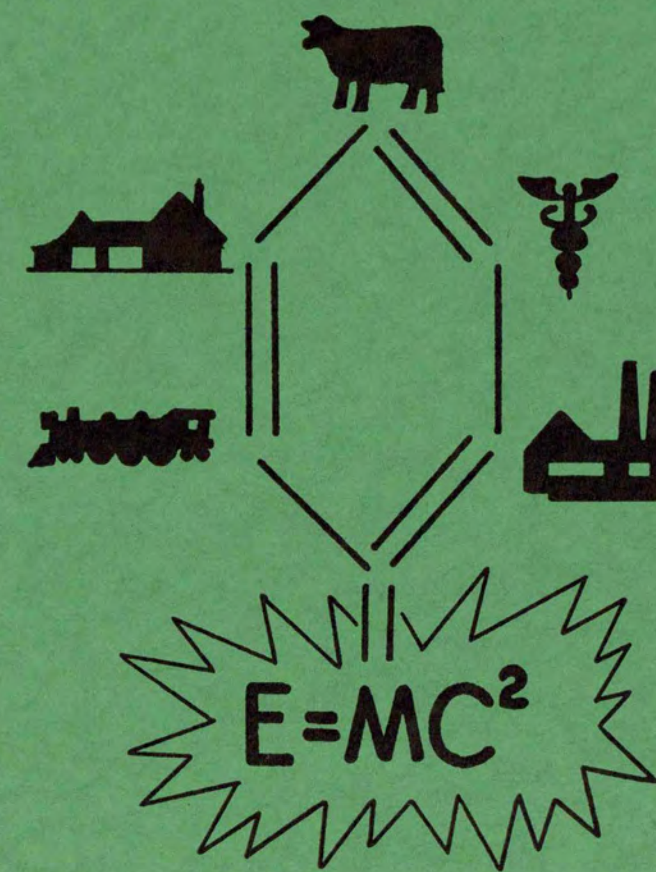
the ATOM & YOU

A Unit for Secondary Schools



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THE DEPARTMENT OF PUBLIC INSTRUCTION

THE STATE OF IOWA
Des Moines

State of Iowa
1950

THE ATOM AND YOU

A Unit for Secondary Schools

VOLUME III

THE IOWA PLAN FOR
ATOMIC ENERGY EDUCATION

ISSUED BY THE
DEPARTMENT OF
PUBLIC INSTRUCTION
JESSIE M. PARKER
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THE IOWA PLAN FOR ATOMIC ENERGY EDUCATION

THE ATOM AND YOU

(A Unit for Secondary Schools)

I. INTRODUCTION

Atomic energy is a part of our lives today and it will progressively become a more important part. When man learned to release energy by breaking the nucleus of the atom, a fundamental advance of knowledge was made, as great as man has ever witnessed; an advance of knowledge which has tremendous implications for all aspects of our life, socially, politically, and economically. An awareness of atomic energy on the part of the public was first brought about by the use of atomic energy as a weapon. The atomic bomb, however, is only the first application of the new knowledge, the potential applications of which seem almost limitless. Atomic energy holds forth great promise for a better and happier life for this and succeeding generations. It also presents a serious threat to our present civilization. In and of itself, atomic energy is neither good nor bad but what man does with it may be either or both.

The existence of atomic energy poses important and far reaching problems, both international and domestic in scope. These problems are vital, real, and demanding of a solution. An intelligent and correct solution to these problems will make possible the potential beneficial results of atomic energy. The price we may have to pay for wrong solutions will be great, perhaps devastating. Attempting to ignore the problems or relying upon impulse and emotion for a solution is a certain means of ensuring wrong solutions. Intelligent, rational, and correct solutions can result only from knowledge and understanding. The very basis of our democracy is sound judgment rendered by a rational, informed citizenry. It is essential that Americans know and understand the facts and issues involved in atomic energy; that they realize the price which might have to be paid for wrong choices; and that it is up to them as to whether atomic energy will make their lives better or destroy them. They must realize that the atomic bomb and international control are only manifestations of a larger problem. The domestic issues involved are similarly far reaching, and decisions concerning them will greatly affect this and succeeding generations.

The absolute necessity of American citizens gaining atomic literacy quickly, places a heavy responsibility upon education at all levels. It is possible, through education, to acquire the necessary facts and understandings for intelligent decisions concerning atomic energy. The basic information is neither secret nor difficult. That our citizens do acquire such knowledge is a responsibility which no educator can avoid.

"The Iowa Plan for Atomic Energy Education" is an attempt to partially meet the need as indicated above. It is an attempt to help remove fears concerning atomic energy and to assist in pointing the way toward a sensible and sane consideration of what American citizens can and should know and do about atomic energy. It is a plan which extends from the elementary grades through adult education. This teaching unit, THE ATOM AND YOU, represents only one phase of the more inclusive program.

