearing. He does an excellent job of presentation and the responses are enlightening.

"These are only two examples of what has been done, it is true. I am sure there must be others. It certainly seems to point up the fact, however, that simple readings, simple art work, and simple demonstrations and such other techniques, as may be devised by the teacher, can be used with elementary school children to advantage and profit.

"I think you are doing a fine piece of work and I have no suggestions to make regarding your prospectus. The finished publication should prove of great value to the teachers of Iowa—and to teachers everywhere.
"With best wishes for the success of your project."

George L. Glasheen
Assistant Director for
Educational Services
United States Atomic
Energy Commission.
Washington 25, D. C.

"Your letter of November 13 finds me with no suggestions, of any nature, relative to your five topics, I'm sorry to say. We are about to begin the revision of our course of study in elementary science, and are now in the midst of the revision of the course for junior high schools. We are having difficulties with the matter of atomic energy, because so far, we have been unable to find material for the teachers, which is not too technical in nature. If you do succeed in developing a list of valuable references on this subject, I would most certainly appreciate a copy.

"I do feel that some emphasis to the subject of atomic energy should be given at the elementary school level. As has been so true of the subject of Aviation—and Meteorology—we are discovering that the child of the elementary school level knows a great deal about the matter now. In fact, he knows a great deal more about it than the teacher, and he should be guided in his thinking and experiences. But how to develop a background in the subject matter for those teachers who have none, especially the older ones who are satisfied with things as they are! We are still working at the business of meteorology background here, and it is a difficult task."

Esther L. Guthrie
Supervisor of Science
Sacramento City Unified
School District
Sacramento, California

"This is in reply to your letter concerning materials on atomic energy which might be used by children in the elementary school. I do not consider this as an area set apart from other science study. To my mind, any material concerning the structure of matter, the production and use of electricity, radioactivity, and the proper use of natural resources is directly related to this problem."

Katherine E. Hill
Associate Professor of
Education
New York University
Washington Square
New York 3, N. Y.

"I have great concern that young children will be stuffed with *facts* concerning atomic energy to the exclusion of *understandings* concerning atomic energy. It is evident that there may be real reason to allay young children's fears concerning the atomic bomb. This I believe teachers should do whenever the occasion arises. I also feel that young children might begin to think of atomic energy and its peace-time potentialities, but I would surely play down the destructive angle of atomic energy for young children."

Beatrice J. Hurley
Assistant Professor of
Education
New York University
Washington Square
New York 3, N. Y.

"The development of atomic energy is changing the child's world as well as the adult's. Since children ask questions about atomic energy, the subject cannot be disregarded. Even though most of the scientific aspects are too advanced for the elementary school level, the development of concepts of the atom can be begun. Can we afford to ignore the social implications at any age level?"

Mrs. Margaret O. Hyde
Lecturer in Elementary
Education
Temple University
Philadelphia, Pennsylvania

"Thank you for sending me a tentative draft of a publication on *Preparing Elementary Pupils for the Era of Atomic Energy*. You and your committee have undertaken a pioneering venture of very great importance. I commend you for your professional insight and zeal. What you are doing will undoubtedly challenge others to undertake similar projects and thus initiate a chain reaction which can bring about the additional developments needed for living with atomic energy."

Philip G. Johnson
Specialist for Science
Division of Elementary and
Secondary Schools
Federal Security Agency
Office of Education
Washington 25, D. C.

"Your letter of November 13 concerning instruction in the area of atomic energy at the elementary school level has been referred to this office for reply. You are undoubtedly pioneering in a field in which there is pressing need for investigation and study with reference to content, method and materials.
"Concerning instruction on the subject of atomic energy and its social implications, I am personally inclined to favor the indirect approach at the elementary level. In other words, it seems to me that the emphasis should be upon helping children to understand and respect persons of all races and nationalities and upon helping them to gain the attitudes, habits, and skills of democratic living. The implications of the release of atomic energy in terms of elementary education would appear to call for an intensification of our efforts along these lines rather than any radically new or different program. To the extent that consideration is given to atomic energy per se, it is my feeling that the emphasis should be placed upon the constructive aspects of atomic power as a newly available source of energy rather than upon its negative destructive aspects."

William B. Melchoir
Supervisor of Curriculum
Development
Long Beach Public Schools
Long Beach 13, California

"I delayed responding to your letter of February 4 until I could discuss it and the enclosure with a committee of New York City teachers which has been working on the problem of atomic energy education at the elementary school level during the past half year. Thus I have indirectly answered one of your questions, namely, that I consider the study of atomic energy in the elementary schools to be most valuable.
"My group thought that the organization of your work as indicated in the table of contents was excellent and should provide, when elaborated, a useful resource for elementary school teachers.
"We are approaching the problem from a somewhat different point of view. We are attempting to draw up source materials which might be used by elementary school teachers of the various levels."

Jerome Metzner
The City College
Convent Avenue and
139th Street
New York 31, N. Y.

"I suggest that we begin as early as possible teaching what we can about atomic energy and the implications of it for our civilization, inasmuch as intelligent decisions regarding the use of atomic energy can only be reached by an educated and informed citizenry. We should not attempt to avoid giving some emphasis to the subject of atomic energy at the elementary school level. We should rather recognize it as something with which all of us are vitally concerned, and we ought, therefore, to begin as early as possible our study and consideration of the problems involved. We can certainly expect that children, and especially boys, will be full of questions on this subject. Consequently, the teacher will need to have at her disposal information and materials to be used in answering such questions."

Victor H. Noll
Professor of Education
Michigan State College
Lansing, Michigan

"I appreciate your letter of the 15th regarding the teaching of atomic energy in the elementary school. I believe I expressed my views on this subject on page 45 of the January, 1947, *Nature Magazine*.

"Constructively I would say that in my judgment the best thing an elementary school can do to prepare youngsters for the atomic age is to teach the simplest techniques of measurement and observation and the Golden Rule."

E. Laurence Palmer
Professor of Nature and Science Education
New York State College of Agriculture
Cornell University
Ithaca, New York

"Thank you for your letter of February 4 with its interesting enclosure on atomic energy as content for the elementary school curriculum.

"The subject of atomic energy obviously has a place in the science and the social studies curriculum as you show in your outline. You outline this fairly well for science.

"With respect to its place in the social studies curriculum, it is my feeling that atomic energy should be treated as merely one more form of mechanical energy which man must learn to use constructively. One of the objectives of elementary school social studies is to help children begin to understand the gap between social invention and mechanical invention—a gap which is a product of the industrial revolution. The development of atomic energy merely makes more urgent the need for increasing the tempo of social invention, but basically the problem is the same as that which we have had with us since the advent of the steam engine. Your 19th item under 'Understandings' shows our agreement on this point. This is what I would favor stressing, along with your items 15 and 16.

"I am glad to see someone taking this problem by the horns. More power to you."

Ralph C. Preston
Associate Professor of Education
University of Pennsylvania
Philadelphia, Pennsylvania

"I am sorry that I cannot approve of your outline for teaching atomic energy in the elementary school. The understandings and attitudes seem quite foreign to even advanced elementary school youngsters. I do admit that there are a few geniuses who will study this material and arrive at some of these attitudes without the help of the teacher.

"May I suggest that you write down some activities which children can do to arrive at the knowledge and the attitudes which you seek. Perhaps you could convince me by having a score or so of such activities."

John G. Read
Associate Professor of Science Education
Boston University
Boston 16, Massachusetts

"In regard to your communication of February 4, I would like to say in preface that it is timely and appropriate. I shall be glad of the opportunity to express my thinking on this challenging issue.

"The tentative table of contents and partially completed introductory chapter have in them food for much thought but are probably a bit overambitious. From my experience, elementary teachers are fearful of attacking any implication bearing on science because of their lack of training in this field. Therefore, I would like to suggest that all printed matter be expressed very simply, that materials, equipment, and experiences be made very elementary, and organized in a slow tempo in approach and in development; otherwise elementary teachers will be too frightened to venture into these unknowns.

"For several years I have had the opportunity of teaching science at the elementary level and of serving as leader in In-Service Elementary Science Courses for Philadelphia teachers, Science Workshops, in demonstrations at Faculty Meetings, etc. This has been done primarily to stimulate interest in the teaching of science in the elementary grades as an essential in the interpretation of the environment to the elementary school age child. Because of this experience, I would like to sanction the advisability of studying atomic energy in the elementary school, since it is a part of our everyday consciousness. At what better time can we hope to reach the child than when he is still naturally curious about the things he hears and sees around him?

"It seems to me that the following might be considered as additional basic assumptions:

1. Let us be objective in all our activities in regard to the study of atomic energy and not subjective: specific and concrete, as far as possible and not indefinite and irrelevant.
2. Let our activities be well within the grasp of children of elementary school age.
3. Let us stress the constructive in all its social implications rather than the destructive. (Use of Visual Aids important)
4. Through knowledge and understanding aim toward building a scientific attitude on the part of the teacher as well as on the part of the children, in order to help overcome fears and superstitions. (There is so much fear attached to the name 'Atom' —especially in children's minds.)
5. Let us stress how people in all societies have always had fear about new ideas, new things, and have tried to build mental walls around the old ways of doing."

Helen D. Ross
Willis and Elizabeth Martin Schools
Philadelphia, Pennsylvania

"I'd prefer to make any work on material of this sort quite incidental, and would preferably tie it into social studies. I doubt that it can be handled in any effective way as science on any grade level below the ninth by a worthwhile share of the pupils of an average class. Moreover, I feel that the elementary science program should be devoted largely to the more immediate experiences of the child. There is too much tendency, according to my viewpoint, to pass diluted college and high school science down to children too young to react favorably to it. Some of the popular texts embrace this procedure."

Victor C. Smith
Ramsey Junior High School
Minneapolis, Minnesota

"I am positively intrigued by your painstaking efforts to establish a learning pattern in nucleonics for elementary children. Of course, nucleonics is probably not the term for this work, although it happens to be the one we are trying to use for general education in this line at the college level. As a matter of fact, a course I am teaching this summer has the informal subtitle—Atomic Energy—'What and So What?'

"I think a very good start has been made on this work —as far as I can tell from the outline. I am particularly delighted that you place so great an emphasis on working this material in with already existing material rather than obliging it to stand unsupported and alone. I am pleased to see the list of assumptions, and am in general agreement with them all.

"Under your item of understandings as objectives of the study, I respectfully submit the following suggested additions. Some of them may be beyond elementary thinking, but I suspect that this may also be true of some of those already on the list. Among these suggested additions are:

"a. We can probably never obtain a limitless source of energy from fission of uranium and similar elements. However, synthesis of hydrogen isotopes may be an effectively inexhaustible source of energy at some time in the near future. In the long run, energy from uranium can supplement other energy sources, but will not replace it.

"b. Our present command of nuclear energy is the result of many long years of hard and patient experimenting. Much of it has been unexpectedly derived as the fruits of pure research.

"c. The energy we get from nuclear sources was not 'packed in there at the factory.' It is there in the form of mass all the time. Atomic material plants merely get the materials into such conditions that the energy can be released when desired.

"d. Nuclear energy comes from mass. This is also true in other energy-producing reactions. In every-day chemical reactions, however, the mass change is far too small to be detected by the most precise measuring instruments.

"I also suggest that among the attitudes might be listed some of these:

"a. Basically there is no national secret about atomic energy. All progressive nations have scientists who know the basic principles of nuclear reactions. Any advantage that this country has over any other is strictly temporary, and concerns special techniques and processes only, not fundamental principles.

"b. Modern communication and transportation have made the world's nations into close neighbors. It is necessary that we learn how to get along peacefully with each other or else face the very real possibility of the destruction of civilization.

"c. As a society we cannot, and as individuals we must not, turn our backs on science or any of its aspects—including nuclear energy. Our task is to become more familiar with the methods and attitudes and principles of science so that we will be more at home in the increasingly scientific world.

"d. Atomic energy is everybody's business. We all have the obligation and the opportunity to help direct our nation's policies so as to make best use of this new tool of science.

"I am most curious about the learning activities you are going to develop in this connection. I find myself particularly at a loss to suggest anything resembling experiments or demonstrations which lead directly toward an understanding of atomic reactions and their results. The closest I can come at the moment is the model chain reactions—one with mousetraps and one with matches. I presume you know about these as well as about many others."

Robert Stollberg
Associate Professor of Science and Science Education
San Francisco State College
San Francisco 2, California

"I am interested in the problem which you are considering in this research and shall note carefully the conclusions at which you arrive. I feel that your keeping in mind the question, 'What knowledge and experiences are of most worth to the elementary pupils?' will serve to guard against the danger of pushing materials of instruction dealing with Atomic Energy down to the elementary level. The comparatively small amount of attention given to this area in the Elementary Department of the University of Nebraska to date does not reflect a lack of interest or concern but rather an unwillingness to plunge into the field before more careful studies, such as your own appears to be, have been made available."

Merle A. Stoneman
Professor, Department of School Administration
The University of Nebraska
Lincoln 8, Nebraska

"At present, science instruction in our elementary schools is informal and incidental, utilizing child interest and experience to a large degree. However, the elementary schools plan to work more intensively and systematically in this curriculum area, particularly in relating science experience to unit work in the social studies. Some study of atomic energy and its implications will probably occur in the grades five and six where the focus of the social studies course is on the nation and the world."

John B. Taulane
Assistant to the Associate Superintendent
The Board of Public Education
School District of Philadelphia
Philadelphia, Pennsylvania

APPENDIX II

ELEMENTARY SCHOOLS WHERE ATOMIC ENERGY HAS BEEN TAUGHT*

ILLINOIS

Glencoe: The Assistant Superintendent of the Glencoe Public Schools, Mr. John Sternig, reports that atomic energy is not taught in unit form until the seventh grade. In the lower grades, from kindergarten through the sixth grade, the science program develops general readiness and background without pulling out special areas for intensive and non-functional study. In other words, the children receive basic science information which serves as a foundation for later more detailed studies, such as information about elements, electrons and atomic particles through a study of electricity which is a familiar subject to even tiny tots. Experiments in chemistry such as first-hand observation of oxidation, and so on, are also useful.

When children reach the seventh and eighth grades where they have scheduled classes in science (though still closely related to all the other curriculum areas), they are ready to take up atomic energy as a special study. They have met most of the terms so they are now ready to see the relation of all the various experiences they have had to the topic of nuclear energy as a special field of science. The specific content of the experience varies from year to year and from group to group but the following presents a fair summary of the main points generally covered in one way or another:

1. Nature of Matter
   a. Solids, liquids and gases
   b. Elements, mixtures and compounds
   c. Molecules, atoms, sub-atomic particles
2. Properties of Matter
3. Laws of Matter and Energy
4. Molecules—in detail
5. Atoms—in detail
6. History of atomic science from Democritus on
7. Atomic knowledge since 1939
8. The Atom bomb and the Hydrogen bomb
9. Nuclear energy for the good of mankind
   a. For medicine and other biological uses
   b. For technological and physical purposes
10. Social problems raised by atomic energy
11. World aspects of the problems

Extensive and varied materials are used—movies, slides, recordings, charts, models, home-made experiments, books, pictures—in fact, anything that may be obtained to make the subject graphic, interesting and functional. The constructive aspects of atomic energy are stressed and the frightening ones minimized without deluding children about them. The educational philosophy in the treatment of this subject is based on the same accepted ideas that govern the rest of the school's curriculum. Teacher-pupil planning and cooperative enterprise is the accepted mode of procedure.

MASSACHUSETTS

Boston: The Assistant Superintendent of Schools in Charge of Curriculum and Research for the Department of Education of the Archdiocese of Boston reports the development of an atomic energy unit for the elementary science course at the eighth grade level.

This unit deals with the fundamental facts necessary for an appreciation of atomic energy. The objectives of the unit are: 1) to learn about atoms and how they can produce energy; 2) to learn how man can develop and control nature through scientific knowledge of the atom; 3) to realize some of the problems that face us in this new atomic age.

The activities associated with the unit are planned so as to develop comparisons between chemical changes and atomic energy changes; for example, sugar may be changed into carbon by treating it with sulphuric acid; iron may be coated with copper atoms by putting an iron nail into a solution of copper sulphate, etc. Such chemical activities help the pupils visualize changes produced by atoms and lead the way to a discussion of changes within atoms.

New terminology is kept to a minimum and is explained in definitions that are as simple as possible without sacrificing any essential factors. The content of the unit deals with the names and definitions of the particles that make up an atom, the characteristics and properties of atoms, elements, and compounds, the production of atomic energy by means of the cyclotron, and a brief discussion of uranium and some of the new elements that have been made from it. Present-day applications of atomic energy are also included in the unit.

The unit serves to introduce atomic energy to pupils who have not had any previous training along these lines. It does not go into too much detail lest the child be overwhelmed by technical facts. It strives to give a general picture of the principles upon which this new and powerful force is based and to incite the pupils to study other material that will increase their knowledge and understanding of atomic reactions.

NEW HAMPSHIRE

Keene: A sixth grade unit was taught at the Wheelock Elementary School last spring by Professor Clifford H. Coles of Keene Teachers College. This was an experiment attempted to determine

*This section has been prepared by Miss Mattie A. Pinette, Department of Educational Services, United States Atomic Energy Commission, Washington, D. C.

how many and what concepts children at this level could handle, with the idea of following this up with units for grades above and below. The unit consisted of six parts. Part I covered Elements and Compounds; Part II, Atoms; Part III, Atomic Structure; Part IV, Radioactivity; Part V, Fission and Chain Reaction; and Part VI, Peacetime Uses of Atomic Energy. Each part was given separately on a different day over a period of three weeks. A seventh session was devoted to an evaluation of the unit in the form of fifteen test items of the objective type. The results were highly satisfactory. Out of a possible total score of 21, the class mean was 16. Another method of evaluation was to ask each child to express his reactions to the complete study in colored illustrations. The results proved that a sizable percentage depicted very constructive usages of atomic energy, and the remainder expressed in their illustrations a very definite understanding of the facts upon which the appreciations depend. Tape recordings were made of the instruction and pupil responses for future guidance; and now disk recordings of the tapes are to be made available for classroom use by other teachers.*

A follow-up of this unit was made ten months later on all those students (now in the seventh grade) who could be reached. Of the original 29 students who participated in the unit, 21 were available for retest. The same test was administered. The class mean was 15.8. On all but 3 of the tests there was a difference of only 1 or 2 points between the 1949 and 1950 scores.