Specific Aspects of the Secondary Education Program

The purpose of this manual is to aid in accomplishing the purposes of the "Iowa Plan for Atomic Energy Education" as they pertain to the high school. It is intended, first, to demonstrate that teaching about atomic energy at the high school level is possible; second, to suggest what can and should be done in the high school; third, to suggest procedures and techniques which it is believed will prove successful; and fourth, to introduce and make available suitable materials for both teachers and pupils. For those schools which have developed programs and materials, it is hoped that this manual will serve as a supplement and as a source for additional suggestions and materials. The manual presents specific objectives, lesson plans, and text references, not for the purpose of limiting programs of study, but rather to give concrete aid to those schools who want to teach about atomic energy but are somewhat at a loss as to what to do and how to begin.

The teaching of atomic energy is not entirely new to the high schools of Iowa. The recently published state course of study includes units which contain most of the scientific facts and some of the social implications of atomic energy. The present material expands upon the suggestions given there and represents a conscious effort at correlation between science and the social studies. The program is conceived as consisting of a fifteen-day unit taught in the social studies class. It is recommended that the science teacher conduct the social studies class for the first seven days of the unit and that the social studies teacher conduct it for the remaining eight days. If possible, it would be desirable for both teachers to be present during the entire unit. A correlated program as here suggested involves some administrative problems in that teacher assignments will have to be adjusted so as to free the science teacher from regular duties during the hours he teaches the social studies class. This does not seem to constitute an insurmountable problem relative to the advantages involved in a correlated program. It does, however, place a measure of responsibility for the effective functioning of this program upon the administration. Even though it is highly recommended that the administration make possible the adoption of the above procedure, the plan does not rule out one teacher's teaching the entire unit. The material is adequate and the manual so designed that either the science or the social studies teacher can conduct the entire program.

The logical grade placement of a unit on atomic energy seems to be in eleventh grade social studies, and this for several reasons: (1) eleventh grade social studies is required of all pupils and this material is of such vital importance that all pupils must be included; (2) eleventh grade social studies commonly consists of American history and atomic energy constitutes a paramount problem in the United States today; and (3) physics is often taught at the eleventh grade level and this facilitates a correlated program. Even though it is recommended that this material be presented at the eleventh grade level, in some schools it may fit better in the twelfth grade program and, therefore, schools should adapt this recommendation to their local situation.

This material may be presented either early in the school year or toward the close of the second semester. The advantage of presenting the material toward the end of the year is that it will serve as an excellent culminating unit for the year's work and chronologically it belongs at the end of the year. It is also felt that pupils who are taking science will have acquired valuable background material by this time. There are, however, some very important advantages in teaching the unit early in the year. It is sincerely hoped that this unit will not end completely after fifteen days, but rather, that it will result in a continuing acquisition of more knowledge and better understanding and some action on the part of the pupils to contribute to a solution of the problems studied. The follow-up activities suggested in this unit are considered a very important part of the unit—a part that no school should overlook. The possibility of successfully and effectively carrying out these follow-up activities, such as an assembly program, is much greater if the unit is taught early in the year. Each school must decide which time best fits its local situation.

A copy of THE ATOM AND YOU is made available to every teacher of Iowa who is concerned with teaching atomic energy. This manual contains: (1) a list of objectives for the unit; (2) teacher lesson plans; (3) student assignment sheets for each day; (4) supplementary and follow-up activities; (5) suggested audio-visual aids; (6) evaluation and test suggestions; (7) recommended materials for the school library; and (8) appendices of content materials for students and teachers. A copy of the unit **Atomic Energy, Double-Edged Sword of Science** by R. Will Burnett, accompanies this manual. A specific text is recommended in order to obtain concrete results from the teaching of this material and the text here included is considered the most suitable of the present available publications.

How to Use This Manual

This manual has been so prepared that the teacher need do no further organizational work, and can use the material here presented directly in the class room. As pointed out previously, this is **not** intended as a restricting factor but is so presented in an attempt to be as helpful as possible. Experimentation, adjustment to local situations, development of new materials, and use of new sources are most highly recommended.

A Teacher Lesson Plan and a Student Assignment Sheet are included for each day and are numbered according to the day to which they apply. The Teacher Lesson Plan states the problem for that day, contains a brief content outline of the material to be covered (with keyed references), lists activities and teaching procedures for that day, and indicates the student assignment for the following day. The references in the content outline refer to the Bibliography of Keyed References and Kits of Materials on page 4 of this manual and are included so that the teacher can readily locate the necessary sources for the material to be covered that day. The numbers within the parentheses designate the reference, the other numbers the pages.

The Student Assignment Sheet is so prepared that it can be reproduced and distributed to the pupils. It states the problem to be considered, gives the student assignment with reading references, and lists study guide questions. If this sheet cannot be reproduced, it can be given to the pupils orally or placed on the blackboard. The Student Assignment Sheet for the 5th day, for example, should be distributed to the pupils on the 4th day.