Hudson: Miss Dorothy Buswell taught a unit to the eighth grade class in geography. Included were sections on the history of the development of atomic energy, the national setup such as the Atomic Energy Commission and the various plants and laboratories, the possibilities of using atomic energy as a fuel supply, the effect of radiation on man, plants and animals, industrial applications other than power, and applications in medicine and other fields. Interest was high with much student contribution in the form of newspaper and magazine articles.

Center Chesterfield: Mr. Lawrence Hoik reports a unit he used for the seventh and eighth grades. The understandings he hoped to develop were: that there are as many kinds of atoms as there are elements; the relative size of the atom; how uranium compares with other elements in weight and structure; the possible benefits to mankind when atomic energy is used constructively. An objective test was used to evaluate. The results were good. A follow-up is planned later on this spring (1950).

NEW YORK

New York City: In the New York City Public Schools there is the School Civic Club program organized to render service in the field of citizenship education, in line with a resolution passed by the Board of Education of New York to promote the teachings of democracy and tolerance. One of the main objectives of this program is to help stimulate through discussion, research, and socially desirable action, on the level of the students, a concept of citizenship, an interest in working with and for the community, and opportunity to carry over classroom training into real life situations.

Dr. Alex H. Lazes, Director of the Clubs, reports that during the present school year a number of elementary schools have undertaken atomic energy projects and come to him for guidance through their School Civic Club. Public School 179 of Manhattan is one that has carried on such a project. The topic "Atomic Energy—Friend or Foe" was selected. In line with established procedure, the students prepared their questions in advance. They included:

(1) Is it dangerous for scientists to work with atomic energy?

(2) Will it ever be possible to use atomic energy instead of electricity?

(3) Should information about atomic energy be shared with other nations?

(4) Is the world safe today with atomic energy?

(5) Can atomic energy be used for health purposes?

Once the questions were decided upon a small delegation of the School Civic Club went to Dr. Lazes for interview with specialists on his staff. The interviews last about one hour and before the students leave, the instructors make sure that they have well understood the facts discussed so that they can report back accurately to their school the results of the interview. A teacher accompanies the pupils both for the purpose of self-education and to insure the accuracy of the reporting. Very often an outside specialist is called in to take part in the interview, such as a representative of the Atomic Energy Commission Operations Office in New York. These interviews are held weekly until the teacher and the Program faculty are satisfied that the subject has been adequately covered and understood. It is the Club's purpose to develop the problem under discussion in terms of its relationship with that of the school and community. In this particular project the students became interested in the part atomic energy is playing in medical research. So they are now planning an interview with an authority on cancer. The culmination of this activity will be in a health drive carried on by the young people to get everyone in the school and community to visit his doctor regularly. A survey will be made to determine how successful the group was in promoting the drive for good health. Delegations from various school clubs come for the interview at the same time thereby providing an opportunity for an interchange of ideas. Such materials as magazine and newspaper articles, cartoon books, booklets, atomic books, film-strips, recordings and movies are used to concretize the interviews.

Similar programs have been held by the School Civic Clubs of Public Schools 74, 87, 93 and 102 of Manhattan, 19 of the Bronx, and 83 and 108 of Queens. Another aspect of atomic energy—

*For complete description of this unit giving precise methods of presenting each part of the course see "The Atom and the Elementary School" appearing in the March, 1950 issue of *School Science and Mathematics*, by Clifford Coles, Wm. Early and Wm. Wollfer.

The Implications of the Atomic Bomb and its Effects on Peace—has been chosen for discussion by Public Schools 155 (Queens), 44 (Brooklyn) and 59 (The Bronx).

RHODE ISLAND

*Providence:** That little third graders are interested in just everything there can be no doubt. They are still filled with wonder at the world and are chock full of whys. Encouraged by this fact and by an introduction to Atomic Energy through Professor Russell Meinhold, of The Rhode Island College of Education, I attempted to share with my third grade pupils my delight at arriving at some knowledge of atomic energy. This introduction to atomic energy was not a part of our regular curriculum but was an extra activity in which we developed a unit of interest.

The thought behind the development was the creation of new attitudes. It was hoped that the children would grow to realize that they were an important part of something bigger than their family, their school, their community. We tried to introduce a hopeful attitude toward atomic energy. We attempted to show that good will and peace are achievements for which people have to work and that peace and good will are only a possibility if atomic energy is used to help man.

The unit development took place in a three week period. Much of the work was accomplished in language time by the writing of stories and letters, and by oral discussions. We used reading periods for class reading of books on atomic energy and for book reports. In the art time we illustrated original stories. We kept a vocabulary list of words on the subject and we added to this list right after morning opening. In short, we tried for that brief time to direct attention to some aspect of atomic energy in each day's assignment.

Our first glimpse of atomic energy came from a language story answering the question, "What do you think was an important happening since your birth?" Out of a class of thirty-six, many mentioned the war and two mentioned the atomic bomb. These stories were read to the class. Much interest was shown in the stories about the bomb. This interest was followed up by putting on the library table two children's books on the subject. These books were handled by most of the children who were impressed and fascinated by the difficulty of the topic and most curious to know more about it. Soon came a request for the teacher's reading of the books to the class. This was done. The children themselves asked at the library for more books on atomic energy and found none. As a result in class we wrote letters to Uncle Ray, who writes a syndicated article in our daily paper, for his articles on the atom and to the General Electric Company for their comic books on the atom. From Uncle Ray we received his article on atoms, radium and atomic power and from the General Electric the books, "Dagwood Splits the Atom," and "Adventures inside the Atom." These were put on display.

*This report was submitted directly to the committee by Miss Elisabeth McCaffrey, Third Grade Teacher, Thayer School, Providence, Rhode Island.

Then during a few activity periods we delved into a little of the scientific aspect. We learned that matter can be changed to energy, as coal, for instance, is changed to heat; that all matter is made of atoms which we can not see; that we know that there are atoms from their actions just as we know there is wind because of what it does; that when an atom is split it releases energy, that this energy may be used for the world's good as well as for harmful purposes.

One group of about eleven children decided to keep booklets on atomic energy. They included original stories, copied paragraphs, letters, book reports and illustrations. How they enjoyed that illustrating! There were pictures of scientists looking through microscopes, planes dropping bombs—and how they loved to sketch a nucleus with electrons circling it. To this book they later added newspaper clippings and their vocabulary list. The corner of the blackboard that contained this list was a very popular spot. It was such fun for these youngsters to read over and over again the strange sounding words.

Definitely this small group was interested, even excited by this activity. It seems that for these few a wide new field has been opened. Everyone in the class has been exposed, as it were, to a great many new ideas. Perhaps the one idea that we hoped many of them would carry away was the desire for peace through understanding. We hoped they might come to realize that peace is a gift and that like any bright, new, shining gift it can last only if we treat it with care and with love, and that peace for all is only possible if atomic energy becomes man's friend and not his enemy.

VIRGINIA

Norfolk: Helen Parker of the Norview High and Elementary School has conducted a teacher-pupil study of atomic energy in her seventh grade classes. It appears that she started at absolute zero upon the strong urging of some of her pupils who had seen a moving picture depicting the bombings of Japan. She accepted the challenge and got busy with her pupils making plans for the study. First they prepared a list of statements telling why they were interested in atomic energy and what they wanted to learn about it most. In open class discussions they set up five objectives for the course—

1. The collection of all available literature and other materials by the class;
2. A study of the historical background and scientific developments leading to nuclear fission;
3. The forming of a necessary vocabulary to talk about atomic energy;
4. An understanding of the destructive and constructive uses of atomic energy;
5. A study of the progress of atomic control.

Two student committees were formed, one to assemble the literature and one to prepare an outline for study. The outline developed covered work projects pointed to the five objectives above. The next step was to decide where in the curriculum the study of atomic energy could be integrated or carried over from the special unit. The problem was finally resolved as follows:

In the Language Class	Every student was responsible for writing at least one letter asking for literature and information, and a thank-you note when the material was received.
In Geography	The air and sea routes to Japan were located and discussed as were Hiroshima and Nagasaki, world deposits of uranium ore, the location of factories, testing grounds, laboratories devoted to atomic energy, and large world cities and harbors needing protection.
In Arithmetic	Problems were developed involving the estimated cost of research, the cost of factories at Oak Ridge, the cost of the Bikini tests, and an estimated tax system was devised to provide funds for the development of atomic energy.
In Spelling	There were the words, terms and meanings accumulated and discussed in the class work.
In Drama	There were oral reports and make-believe radio broadcasts covering the entire outline set up around the idea of the "Chicago Round Table." These covered news, tests at Bikini, the United Nations efforts at control, domestic control, and medicinal uses.
In History	There were discussions and written reports on problems concerning Europe, Britain, Asia, Russia, and the United States.
In Art and Construction	There were bulletin board displays on atomic energy, models and drawings of atoms and their behavior, the painting of a mural depicting the weapons of the world; chain-reaction models made with matches, mouse traps and dominoes; study of the Tesla coil; a model of the first Morse code sending set; and an electrical atom display.
Materials used	Motion pictures, recordings, a kit of pamphlets obtained from the Teaching Materials Center at Norfolk, and life stories of famous scientists, from Democritus to Dr. Vannever Bush.

In her outline of the study the teacher reports that more interest was displayed in this subject than in any other—it was an experience in which every pupil entered and enjoyed his activities. At no time is the study closed. The pupils are continually bringing in newspaper articles for discussion and writing for the open forum sections of the daily papers expressing intelligent opinions; it has aroused a keen interest in career opportunities in atomic energy and a desire to know more about the qualifications of the men who control this vast new energy. In short, it has been a stimulating and satisfying experience for both the teacher and the pupils.

APPENDIX III

GLOSSARY OF TECHNICAL TERMS

INTRODUCTION

This glossary of terms is primarily for the teacher. It consists of terms especially related to atomic energy. In a number of instances both a semi-technical definition (T.D.) *and a child's definition or child's use* (C.U.) of the term are given. The *child use* definitions were given by four fifth-grade children who had just completed a study of atomic energy (see chapter VI). The children were from average to well above average in ability. They met with the chairman of the committee which prepared this publication. He would give them the technical word and they, in turn, would explain what the word meant to them and use the word in a sentence. A stenographer took nearly verbatim replies.

The technical definition should help a teacher build her own vocabulary for a better understanding of atomic science. The child's definition when used will help her to understand the limits of a child's ability to use the term. In all cases the child's *use* is either directly in his own words or nearly so.

In some instances it may be expected that children in the upper intermediate and early junior high school grades will have a substantial understanding of even the technical definitions.

Much of this publication is devoted to the social implications of atomic energy and consequently to concepts and terms primarily in the field of the social studies. This glossary, however, has been confined to terms that are more closely related to the science aspect of atomic energy. It was felt by the committee that an especial need for a clarification of scientific terms was needed.

Glossary*

Absorb

T.D.: To soak in as does a sponge; take in as taking in heat or light or radioactive waves.

C.U.: It gathers up. For example, when you put a sponge in water it soaks up water. People may absorb radioactive waves or particles. Scientists have shields on the outside of the atomic furnace in order to protect people.

Artificial

T.D.: Opposite of natural; made by human skill or labor; would not occur naturally in nature; Plutonium is an artificial element made in an atomic pile (furnace) by man from the natural element uranium.

C.U.: Artificial transmutation means man changes it. For instance, changing uranium to plutonium. Maybe man can even change some elements into gold. Artificial is by man and natural is by nature.

Artificial Radioactivity

T.D.: When atoms give off rays because the nuclei have been made unstable, as in an atomic furnace; atoms are often made radioactive by the addition of particles such as protons or alpha particles to their nuclei.

C.U.: When you take zinc and put it in an atomic furnace, before, it doesn't give off rays, afterwards, it does and then it gets to be radioactive. Also, when they inject radioactive iodine into a mouse the mouse becomes radioactive artificially. (Actually the mouse itself is not radioactive—only the iodine in the mouse).

Atom

T.D.: The smallest particle of matter that has separate and distinct chemical characteristics, i.e., the smallest particle of matter that is capable of entering into chemical combination.

C.U.: An atom is made up of three things; they are neutrons, protons, and electrons. It is very small; you can't see it.

Atom Bomb

T.D.: A bomb whose intense explosive power is caused by the sudden release of atomic energy. The release results from the fission of nuclei (plutonium, uranium) by bombardment with neutrons.

C.U.: A bomb that can destroy things through uncontrolled chain reaction, which means the atoms start splitting and when they split, parts go off and split others. It happens so quickly; they all split and this splitting has to stop because there's no more uranium atoms to split. It gets very hot.

Atom Smasher

T.D.: A term sometimes used to describe machines which accelerate sub-atomic particles—machines such as the cyclotron, betatron, Van de Graaff generator.

C.U.: A machine like the cyclotron.

Atomic Number

T.D.: The number of positive charges on the nucleus of an atom; the elements (atoms) are given a number according to the number of protons in the nucleus. The atomic number of an element determines its place in the periodic table.

C.U.: How many protons there are in the nucleus. The atom with the largest number of protons has an atomic number of 98. This element is called Californium. This is a man-made element.

Atomic Pile

T.D.: An arrangement of fissionable materials that splits atoms and thus releases tremendous amounts of nuclear energy; an arrangement of fissionable materials with something like carbon for regulating the speed of the neutrons; designed for producing and controlling a chain reaction; plutonium is made from uranium in an atomic pile.

C.U.: It is an atomic furnace—to start off chain reactions.

Atomic Weight

T.D.: The relative weight of the atom of an element with oxygen (16) as standard; the weight of an atom depends upon the number of the protons and neutrons in the nucleus. Oxygen has atomic weight 16 and atomic number 8, so its nucleus must have 8 protons and 8 neutrons.

C.U.: The number of protons and neutrons added together. Hydrogen has an atomic weight of 1 because it has one proton and no neutrons. U235 has an atomic weight of 235.

Bombard

T.D.: To cause small particles or rays to strike something.

C.U.: They bombard the atom. The neutrons bombard other atoms. It means to hit things.

Cadmium

T.D.: A bluish-white, ductile, malleable element resembling tin; its atomic number is 48 and its atomic weight 112.41.

C.U.: That's one of the elements. Cadmium rods are pushed back into the atomic pile to regulate or stop the chain reaction.

Carbon

T.D.: A very common non-metallic element. Diamonds and graphite are pure carbon while coal is impure carbon. Graphite is used to slow down the speed of neutrons in the atomic furnace. It is called a *moderator*.

C.U.: That's what coal is made of. It is part of carbon dioxide; also graphite in the atomic furnace.

Chain Reaction

T.D.: One atom causes another atom to explode and that atom makes another atom explode, etc.; the neutrons shot out from the first exploding atom break up the nuclei of other atoms, etc.

C.U.: Like when an atom is split, a particle flies off and hits another atom and then that one breaks and then it just keeps on breaking other atoms. Like on a trapeze when you swing from one to another.

Chemical Symbols

T.D.: Letters of the alphabet which are used to represent different elements. The initial letter and sometimes a second letter are nearly always from the Latin name of the elementary substance.

C.U.: That would be like H_2O because these letters define the make-up of it. They are letters meaning the word like in uranium they have letters that stand for uranium. I'm positive the symbol is just U. That is what it shows on our element table.

Chlorophyl

T.D.: The green coloring matter of plants. In the presence of radiant energy from the sun it helps to make carbohydrates from carbon dioxide and water.

Composition

T.D.: The way a thing is made up. For instance, the chemical composition of a substance is determined by the number and kinds of atoms in a molecule. Common table salt is a composition of sodium and chlorine; table sugar is a composition of carbon, oxygen and hydrogen.

C.U.: Something that is put together. The atom is a composition of protons, neutrons, and electrons.

Compound

T.D.: Composed of or produced by the union of two or more elements. Water is a compound of hydrogen and oxygen.

C.U.: Something made of two or more elements. Water is a compound because it is made of oxygen and hydrogen. . . . Two parts of hydrogen and one part of oxygen, I believe.

Converted

T.D.: Changed into something else.

C.U.: To change; like if you convert or change one element to another it would be transmutation. Like converting uranium to radium to lead.

Create

T.D.: To bring into existence; the act of developing a new characteristic to form something new.

C.U.: To make something original. Atomic energy can create artificial radioactivity. The atom was created by nature.

Critical Size

T.D.: The size that an atomic pile or an atomic bomb must reach before a chain reaction begins. Uranium, for instance, will not explode under its critical size because fission of the atoms will not continue as a chain reaction until a certain amount (critical size) of uranium is brought together.

C.U.: You have to get so much uranium together to start a chain reaction. It's the amount of uranium needed to make the atomic bomb explode, for instance.

*T.D.=semi-technical definition. C.U.=child use.

Cyclotron

T.D.: A machine for splitting atoms; a machine which imparts high speeds to electrified particles; a machine in which the nuclei of atoms are bombarded to produce changes in the nuclei and thus induce artificial radioactivity.

C.U.: A machine that is used to split the atom. It bombards the atom with proton bullets.

Deflect

T.D.: To change direction of; to bend or turn aside; to cause a deviation in the path of.

C.U.: It means to bounce off, or something like that. It's something like reflect.