The lesson plans for the 1st and 15th days are not in strict conformity with the above, for the 1st day is devoted to an introduction and motivation and the 15th day to evaluation. Ample suggestions are included for both days. The suggested test consists of multiple-choice items, and again, this is not meant to imply that other types of questions are not suitable or desirable. In some instances it was felt that additional material or suggestions for demonstrations would be helpful. Therefore, a supplement has been attached to some Teacher Lesson Plans.

One of the purposes of this manual is to indicate and make readily available to the schools the best material on atomic energy presently available at the lowest possible cost. In order to accomplish this the following procedure has been adopted. From the great amount of printed material available, that which is listed under Keyed References and Kits of Materials was selected as best suited and contains both teacher and pupil references. These materials are available through the State Department of Public Instruction and for convenience in ordering are packaged in kits as indicated under Keyed References and Kits of Materials. These kits can be ordered in any desired amounts to meet local needs. The following amounts are recommended as a minimum: (1) one **Kit A** for each teacher concerned; (2) one **Kit B** for every four pupils; and (3) a sufficient number of **Kit C** to provide each pupil with a copy of the basic text. A postcard order blank is inserted in this manual so as to make the ordering of material as convenient as possible. On this postcard are listed the available kits and the price of each. In ordering, it is only necessary to indicate the quantities desired. These kits contain a wealth of material at very low cost, made possible through quantity purchase and the excellent cooperation of many publishers. In some instances the materials have been furnished free; in other cases the cost is much below the market price.

A list of recommended material on atomic energy for the high school library is also included in this manual. It is hoped that each school will be interested in and able to add material on atomic energy to the school library each year, in addition to that contained in the available kits. The materials suggested in this list will cost approximately $25.00. Even though this amount may not be available in one year, some purchases can and should be made each year.

It is anticipated that teachers who use this manual will make changes, modifications, and improvements in it. In the interests of future revision, teachers are urged to record their experiences and criticisms and to send these to the Chairman, John H. Haefner, University High School, Iowa City, Iowa.

It is sincerely hoped that this manual will prove useful to the high school teachers of Iowa. Obviously, it is only a beginning, and changing conditions will require new teaching materials and methods as time goes on. But there is urgent need for constructive action toward teaching the fundamentals of atomic energy, and it is later than we think.

II. GENERAL OBJECTIVES

1. To realize the significance of atomic energy for the future of the United States and the world.
2. To understand the fundamental scientific principles of matter and energy as related to atomic energy.
3. To acquire a basic scientific knowledge of atomic energy to aid in an understanding of its social implications.
4. To understand the potentialities of atomic energy.
5. To become aware of the importance of international control of atomic energy.
6. To become acquainted with some of the major problems involved in domestic and international control of atomic energy.
7. To become acquainted with the Atomic Energy Act and the organization and functions of the Atomic Energy Commission.
8. To acquire a command of terminology peculiar to atomic energy in order to understand current discussion of the subject in newspapers, magazines, and on the radio.
9. To think clearly and critically on social, political, and scientific problems as they are related to atomic energy.
10. To acquire the attitude that atomic energy "affects everyone" and become aware of opportunities and responsibilities of youth in the Atomic Age.
11. To develop lasting interest in matters relating to atomic energy.
12. To develop the ability to evaluate the impact of science and technology on society.

IV. TEACHER LESSON PLANS AND STUDENT ASSIGNMENTS

III. KEYED REFERENCES AND KITS OF MATERIALS

Each item in this reference list has a number. These numbers are referred to in the keyed references of the teacher's daily lesson plans. In these keyed references, the item number is given first, in parentheses, with the page numbers following; e.g., (7) 5-6 means item #7, pages 5-6. In some cases (e.g., certain pamphlets), page numbers are not given.

The available kits of materials are listed at the end.