Detect

T.D.: Find or discover. Note the presence of something.

C.U.: Be able to find something. You might detect a break in an atomic furnace. The Geiger counter detects uranium because uranium is radioactive.

Disintegrate

T.D.: Break up or fall apart.

C.U.: To dissolve. Radium when it throws off its rays begins to disappear or disintegrate. When the atom is giving off rays it is sort of dissolving.

Electricity

T.D.: A form of energy that can produce light, heat, magnetism and chemical changes, and which can be generated by friction, induction or chemical changes; one of the fundamental quantities in nature consisting of elementary particles called electrons (—) and protons (+); an electric current consists of the flow of electrons.

C.U.: It's something that makes light glow and provides power for the home. It's produced by electrons. We get it from electrical power plants. A generator makes it.

Electron

T.D.: The smallest known negatively charged particle.

C.U.: Negative particle of electricity which revolves around the nucleus in an orbit.

Element

T.D.: One of the simplest substances, such as gold or iron, that cannot be separated into simpler parts by ordinary means; substances composed of atoms that are chemically alike. There are 98 known chemical elements at this writing.

C.U.: It is one basic thing; something which most other things are made of. Aluminum is an element because it is one basic thing itself.

Emitted

T.D.: Thrown off; discharged from; the sun gives off (emits) heat and light.

C.U.: It's when the neutrons fly off. If the rays come off from uranium they would be emitted.

Energy

T.D.: Capacity for performing work.

C.U.: Something we use everyday. Like atomic energy, it's doing something. When you run, you use up energy. When an atom splits it lets off energy.

Equivalent

T.D.: Alike in value. Having the same combining or reacting value, as the equivalent quantities of two elements.

C.U.: It would be the same amount; like 400 box cars of TNT are equivalent to the energy in a piece of uranium the size of a golf ball.

Experiment

T.D.: To test or try out something.

C.U.: To try something new. Scientists are experimenting with atomic energy.

Explosion

T.D.: A violent bursting with noise as in the case of explosives; a blowing up with a loud noise.

C.U.: Like in the atomic bomb when the atoms are split they release their energy and make an explosion.

Fantastic

T.D.: Hard to believe.

C.U.: Unbelievable. How small an atom is, is fantastic.

Fission

T.D.: Breakup into parts; the splitting of an atomic nucleus into two nuclei of nearly comparable masses as when bombarded with neutrons; when uranium is split the nucleus of the atoms release enormous quantities of energy.

C.U.: Something to do with the atoms' splitting. It is when the little neutrons fly off from the nucleus and they may hit the nucleus of other atoms causing them to split.

Fissionable Materials

T.D.: Materials such as U235 and plutonium which have atoms that are relatively easy to split under neutron or proton bombardment.

C.U.: It's something about the atom splitting. Materials that would have atoms that can split easily. Uranium is fissionable material because it has atoms that split easily.

Force

T.D.: A push or a pull.

C.U.: When you're moving something heavy, it takes force to move it. In the B-B gun when the spring pushes the B-B it forces it out. (Actually, it is the compressed air that forces the B-B out. *Editor*)

Gamma Rays

T.D.: Waves somewhat shorter than X-rays and emitted during some nuclear changes.

Gas

T.D.: A substance that has neither independent shape nor volume; a substance that tends to expand indefinitely; not a solid or a liquid; air is a mixture of several gases, chiefly nitrogen and oxygen. Individual molecules widely separated.

C.U.: Sometimes it's used as fuel.

Geiger Counter

T.D.: A metallic tube with a needlelike electrode projecting within, which detects the passage through its walls of any ionizing particles, such as radioactive rays from uranium.

C.U.: A machine that is used to pick up uranium and other radioactive things. In other words, it picks up radioactive waves.

Graphite

T.D.: Stuff or substance like that in a lead pencil. It is carbon in hexagonal crystals.

C.U.: Something like the lead of a pencil. It is used to slow down the neutrons in the atomic furnace.

Heavy Hydrogen

T.D.: An isotope of hydrogen called deuterium. This isotope has one proton and one neutron in the nucleus, while the simple hydrogen atom has only one proton. (Heavy water is two atoms of heavy hydrogen and one of oxygen.)

C.U.: Like when you add a neutron to the hydrogen atom it makes it heavier, with an atomic weight of 2.

Helium

T.D.: A very light, inert gas that will not burn. It is an element not found in abundance, and first discovered in the sun's atmosphere. The sun's energy is believed to be the result of the particles in hydrogen atoms being rearranged to form helium atoms, and at the same time giving off great quantities of energy.

C.U.: It's a gas and also an element. It's number 2 in atomic number, but it has an atomic weight of 4 because it has two protons and two neutrons.

Hydrogen Atom

T.D.: The hydrogen atom is the simplest atom, having a nucleus which contains one proton with one electron revolving in the surrounding orbit.

C.U.: An atom of hydrogen. You use hydrogen in blimps. It may have some connection with the hydrogen bomb. It has an awfully low atomic weight. It has one proton and no neutrons. It's No. 1 in the periodic table.

Hydrogen Bomb

T.D.: It is believed that such a bomb, if produced, would have unsurpassed violent explosive power due to the sudden release of atomic energy as atoms of hydrogen (or hydrogen isotopes) fuse to form atoms of helium. The H Bomb would probably operate on the principle of atomic fusion (or synthesis) as opposed to the A Bomb, which operates on the principle of atomic fission.

Indestructible

T.D.: Cannot be destroyed; cannot be done away with.

C.U.: It cannot be destroyed; brick is more indestructible than wood.

Indicate

T.D.: To show or point out.

C.U.: To show something; like if someone were showing a person around an atomic plant, they would indicate that something was a cyclotron, etc.

Indivisible

T.D.: Cannot be taken apart or divided.

C.U.: It cannot be divided. Some atoms can be divided with a cyclotron. (However, neutrons and electrons cannot be divided; they are indivisible. *Editor*.)

Invisible

T.D.: Not capable of being seen.

C.U.: Can't see it. The atom is invisible.

Ion

T.D.: A particle with an electrical charge; an electrically charged atom or group of atoms; in gases a molecule may lose an electron, thus becoming a positive ion; the free electron may attach itself to another molecule forming a negative ion.

Isotopes

T.D.: Atoms with the same number of nuclear protons but a different number of neutrons (also called "chemical twins").

C.U.: Something that is the same element, but it has a different atomic weight.

Liquid

T.D.: A substance that flows freely like water; a substance that has a definite size and takes the shape of the container.

C.U.: Something like water; sometimes you can see through it, sometimes you can't. It's moving like running water. It's different things that you can pour, not little bits like rocks, but rather one piece.

Matter

T.D.: That of which any physical object is composed; matter occupies space.

C.U.: Everything is made of matter, so matter is everything, like walls, books, and trees. Matter would have to be made up of atoms. ("Stuff" is a synonym for *matter* which children seem to understand quite well. *Editor.*)

Miniature

T.D.: A representation on a much reduced scale; anything represented on a small scale.

C.U.: The same thing but smaller. A miniature deck of cards is smaller than a large deck. In a way the atom is like a miniature solar system.

Molecular Weight

T.D.: The relative weight of a molecule of any substance as compared to the weight of an atom of oxygen (oxygen has been accepted as the standard).

Molecule

T.D.: Smallest particle into which a substance can be divided without chemical change. If a molecule of water (H_2O) is broken up it changes into the elements, hydrogen and oxygen, and these elements no longer have the properties of water.

C.U.: A molecule of water is made up of H_2O or two atoms of hydrogen and one atom of oxygen.

Natural

T.D.: Produced by nature; happening in the ordinary course of events without man's influence.

C.U.: Something done by nature. In millions of years uranium might change naturally to lead. (Actually, the "half-life" of uranium is several billion years—and that is only *the half-life*. *Editor*)

Negative Charge

T.D.: The kind of electricity produced on ebony by rubbing it with cat's fur. The charged atom has an excess of electrons, thus more than just balancing the positive charges contained by the protons in the nucleus.

C.U.: That's a minus charge. Electrons are minus charges in the atom. If anything has a negative charge it has more electrons than protons.

Neutral

T.D.: Neither positive (+), nor negative (—).

C.U.: Neutral in a car means it isn't going and it isn't stopping. It's sort of half and half. The neutron in an atom is neutral because it is neither positive nor negative. (It might be a better analogy to say that one is neutral in an argument when he neither agrees or disagrees with another person. *Editor*)

Neutron

T.D.: An uncharged particle with a mass about the same as that of a proton.

C.U.: A neutron is one of the things an atom is made of. It is neither positive nor negative. It is in the nucleus of the atom.

Nuclear Fuel

T.D.: This is merely another term for fissionable materials.

C.U.: It's uranium because it is fuel for the atomic furnace.

Nuclear Reactors

T.D.: Machines in which atomic energy is put to work (1) to produce fissionable materials, (2) to produce power, and (3) in atomic research.

Nuclear Synthesis

T.D.: When two atoms fuse together to produce an atom of a new element. For instance, the sun is believed to get its energy from nuclear synthesis. Here, atoms of hydrogen unite (or fuse) to make atoms of helium thus releasing a great quantity of energy in the form of light and heat. In the process there is a slight loss of mass. Einstein's famous formula $E = MC^2$ applies here in explaining why such a small loss in mass will produce such a tremendous amount of energy.

Nucleus

T.D.: The center or core of an atom; an atom is made up of a nucleus and one or more electrons revolving about it.

C.U.: Center of the atom made up of neutrons and protons.

Orbit

T.D.: A circular or elliptical path; the path made by one body in its revolution about another; the earth goes about the sun in an orbit; an electron revolves (makes an orbit) about the nucleus of an atom.

C.U.: The electrons go around the nucleus in an orbit. It's sort of an imaginary path. It isn't a real thing that you can lift.

Particle

T.D.: A very tiny bit of matter.

C.U.: A piece or part of something, like a particle of dust. It could be either large or small; like a piece of an iceberg would be large—or a piece of an atom could be a neutron and would be very small.

Periodic Table

T.D.: A table of the elements arranged according to periodic law. Atomic numbers are in bold face type and atomic weights are in light face type following the symbols of the elements.

C.U.: A table of elements along with their atomic weights and numbers. They are arranged according to the number of protons in the atom of each element.

Phenomenon

T.D.: A fact or occurrence that can be observed; sometimes, thought of as being quite unusual or extraordinary.

Photosynthesis

T.D.: Process by which plant cells make sugar from carbon dioxide and water in the presence of chlorophyl and light.

Pitchblende

T.D.: A brown to black heavy mineral with pitch-like lustre. It is a source of uranium and radium.

C.U.: They mine for pitchblende and it has uranium in it.

Plutonium

T.D.: Man-made element produced in an atomic pile. (Atomic number 94, atomic weight 239.)

Positive Charge

T.D.: The kind of electricity produced on glass by rubbing it with silk. In this case a negative charge is produced on the silk. The atom does not have enough electrons (with negative charges) to balance the protons (with positive charges).

C.U.: A charge of electricity. If you have a positive charge and a negative charge, each in a different cloud, it makes lightning. It is a plus charge of electricity. The proton has the plus charge and the proton is in the nucleus of the atom.

Proton

T.D.: A positively charged particle equal in magnitude of charge to that of an electron (which is negative in charge). The proton, however, weighs about 1840 times more than the electron.

C.U.: It's the positive particle found in the nucleus of the atom.

Radiant Energy

T.D.: The energy of electro-magnetic waves, such as radio waves, visible light, X-rays and gamma rays.

C.U.: It's probably when rays are given off like uranium gives off radioactive waves. We used the Geiger counter to demonstrate it. X-rays and radio rays . . . all those kinds of rays are radiant energy.

Radiation

T.D.: One of the processes by which energy is given off from molecules or atoms due to some internal change.

C.U.: Something that has something to do with radioactivity. When rays come out of uranium, we have a form of radiation.

Radioactivity

T.D.: The process whereby certain elements or isotopes (especially radium, uranium, thorium and their products) give off radiant energy by the breaking up of the nuclei of their atoms.

C.U.: Radioactivity is going on inside the atomic pile. If something is radioactive it is giving off rays. Radium giving off rays is a form of radioactivity.

Radium

T.D.: A radioactive metallic element found (combined) in very small quantities in uranium ores (such as pitchblende). Radium atoms are constantly disintegrating and in this process give off alpha, beta, and gamma rays; used in treating cancer, in making luminous paint, etc.

C.U.: A radioactive element. Uranium changes to radium. It is changed artificially and by natural transmutation.

Ray

T.D.: A line or direction of flow of radiant energy, such as heat and light. A "convenience term" applied to a small quantity of radiation or moving nuclear particles.

C.U.: Something coming like the rays of the sun. Rays also come off of uranium and other radioactive elements.

Remote Control

T.D.: Handled from a distance without touching it with one's hands.

Shields for Reactors

T.D.: Shields which have high capture value by their ability to absorb neutrons and gamma rays so that they will not harm people or contaminate equipment.

C.U.: Something like the shield on the atomic furnace.

Space

T.D.: Characterized by extension in all directions; has no extremities or bounds; the earth moves through space; sometimes we speak of a limited amount of space as that within a room.

C.U.: Something you look into and see through it. When you look at something away from you there is space between you and it.

Speculate

T.D.: To make the best guess possible without sufficient evidence to be sure; to wonder about and try to think out an answer.

C.U.: Be able to see ahead to something. To plan and think about something. It is before you have all of the answers.

Structure

T.D.: The way a thing is built or the way its parts are arranged together.

C.U.: Something that is built; like this building is a structure. The atomic pile is a structure. The atom is a structure because it is made up of different parts.

Substance

T.D.: Material of which something is made; any particular kind of matter, whether element, compound, or mixture.

C.U.: It's just something; like powder is a substance or a liquid is a substance. It is something made up of different things. Gold is a heavy substance.

Tracer Element

T.D.: A radioactive element which when fed to plants or animals can be traced by a Geiger counter or photographic plate due to the radioactivity of the element.

C.U.: They use a radioactive element and they add it to the iodine and then inject it into a person. Then they follow it with a Geiger counter through the body.

Transmutation

T.D.: The conversion of one element or isotope into another by changing its number of protons (and electrons). In such radioactive elements as uranium, transmutation occurs naturally. U235, for instance, (atomic number 92) will gradually disintegrate to become radium (atomic number 88) while continued disintegrating through natural radiation produces lead (atomic number 82). Other elements can be transmuted by bombardment with subatomic particles. This is called *artificial* transmutation.

C.U.: Like for instance when a proton enters the nucleus of the atom to change its atomic number and weight. For instance, when uranium is changed to plutonium. Uranium has an atomic number of 92 and it can be changed to plutonium which has an atomic number of 94.

Uranium

T.D.: A radioactive element found in combination in pitchblende and certain other minerals.

C.U.: An element. It's radioactive. You find it in mines.

U. S. Atomic Energy Commission (A.E.C.)

T.D.: The Atomic Energy Act of 1946 provided for public ownership and control of atomic energy and created a 5-man Atomic Energy Commission to carry out the provisions of the act. This act gives the A.E.C. complete control of all phases of atomic energy development from the mines to finished materials. The major purpose of this act is to assure national defense and security. It also makes provision for the development of peacetime uses of atomic energy for the purpose of increasing our standard of living and to promote world peace. The Atomic Energy Act is one of the most important acts ever passed by Congress.

Velocity

T.D.: Time rate of motion; quickness of motion; speed.

C.U.: Speed. The electrons go around the nucleus with great velocity.

Volt

T.D.: Commonly defined as the unit by which electrical force is measured. More technically it refers to the energy possessed by a certain quantity of electrical charge.

C.U.: Something might have volts of electricity. Electricity comes in volts. It is a way to measure electricity.

X-rays

T.D.: A ray that can penetrate opaque substances; any of the radiations of the same nature as light radiation but of an extremely short wave length.

C.U.: You can see through a body with X-rays. X-ray is a form of radiation.

APPENDIX IV

ANNOTATED LISTS OF STUDENT AND TEACHER MATERIALS

INTRODUCTORY STATEMENT

The resourceful teacher will draw from a wide variety of materials for developing the desired concepts in the study of atomic energy.

An attempt has been made here to carefully select samples of desirable materials both for the pupils and for the teacher. Since development in the field of atomic energy is at present very rapid, articles published now will very likely be obsolete in a few years. These articles are listed merely as examples of the type of materials that can be found and used. *The periodicals in which they are listed, however, are likely to be continuing sources of current information.*

Producers of audio and visual teaching materials in the field of atomic energy have prepared most of these aids for use on the secondary and adult level. Some of the films and filmstrips are of the propaganda type, constructed to create attitudes more than understandings. Films such as *Where Will You Hide?* is of this nature. Others are extremely technical in nature, with concepts and vocabulary far too difficult for elementary children. (e.g. Atomic Physics)

It is quite generally accepted that a teaching aid too difficult for a given group has little value. In the area of atomic energy, this is especially true, since scientific vocabulary and principles are quite essential in a detailed explanation of atomic power. All films, filmstrips, and recordings should be previewed carefully by the teacher, and detailed analysis made of the vocabulary and scientific concepts that are presented. If they are too difficult, the aid should not be used.

The teaching of atomic energy lends itself naturally to the use of multi-sensory aids. Since it deals with such abstract terms as neutrons, protons, isotopes, U235, and chain reaction, concrete materials are necessary. The chalkboard can be used effectively for diagrams and illustrations. Colored chalk will be very helpful for this purpose. Matches have been used to illustrate chain reactions, arranged in such a way that each match head would in turn light two or more matches. The "mousetrap" atom described in Chapter VI of this bulletin is an excellent example of concrete material.