* * *

1. Basic Text: Burnett, R. W., **Atomic Energy, Double-Edged Sword of Science,** Charles E. Merrill Co., Rev. Ed., 1950.
2. Evans, Crary, Hass, **Operation Atomic Vision,** National Education Association, 1948.
3. **The World Within the Atom,** Pamphlet, Westinghouse Electric Corp., 1946.
4. **The Atom,** LIFE Reprint, May 16, 1949.
5. Musial, Joe, **Learn How Dagwood Splits the Atom,** King Features Syndicate, Inc., 1949. (Out of print)
6. **Adventures Inside the Atom,** Adventure Series, General Electric Co., 1948.
7. **Atoms, Energy, Electrons,** F. E. Compton and Co., Reprint, 1950.
8. **Atoms at Work,** Council on Atomic Implications, Inc., 1950.
9. a. **How You Can Survive an A-Bomb Blast,** SATURDAY EVENING POST, Jan. 7, 1950. (Reproduced by permission).
   b. **The Hydrogen Bomb,** DES MOINES REGISTER Reprint.
10. **Atomic Energy Education,** U. S. Office of Education, Reprint from SCHOOL LIFE, March, 1949.
11. **Medical Aspects of Atomic Weapons,** U. S. Government Printing Office, 1950.
12. **City of Washington and An Atomic Bomb Attack,** A.E.C. Pamphlet. (Reproduction)
13. **The Atomic Energy Act of 1946,** Brief for Action, League of Women Voters. (Reproduction)
14. a. **Domestic Control of Atomic Energy,** Address by Commissioner Sumner T. Pike. (Reproduction)
    b. **Remarks by Commissioner Lewis L. Strauss** at Town Hall, Los Angeles, Calif., Nov. 9, 1949. (Reproduction)
15. **U. S. Atomic Energy Proposals** (Baruch Report), Dept. of State Pub. #2560.
16. **Comparison of the UN Plan of Atomic Energy Control with Soviet Control Proposals,** Dept. of State. (Reproduction)
17. **Farm People and the Atom,** Address by David E. Lilienthal. (Reproduction)
18. Crary, Evans, Gotlieb, Light, **The Challenge of Atomic Energy,** Teachers College, Columbia University.
19. Hersey, John, **Hiroshima,** Alfred A. Knopf, Inc., 1946.
20. **Atomic Energy Here to Stay,** U. S. Office of Education, Supplement to SCHOOL LIFE, March, 1949.
21. **Atomic Energy Act of 1946, Public Law 585,** U. S. Government Printing Office.
22. **Minutes to Midnight (International Control of Atomic Energy),** Bulletin of Atomic Scientists, 1950.
23. a. **Youth in the Atomic Age,** Address by David E. Lilienthal. (Reproduction)
    b. **Opportunity and Responsibility in the Atomic Age,** Address by Dr. Robert Bacher. (Reproduction)

SUPPLEMENTARY MATERIALS

24. Any standard high school physics textbook.
25. Any recent encyclopedia.

AVAILABLE KITS OF MATERIALS

Kit A—Teacher's Kit—Includes all listed reference materials from (1) through (23).

Kit B—Student's Kit—Includes all listed materials from (1) through (17), plus (23).

Kit C—Basic Text Kit—Includes Basic Text (No. 1) only, put up in numbers of **five per kit.**

Kit D—Basic Teaching Materials—Includes one Basic Text (No. 1) plus complete Teacher's Manual for the unit.

STUDENT ASSIGNMENT—2nd Day

Problem 1. What are some of the characteristics and properties of matter?

ASSIGNMENT:

1. **The Atom,** LIFE Reprint, pp. 4-7.
2. Any standard high school physics text such as:
   - a. **Physics for the New Age,** Carleton and Williams, pp. 52-54.
   - b. **Modern Physics,** Dull, pp. 3-13, 89-93.
   - c. **Dynamic Physics,** Bower and Robinson, pp. 26-30, 33-36, 153-156.
3. **Summary of the Kinetic Molecular Theory of Matter,** Appendix A, p. 45 (this manual).

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. Define matter in your own words.
2. In what three basic forms or states is all matter found?
3. Can any one kind of matter exist naturally in all three forms? Explain.
4. What is the smallest physical unit of matter?
5. What is a physical change?
6. What is a chemical change?
7. What are some of the characteristic properties of matter by which it is described and identified?
8. What is the difference between weight and mass?
9. How small are molecules?
10. What is the Kinetic Molecular Theory of Matter?
11. Of what small particles are molecules composed?
12. What is an element?
13. What is a compound?
14. Select **at least one** of the following phenomena and be able to explain it in terms of the Kinetic Molecular Theory of Matter.
    - a. Air pressure
    - b. Pressure of any enclosed gas
    - c. Diffusion
    - d. Evaporation

NOTES:

TEACHER LESSON PLAN—1st Day

SUGGESTED INTRODUCTORY AND MOTIVATING ACTIVITIES:

From this list of activities, select those best suited to your school situation. Some activities should be previously assigned to students; others can be developed during the first class period.

1. Solicit and list on the blackboard questions concerning atomic energy to which the pupils desire answers.
2. Record current conceptions held by students regarding atomic energy and alter erroneous ones as new generalizations and understandings develop.
3. Compile a list of possible sources of information about atomic energy to be used with the unit and for follow-up activities.
4. Appoint a committee to check books and magazines already in the public and school libraries and make a report to the class on useful articles found.
5. Show any of these films if available: (See Section VI, p. 36 for sources)
   - a. **Atomic Energy**
   - b. **Atomic Power**
   - c. **One World or None**
   - d. **How To Live With The Atom** (Highly recommended filmstrip)
6. Prepare brief biographies of scientists who have had a part in the progress of nuclear physics.
7. Appoint a class committee to prepare a bulletin board on atomic energy and keep it up-to-date with newspaper and periodical clippings.
8. Delegate one member of the class to check radio programs for any significant broadcasts about atomic energy. Broadcast times and stations should be posted in the classroom. If a wire or tape recorder is available, record the best programs broadcast when the class is not in session.
9. Have a qualified speaker give an address on the significance of atomic energy and the citizen's responsibility of knowing more about it.
10. Organize a committee to poll people of various occupations, educational levels, and ages in order to determine their knowledge of and attitudes toward atomic energy. (Teacher should provide questions or give careful guidance in their selection by students.) Summarize answers to questions and have them reported to class or placed on bulletin board.
11. Appoint a committee to prepare news articles reporting on current phases of class study of atomic energy. Give special emphasis to any exhibits or projects the class has completed. Submit reports to local newspaper.
12. Appoint a committee to be responsible for the preparation of a summary of the unit which they can present before a school assembly.
13. Read several challenging statements made by prominent people regarding atomic energy, and/or read selected sections from **Must Destruction Be Our Destiny?** by Harrison Brown, or **Modern Man Is Obsolete** by Norman Cousins. Portions of John Hersey's **Hiroshima** (included in Kit A) are also suitable for motivation. Either a teacher or a pupil may select portions and read them to the class. Discuss briefly the significance of the statements or sections.