SECTION I

REFERENCES AND AUDIO-VISUAL AIDS FOR THE TEACHER

Bulletins

1. Burnett, R. Will, *Atomic Energy, Double-Edged Sword of Science*; Chas. E. Merrill Co., Inc., Columbus 15, Ohio.
   This unit was prepared for the Committee on Experimental Units of the North Central Association of Colleges and Secondary Schools. The material is too difficult for presentation as a unit to elementary children, but will be valuable for the teacher in developing an understanding of many of the facts and implications of atomic energy.
2. Council on Atomic Implications, Inc., *Atoms at Work;* Murray and Gee, Inc., Culver City, Cal., 1950.
   Two excellent articles are included; (1) "Power from the Atom" by Dr. Lee A. DuBridge, and (2) "Atomic Energy Benefits—Radioisotopes" by Dr. Paul C. Abersold. The bulletin presents, in layman's language, what is meant by "peacetime uses of atomic energy."
3. Crary, Ryland W. et al., *The Challange of Atomic Energy;* Bureau of Publications, Teachers College, Columbia University, New York, 1948.
   This resource unit contains valuable material for the teacher. It will aid in developing an understanding by the teacher of fundamental concepts of atomic energy and some of the resulting implications.
4. Hand, Harold C., *Living in the Atomic Age*; University of Illinois, Urbana, Illinois, 1946.
   A resource unit for teachers of atomic energy. Part II, "Orientation for the Teacher" would be especially helpful for the teacher in preparing himself for teaching this material. The actual learning experiences in this bulletin are too involved for elementary school children.
5. Life magazine, *The Atom;* Dept. A, Life Magazine, 9 Rockefeller Plaza, New York 20, New York.
   This is a reprint of the article published in the May, 1949 issue. The illustrations and photographs are excellent material for bulletin board display purposes.
6. National Association of Secondary School Principals, *Operation Atomic Vision;* 1201 Sixteenth Street, N.W., Washington 6, D. C., 1948.
   A teaching-learning unit for high school students but useful background reading for elementary teachers. Presents both sides of the atomic picture with the bright side the center of attention. The dark side, however, will make it clear to elementary teachers that we must not remain apathetic about the problems raised by this great new power. Contains a valuable glossary.
7. U. S. Atomic Energy Commission, *Handling Radioactive Wastes in the Atomic Energy Program;* U. S. Government Printing Office, Washington 25, D. C., October, 1949.
   This bulletin deals with the meaning of radioactivity, and explains precautions being taken to dispose of radioactive wastes. The problems of gaseous, liquid and solid wastes are presented, and methods of handling these wastes safely are discussed.
8. U. S. Office of Education, *Atomic Energy—Here to Stay*; Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
   This bulletin is a supplement to *School Life* for March, 1949. It contains articles which deal with the teacher's responsibilities in educating the children in the fundamentals of atomic science and its implications. The pamphlet will be a valuable aid to the teacher who is just beginning a unit of this kind.

9. U. S. Office of Education, *Atomic Energy Education*, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
A number of articles are included in this bulletin that are well worth reading by the teacher. These articles deal with the science of the atom, using atomic energy for peacetime purposes, and the efforts being made to control the use of atomic power.

Books

1. Eidinoff, Maxwell Leigh, *Atomics for the Millions*; McGraw-Hill Book Co., New York, 1947. 276 pages.
The authors of this book have attempted to give a simplified explanation of atomic energy, its terminology, and the experiments used to develop this power. However, it will require serious study. Sections of the book are: (1) Exploration, (2) Architecture, (3) Practical Atomic Energy, and (4) Your Atomic Age.

2. Potter, Robert D., *Young People's Book of Atomic Energy*; Dodd, Mead & Co., New York, 1948. 181 pages.
A book written in language which can be understood by high school students. The book includes historical data on the development of atomic energy and scientific explanations of the principles of atomic power. A discussion is also presented on the implications of atomic power in war and peace.

3. Yates, Raymond F., *Atom Smashers*; Didlier Publishers, New York, New York, 1946. 187 pages.
Somewhat technical, yet should be valuable material for the teacher. Most of the emphasis is placed on constructive use of atomic energy. Historical material is included. A chapter on new discoveries and future uses (Chapter 8) should be especially helpful.

Magazine Articles

1. "Atomic Energy for Peace." Reprinted for the United States Atomic Energy Commission, Washington 25, D. C., December 9, 1949.
This article consists of a report on an interview with David E. Lilienthal in which he discusses, in layman's language, such things as government monopoly, the problem of secrecy, and the use of atomic energy in industry, agriculture, and medicine.

2. Blakeslee, Howard W., "David and the Atomic Slingshot." Reprinted for United States Atomic Energy Commission, Washington, 25, D. C.
A description of the construction and principles of the cyclotron. This article was originally printed in *Steelways*, the magazine of the American Iron and Steel Institute.
The material in this bulletin is illustrated in color, and will make excellent display material.

3. Davis, Watson, "Peace Through Science," *Science News Letter*, February 12, 1949, pages 101-102.
An article dealing with the part UNESCO is playing in promoting world peace through an international knowledge of science. Each issue of this publication contains several articles directly or indirectly related to the study of atomic energy.

4. Dunham, Charles L., "Peacetime Applications of Atomic Energy," *U. S. Atomic Energy Commission*, February 27, 1950.
An article devoted to the medical applications of atomic energy. Some of the actual uses of radioactive materials are described, and predictions are made in regard to some possible future uses.

5. Ellsworth, Charles, "Tagged Atoms Go to Work for Steel." Reprinted for the United States Atomic Energy Commission, Washington 25, D. C.
A description of how radioisotopes are used in the steel industry to study chemical and physical production problems. This article originally appeared in the September, 1948, issue of *Steelways*.

6. "From Bombs—Toward Power," *Business Week*, April 30, 1949. Reprints available from Reader Service Dept., Business Week, 330 West 42nd Street, New York 18, New York.
An article pointing out development in production of atomic power for the year 1949. Much emphasis is placed on the peacetime use of atomic power.

7. Lilienthal, David E., "Atomics for Teens," *The American Girl*, April, 1949, pages 10-11.
An article devoted to a brief explanation of the release of energy from the atom, and of the great need for control of the use of atomic energy. A number of worthwhile activities for study of atomic energy are given.

8. Maxwell, Dr. Leigh, and Ruchlis, Hyman, "Plutonium—Large Scale Alchemy," *Science Digest*, Volume 22, October, 1947, pages 10-13.
A description of the search for plutonium and other new elements. This article is scientific in nature, and is excellent background material for the teacher.
Science Digest has published during the period from January, 1947, to December, 1948, forty-five different articles on all phases of atomic energy. This publication would be desirable for a teacher's professional library.

9. "Radioactive Isotopes, The," *Consumer Reports*, Vol. 15, No. 4, April, 1950, pages 170-172.
An article describing the use of radioactive isotopes in medicine for research and in industry. The importance of certain isotopes as diagnostic tools in medical practice is described. The article can be read and understood by elementary school children.

10. "Simple Atomic Experiments," *Chemistry*, February, 1949, pages 17-23.
A number of simple experiments are described which can be used to illustrate chain reactions, atom smashing, radioactivity, and an electroscope. The article illustrates how experiments can be carried out by using simple materials and equipment.

11. Wolfe, Dr. Hugh C., "Answers to the Hydrogen Riddle," *United Nations World*, March, 1950, pages 1-2.
Uses of the H-bomb are discussed. A very brief discussion of the science of this bomb is included. The problem of control of the H-bomb is frankly discussed, and the problems involved in its use for war purposes presented.
This is one article typical of those that are published in this magazine. The articles are up to date, and are written by leading authorities.

Films

1. *Atomic Energy*, 11 min., Sd., Encyclopedia Britannica Films, Wilmette, Illinois.
Shows some of the basic principles of atomic energy. The film should be used a number of times in order to clarify concepts that are presented.

2. *Atomic Power*, 19 min., Sd., March of Time Forum Edition, 269 Lexington Avenue, New York 17, New York.
Historical material and the nature of atomic energy are presented. The need for better understanding of the atomic energy problem is also presented.

Slides

1. *Atomic Energy*, 3½" x 4" glass slides. Keystone View Co., Meadville, Pennsylvania.
Through careful selection, an elemetary teacher will find some slides from this set of 60 that will be suitable for her class. The entire set will aid in giving the teacher background information.

SECTION II

REFERENCES AND AUDIO-VISUAL AIDS FOR THE PUPIL

Bulletins

1. General Electric Company, *Adventures Inside the Atom*; General Electric Company, Schenectady, New York.
A "comic book" type of bulletin that attempts to explain atomic energy in language for elementary children. It explains protons, neutrons, and electrons—also radioactivity, cyclotron, and other technical terms. Helpful analogies are given, such as "Destroying completely the atoms of this match stick would melt all the snow in Switzerland" and "Explosive force of U235 the size of a golf ball equals the explosive force of 400 freight cars full of TNT."

2. General Electric Company, *Adventures In Electricity, No. 1*. General Electric Company, Schenectady, New York.
This bulletin can be used to teach concepts relating to electrons. It is of the "comic book" type.