   Note: **Be sure to make** this assignment for following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. LIFE Reprint, **The Atom,** pp. 4-7.
2. Any standard high school physics text such as:
   - a. **Physics for the New Age,** Carleton and Williams, pp. 52-54.
   - b. **Modern Physics,** Dull, pp. 3-13, 89-93.
   - c. **Dynamic Physics,** Bower and Robinson, pp. 26-30, 33-36, 153-156.

NOTES:

STUDENT ASSIGNMENT—3rd Day

Problem 2. What is the basic structure of an atom?

ASSIGNMENT:

1. **The Atom,** LIFE Reprint, Inside cover, pp. 1, 8-13.
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 3-4.
3. Any standard high school physics text such as:
   a. **Physics For the New Age,** Carleton and Williams, pp. 599-603.
   b. **Dynamic Physics,** Bower and Robinson, pp. 31-32.
4. **Atoms, Energy, Electrons,** Compton's Reprint, pp. 456-460.
5. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 41-43.
6. **The World Within the Atom,** Westinghouse Electric Corp., pp. 3-30.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What is the meaning of the term **atom**?
2. To what known system is the overall structure of an atom usually compared? Explain what this system is like.
3. Who discovered the electron?
4. Where are electrons found?
5. What are the characteristics of an electron?
6. How are electrons related to electricity?
7. What are the laws of electrical charges?
8. What is the meaning of **valence** and **valence shells**?
9. How are electrons involved in chemical reactions?
10. Of what is the nucleus of any atom composed?
11. What is the difference between an electron, proton, and neutron?
12. Why is the weight of an atom concentrated in its nucleus?

NOTES:

TEACHER LESSON PLAN—2nd Day

Problem 1. What are some of the characteristics and properties of matter?

CONTENT OUTLINE:

I. Matter (24); (4):
   A. Definition
   B. Forms and states of matter
   C. Structural units of matter
   D. Properties of matter
   E. Physical and chemical changes

II. Kinetic Molecular Theory (24); (4):
   A. Statement and meaning of the theory
   B. Relationship between the theory and common phenomena such as:
      1. Air pressure
      2. Diffusion
      3. Evaporation

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss content outline using as many of the following activities as possible. Demonstration directions are given in Appendix B, p. 45, of this manual.
   A. Demonstrate states of matter
   B. Demonstrate evaporation
   C. Demonstrate Brownian movement
   D. Demonstrate diffusion
   E. Demonstrate combined volume using alcohol and water
   F. Demonstrate molecular motion apparatus
   G. Show films, (1) **Matter and Energy,** Coronet Productions
      (2) **Molecular Theory of Matter,** Encyclopedia Britannica Films, Inc.
2. Make class assignment for the following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **The Atom,** LIFE Reprint, Inside cover, pp. 1, 8-13.
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 3-4.
3. Any standard high school physics text.
   a. **Physics for the New Age,** Carleton and Williams, pp. 599-603.
   b. **Dynamic Physics,** Bower and Robinson, pp. 31-32.
4. **Atoms, Energy, Electrons,** Compton's Reprint, pp. 456-460.
5. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 41-43.
6. **The World Within the Atom,** Westinghouse Electric Corporation, pp. 3-30.

NOTES:

STUDENT ASSIGNMENT—4th Day

Problem 3. How are all of the atoms and elements related?

ASSIGNMENT:

1. **The Atom,** LIFE Reprint, p. 14.
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 4-7.
3. **Atoms at Work,** Council on Atomic Implications, Inc., pp. 11-18.
4. **Operation Atomic Vision,** Evans, Crary, Hass, p. 45.
5. **The World Within the Atom,** Pamphlet, Westinghouse Electric Corp., pp. 13-16.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What is the atomic chart or the periodic table of the elements?
2. What relationship exists between the different elements and the numbers of their electrons?
3. How do the elements on the atomic chart get their numbers?
4. What is the meaning of atomic weight?
5. What element has been used as the basis for determining relative atomic weights? Why?
6. Why are atomic weights not the exact multiples of the atomic weight of hydrogen?
7. What is the meaning of the word **isotope**?
8. How do the various isotopes of any one element differ?
9. What is the difference between **uranium 235** and **uranium 238**?
10. Which part of the periodic chart contains the metals? Which part contains the non-metals?
11. Which part of the atomic chart contains the most active elements and which part contains the least active elements?
12. Which part of the atomic chart contains the heaviest elements and which part the lightest elements?

NOTES:

TEACHER LESSON PLAN—3rd Day

Problem 2. What is the basic structure of an atom?

CONTENT OUTLINE:

I. Particles composing an atom (3) 3-31; (1) 3-7; (4) 10-13:
   - A. Electron (3) 8-9; (2) 42
   - B. Proton (3) 13; (2) 43
   - C. Neutron (3) 16; (2) 43
   - D. Laws of electric charges (7) 316, 457

II. Overall structure of an atom (3) 13; (2) 42-45; (1) 3-7; (4) 10-13; (7) 458-459; (18) 13-16:
   - A. Solar system model (2) 43; (1) 3; (7) 458; (4) 12-13
   - B. Valence shells (1) 4; (7) 459
   - C. Nucleus (1) 4; (7) 458

III. Specific structure of simpler atoms (3) 14; (7) 458; (18) 14-15; (4) 12-13.

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss content outline (make liberal use of blackboard drawings of atomic models; the photo models as found in LIFE, **The Atom,** pp. 12-13, will be helpful).
2. Make class assignment for following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **The Atom,** LIFE Reprint, p. 14.
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 4-7.
3. **Atoms At Work,** Council on Atomic Implications, Inc., pp. 11-18.
4. **Operation Atomic Vision,** Evans, Crary, Hass, p. 45.
5. **The World Within the Atom,** Pamphlet, Westinghouse Electric Corp., pp. 13-16.

NOTES:

STUDENT ASSIGNMENT—5th Day

Problem 4. What is the relationship between the atom and energy?

ASSIGNMENT:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, R. W., pp. 8-10.
2. **The Atom,** LIFE Reprint, pp. 4-5.
3. **The World Within the Atom,** Pamphlet, Westinghouse Electric Corp., 1946, pp. 18-21.
4. **Adventures Inside the Atom,** Adventure Series, General Electric Co., 1948, pp. 6-9.
5. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 43-44.
6. **Atoms, Energy, Electrons,** Compton's Reprint, pp. 344, 463-464.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What are the common definitions for the words **matter** and **energy**?
2. What parts of the atoms are involved in the production of heat energy from burning carbon?
3. Why did the concept that matter changed only into some other form of matter persist for so long?
4. How do mass changes in nuclear reactions compare with mass changes in chemical reactions?
5. How large, as compared with the force of gravity, is the binding force holding nuclei together?
6. What is the meaning of Einstein's famous equation $E = mc^2$?
7. From what part of the atom does atomic energy come?
8. When matter is changed into atomic energy, in what forms does the energy appear?
9. What examples of the release of atomic energy are found in nature?
10. Compare the amount of energy released when an atom takes part in a nuclear reaction with the amount released when it takes part in a chemical reaction.

NOTES:

TEACHER LESSON PLAN—4th Day

Problem 3. How are all of the atoms and elements related?

CONTENT OUTLINE:

I. Atomic numbers:
  A. Relationship between electrons and atomic number (1) 4; (2) 42
  B. Relationship between protons and atomic number (1) 4-5
  C. Serial listing of the numbers (4) 14

II. Atomic weight:
  A. Oxygen as the standard (See Standard Chemistry Text)
  B. Relative weight (1) 5-6; Atomic Weight Supplement, Appendix C, p. 46, this manual.
  C. Isotopes (1) 6-7; (18) 15-16; (8) 11-18

III. Relationship of the elements:
  A. Metals and non-metals (See Standard Chemistry Text)
  B. Active and non-active elements (7) 460
  C. Light and heavy elements (7) 458

TEACHING PROCEDURES AND SUGGESTED ACTIVITES:

1. Discuss content outline.
2. Make class assignment for following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 8-10.
2. **The Atom,** LIFE Reprint, pp. 4-5.
3. **The World Within the Atom,** Pamphlet, Westinghouse Electric Corporation, pp. 18-21.
4. **Adventures Inside the Atom,** Adventure Series, General Electric Company, pp. 6-9.
5. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 14-44.
6. **Atoms, Energy, Electrons,** Compton's Reprint, pp. 344, 463-464.

NOTES:

STUDENT ASSIGNMENT—6th Day

Problem 5. What are the results of nuclear fission and the significance of these results?