3. Musial, Joe, *Dagwood Splits the Atom*, Educational Division, King Features Syndicate, Inc., 235 East 45th Street, New York 17, New York.
A "comic book" type of bulletin, containing a number of the favorite characters of our popular comics. Prepared with advice of well known scientists.

Magazine Articles

1. "Big Part Played by the Tiny Atom," *Young Citizen*, Vol. VIII, No. 21, February 21, 1949.
This article is written for the pupil. The parts of the atom are discussed and explained, and a very simple explanation of atomic fission is included.

2. "Hot Labs," *Current Science and Aviation*, Vol. XXXIV, No. 26, September 13-17, 1948; American Education Press, Inc., 400 South Front Street, Columbus 15, Ohio.
Articles in this publication are geared to high school students, but much of the material can be used for children in lower grades. Articles dealing with atomic energy appear regularly.

3. Mann, Martin, "U. S. Lights New Atomic Pile for Peace," *Popular Science*, April, 1949.
Articles in this publication are well illustrated, and usually are written in simple language. The publication presents discussions of various aspects of atomic energy regularly, and therefore would be a valuable supplement to teaching of this unit.

4. McDermott, Wm. F., "Bringing the Atom Down to Earth," *Popular Mechanics Magazine*, Vol. 84, No. 5, November, 1945.
Articles in this magazine will challenge the better students in their reading. Much of the material may be too difficult for children of average ability in grades below the seventh. This particular article presents a simple historical time line and rather optimistically presents a number of valuable constructive uses of atomic energy.

5. "Science Gives the Atom Useful Jobs," *The Young Citizen*, Vol. IX, No. 23, March 6, 1950; Civic Education Service, Inc., 1733 K Street N.W., Washington 6, D. C.
This is typical of articles published regularly in this periodical. The vocabulary used and concepts presented are suited to the ability of elementary school children.

6. "The U. S. Offers a Prize," *My Weekly Reader*, Ed. No. 5, Vol. XXVII, No. 8, November 1-5, 1948; American Education Press, 400 South Front Street, Columbus 15, Ohio.
This article deals with the search for uranium in Utah and Colorado. It is typical of articles written for children of the elementary grades in this periodical.

7. "U N Still Cannot Control Use of Atomic Power," *Junior Review*, Vol. XXII, No. 6, October 10, 1949.
The need for a definite plan of atomic energy control by the nations of the world is presented. The article discusses causes for disagreements among nations, and the work being done by the U N to bring the nations together in a common plan for control.

8. "Unlocking the Secrets of Atomic Energy," *My Weekly Reader*, No. 6, May 3-7, 1948.
Some of the problems of producing atomic energy are discussed. Emphasis is placed on atomic power for industry, in fighting disease, and in studying plant life.

9. "This Atomic Age," *Junior Scholastic*, May 24, 1948; Junior Scholastic, 220 East 42nd Street, New York 17, New York.

   This article presents the two problems of atomic energy—destructive use and peacetime use. It is one of a few articles presented on a level suitable for upper elementary children.

Reference Books

1. *Britannica Junior*, Vol. II, A., Encyclopedia Britannica, Inc.; University of Chicago, Chicago, Illinois, 1947, pages 447-455.

   A useful presentation of atomic information. The material is simply explained so that all upper elementary children should be able to read and understand it.

2. *Compton's Pictured Encyclopedia*, Vol. I-A; F. E. Compton and Company, Chicago, Illinois, 1947, pages 360-362.

   A well-illustrated discussion of atoms, atomic power, atomic fission, chain reactions and uses of atomic power. The material is somewhat diffiicult and would be of value for only the better students.

3. Lewellen, John, *You and Atomic Energy*; Childrens Press, Inc., Jackson and Racine, Chicago, Illinois, 1949.

   This book is written for the upper elementary grades. The book attempts, in non-technical language, to explain the use of the atomic furnace and the generation of power through the release of atomic energy. The material in the book is attractively illustrated. A glossary of terms needed for understanding of the text is also given.

4. Meyer, J. S., *Picture Book of Molecules and Atoms*; Lathrop, Lee & Shepard Co., New York, New York, 1947. 47 pages.

   Illustrated book. Some in color. Emphasis is placed on peacetime use of atomic energy. The book is written for use by children in grades five through eight.

5. Schneider, Herman and Nina, *How Big Is Big?*; Wm. R. Scott Co., New York, 1948.

   The story of a little boy who discovers, through comparisons that he is not very big. He compares his size to the sun and stars. Through a similar group of comparisons, he finds many things smaller than he is, such as a flea, amoeba, and an atom. The book is very interesting reading for children.

6. *World Book Encyclopedia*, Vol. I-A; The Quarrie Corporation, Chicago, Illinois, 1949. Pages 515-523.

   A brief discussion of the science of the atom and the development of the atomic bomb. Historical aspects are included.

Textbooks

1. Beauchamp, Wilbur L., Mayfield, John C., and West, Joe Y., *Science Problems*; Book 2; Scott, Foresman & Co., Chicago, Illinois, 1939.

   Unit 5—How Do We Use Energy? pp. 223-249.

2. Craig, Gerald S., and Hyde, Margaret, *New Ideas in Science*; Ginn and Company, Chicago, Illinois, 1946.

   Chapter I—Getting Acquainted With Molecules.

3. Craig, Gerald S., and Lewis, June E., *Going Forward With Science*; Ginn and Company, Chicago, Illinois, 1947.

   Two chapters apply to this unit. They are "Energy for Today and Tomorrow" and "Juggling Atoms and Molecules."

4. Meister, Morris, Keirstead, Ralph E., and Shoemaker, Lois M., *The Wonderworld of Science*; Chas. Scribner's and Sons, New York, New York, 1944.

   The following sections are useful: (pages 183-343)

   Energy for a World at Work
   Energy for Transportation
   Energy for Communication

Films

1. *Atomic Energy*, 11 min., Sd., Encyclopedia Britannica Films, Wilmette, Illinois.

   Shows one of the basic principles of atomic energy. The film should be used a number of times in order to clarify concepts that are presented. Usable in grades above the sixth.

2. *The Nature of Energy*, 11 min., Sd., B & W, Coronet Films, Chicago 1, Illinois.

   A film designed to simplify the concept of energy in a simple and interesting manner. The relationship between atomic energy and other forms of energy is shown. The film will need a careful introduction on the part of the teacher if it is to be used in the elementary grades.

Filmstrips

1. *The Atom*, 55 frames. Color. Produced by Life Magazine, 9 Rockefeller Plaza, New York 20, New York.

   A simple explanation of the structure and behavior of the atom. The filmstrip begins with historical information, then describes by clear and striking illustrations the structure of the atom. Parts of the strip are suitable for the upper elementary grades.

2. *Atomic Energy*, 55 frames. Black and White. Produced by The New York Times, School Service Department.

   A filmstrip showing the basic scientific principles involved in the development of atomic energy, the various plans for control of this power, and finally a number of suggestions for peacetime use of atomic power.

   Parts of the filmstrip are too difficult for elementary school children, although much of it would have value for them.

3. *Jimmy and Nancy Meet Mr. Atom*. 36 frames. Color. Council on Atomic Implications, Box 296, University of So. Cal., Los Angeles 7. The first attempt to translate atomic implications for primary grade children, its objectives being to change fear to favor and apathy to interest.

4. *Up and Atom*, 68 frames; Film Publishers, Inc., 12 E. 44th Street, New York 17, New York.

   A filmstrip which uses the cartoon idea in presenting the problems of control of atomic energy.

Recordings and Transcriptions

1. *Atomic Bomb, The*, 20 minutes. 2-12" discs. Lewellyn's Club Productions, 8 South Michigan Avenue, Chicago 3, Illinois.

   These recordings have an accompanying filmstrip. Narration is done by Mr. Neil Hamilton, with Dr. Glenn T. Seaborg as technical advisor.

   The last three recordings give an excellent summary of the unit. However, the nature of the first record makes it unsuitable for use with elementary children.

2. *Beyond Victory*. Four programs on Atomic Energy for Peace. 33⅓ RPM.

   Each program 14 minutes in length. Carnegie Endowment for International Peace, 405 W. 117th Street, New York 17, New York.

   Program 178, "Atomic Energy—Servant of Man"
   Program 179, "Atomic Power Plants of the Future"
   Program 180, "Peacetime Use of Atomic Energy"
   Program 181, "The World Significance of the Atom"

3. *Peacetime Uses of Atomic Energy*. 78 RPM, 20 min., 12" records. Lewellen's Club Productions, 8 So. Michigan Avenue, Chicago 3, Illinois.

   These recordings outline the benefits that can be derived from atomic energy, providing a system of international control can be set up. A filmstrip accompanies the recordings.

4. *What is the Atom?* 78 RPM, 30 min., 3-12" discs. Recordings Division, New York University Film Library, 26 Washington Place, New York 3, New York.

   These recordings are designed to tell the story of the atom in a dramatic and informative way. They should be of interest to both adults and older children.