ASSIGNMENT:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 10-17.
2. Any standard high school physics text such as: **Physics for the New Age,** Carleton and Williams, pp. 603-617.
3. **Atoms, Energy, Electrons,** Compton's Reprint, pp. 461-469.
4. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 45-49.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What is the meaning of transmutation of elements?
2. Why is the neutron commonly used in nuclear bombardment to produce fission?
3. Trace the main events leading up to nuclear fission.
4. What products have been found to result from the controlled nuclear fission of uranium? (U-235).
5. Would the same products result from neutron bombardment of iron?
6. What are transuranic elements? Name them. How are they obtained? What is their importance?
7. What conditions are essential to the establishment of a chain reaction?
8. How are radioisotopes produced in an atomic pile?
9. Do atomic piles and atomic bombs operate on the same principle? How do they differ?
10. Why was the discovery of plutonium such a boon to the development of the atomic energy program?
11. How do nuclear fission and nuclear fusion differ with respect to:
    a. The process itself
    b. Elements capable of taking part in each process
    c. Results

NOTES:

TEACHER LESSON PLAN—5th Day

Problem 4. What is the relationship between the atom and energy?

CONTENT OUTLINE:

I. Old concept of matter changing only to other forms of matter (1) 8; (24); (4) 5:
   A. Small change in mass in ordinary physical and chemical reactions not measurable (1) 8-9; (4) 5
   B. Involvement of only outermost electrons (7) 459; (24)

II. Nuclear reactions involve the heart of the atom (1) 8-10:
   A. Nuclear changes involve relatively large changes in the mass of the reacting materials (3) 16-19
   B. Mass loss is measurable (1) 8-9; (3) 18

III. Interpretation of $E = mc^2$ (18) 19-20; (7) 463-464; (2) 43-44.

IV. Matter and energy as manifestation of the same thing (1) 8-10.

V. Binding force holding protons together (1) 8; (7) 464; (5) 20.

VI. Our knowledge of the nucleus is incomplete (1) 8.

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss content outline using as many of the following activities as possible:
   a. Show the loss of mass in ordinary chemical reactions to be immeasurable by either repeating demonstration found in LIFE, **The Atom,** p. 5, or by using LIFE'S explanation of the demonstration.
   b. Using E (ergs) = m (grams) c^2 (centimeters per second)^2, show what energy is produced by the complete conversion of one gram of matter. (To convert ergs to kilowatt-hours multiply ergs by 2.78 X 10^{-14}. Cost of one kilowatt hour averages $0.05).
   c. Show what amounts of energy are produced by the conversion of about 1% of the mass. (One per cent used as present efficiency rate.)
   d. Demonstrate spontaneous radioactivity. Demonstration outline will be found in Appendix D, p. 46, of this manual.
2. Make class assignment for the following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 10-17.
2. Any standard high school physics text, such as: **Physics for the New Age,** Carleton & Williams, pp. 603-617.
3. **Atoms, Energy, Electrons,** Compton's Reprint, pp. 461-469.
4. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 45-49.

NOTES:

STUDENT ASSIGNMENT—7th Day

Problem 6. How can a world at peace benefit from atomic energy?

ASSIGNMENT:

1. **Peacetime Application of Atomic Energy,** Appendix E, p. 46. (Teacher's Manual)
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 20-23.
3. **Atoms At Work,** Council on Atomic Implications, Inc., pp. 20-48.

STUDY GUIDE QUESTIONS:

1. How are radioactive isotopes contributing to man's knowledge of the life processes?
2. Assume a man's arm must be amputated because of faulty blood circulation. How might the surgeon determine at what point to perform the surgery?
3. In what ways has radiation been used in the treatment of disease?
4. How might agriculture in Iowa be aided as a result of atomic research?
5. What are the aspects of nuclear power production that hinder automobile manufacturers from producing atomic-powered cars?
6. Why is the process of "breeding" so desirable in the production of nuclear power for industrial uses?
7. Are there any industries in your community that are using radioactive isotopes? For what purpose are they used?
8. Should we dispose of radioactive waste materials by putting them in rivers? Explain.

NOTES:

TEACHER LESSON PLAN—6th Day

Problem 5. What are the results of nuclear fission and the significance of these results?

CONTENT OUTLINE:

I. Historical developments leading to the realization of atomic fission:
  A. The work of Rutherford, the Curies, Fermi, Hahn and Strassmann, Meitner and Frisch (1) 10-11; (7) 461-464
  B. Production of artificially radioactive isotopes (1) 10-11

II. Uranium fission:
  A. Meaning of atomic fission (7) 464; (1) 11; (18) 16-17
  B. Fission products (7) 465; (1) 11; (3) 27 (diagram)

III. Implications of atomic fission:
  A. Chain reaction and the atomic pile (7) 466; (1) 14-15; (18) 21-26; (2) 45-49
  B. Bomb developments (1) 13-16; (7) 467
  C. Transuranic elements (7) 466, 468; (1) 14-15; (2) 47-49

IV. Nuclear Fusion:
  A. Energy resulting from combining nuclei (7) 467-469; (1) 10, 17
  B. Fusionable elements (1) 17; (7) 468

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss content outline.
2. Make class assignment for following day. Assign reports to be given on different aspects of the peacetime applications of atomic energy.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **Peacetime Applications of Atomic Energy,** Appendix E (this manual).
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 20-23.
3. **Atoms at Work,** Council on Atomic Implications, Inc., pp. 20-48.

NOTES:

STUDENT ASSIGNMENT—8th Day

Problem 7. What are the physical, social, and economic effects of atomic bombs?

ASSIGNMENT:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 16-19.
2. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 11-13, 24-41.
3. **Medical Aspects of Atomic Weapons,** Pamphlet, Gov't. Printing Office.
4. **City of Washington and An Atomic Bomb Attack,** Pamphlet. (Reproduction).
5. **The Hydrogen Bomb,** DES MOINES REGISTER Reprint.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. How does the atomic bomb compare with other explosives in destructive power?
2. What are the ways in which people may be injured from an atomic bomb explosion?
3. What would be the best action for you to take in case of an atomic bomb attack on your community?
4. How would your community as a unit be affected socially and economically from a successful attack?
5. What would be the probable physical destructive effect on your community in case of an **atomic bomb** explosion in the central part of town? In an outlying area one mile from the city limits?
6. What would be the probable physical destructive effect on your community in case of a **hydrogen bomb** explosion in the central part of town? In an outlying area one mile from the city limits; in an outlying area ten miles from the city limits?
7. What are the military limitations of atomic bombs?
8. What experiments have been carried on by the U. S. A. to further study the destructive effects of atomic bombs?

THOUGHT QUESTIONS FOR CLASS DISCUSSION:

9. "The atomic bomb is just another explosive." Do you agree with this statement? Give your reason.
10. "Atomic explosives demand not 90 per cent, but 100 per cent defense. This we do not know how to achieve."—Ivan A. Getting, Professor of Physics, Massachusetts Institute of Technology. Do you agree with this statement? State your reason.
11. Be prepared to challenge or defend: "The only defense is Peace."—Dr. J. R. Oppenheimer, Wartime Director of the Laboratory at Los Alamos, New Mexico.

NOTES:

TEACHER LESSON PLAN—7th Day

Problem 6. How can a world at peace benefit from atomic energy?

CONTENT OUTLINE:

I. Atomic Energy in Medicine:
   A. By-products of the atom bomb contribute to our knowledge of normal and pathological conditions in the human body (1) 21-22; (8) 20-34
   B. Atomic energy's role in medical treatment. (8) 34-38

II. Atomic Energy in Agriculture:
   A. Tracer elements reveal nature's secrets of plant life (1) 23-24; (8) 38-42
   B. Effects of radiation on plant life (p. 49, Appendix E, in this manual)

III. Atomic Energy in Industry:
   A. Science attempts to harness the atom (1) 20-21; (18) 26-28, 30-33
   B. Industry's new source of knowledge—the tracer (1) 22-23; (8) 42-47

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss content outline.
2. Present student reports on peacetime applications of atomic energy in:
   a. Medicine
   b. Agriculture
   c. Industry
   d. Your community
3. Make class assignment for following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. Brief reading report by several pupils on important motivating phases of **Hiroshima** by John Hersey and **The Challenge of Atomic Energy,** Crary, Evans, Gotlieb, Light, pp. 47-53.
2. Brief oral report by one pupil on, "What would be the social, physical, and economic effect on our community if one atomic bomb were dropped in the center of town?"
3. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 16-19.
4. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 11-13, 24-41.
5. **Medical Aspects of Atomic Weapons,** Pamphlet, Gov't. Printing Office.
6. **City of Washington and an Atomic Bomb Attack,** Pamphlet (Reproduction).
7. **The Hydrogen Bomb,** DES MOINES REGISTER Reprint.

NOTES:

STUDENT ASSIGNMENT—9th Day

Problem 8. How are we controlling atomic energy in the United States?

ASSIGNMENT:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 13, 15, 24.
2. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 13-15, 55-63.
3. **The Atomic Energy Act of 1946**—Brief for Action Pamphlet (Reproduction).
4. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 6-7.
5. **Domestic Control of Atomic Energy,** Commissioner Sumner T. Pike, pp. 1-5 (Reproduction).
6. **Remarks by Commissioner Lewis L. Strauss at the Town Hall,** Los Angeles, California, November 9, 1949, pp. 1-5 (Reproduction).

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What is meant by "controlling" atomic energy?
2. Where are the following cities and for what are they famous: Oak Ridge, Hanford, Los Alamos?
3. Why did Congress, after World War II, decide to keep atomic energy under governmental control?
4. Why did Congress decide to have civilian rather than military control?
5. In what year was the Atomic Energy Act passed by Congress?
6. Make a list of the main provisions of the Atomic Energy Act.
7. How many members are there on the U. S. Atomic Energy Commission (A. E. C.) and how are they chosen?
8. What is the purpose of the Congressional Committee on Atomic Energy?
9. In what way does the Congressional Committee on Atomic Energy differ from all other committees set up by Congress?
10. What are the duties of the General Manager of the A. E. C.?
11. What are the duties of the General Advisory Committee; of the Military Liaison Committee?
12. State some of the most important functions of the A. E. C.
13. Where are the A. E. C.'s great atomic research centers located?

THOUGHT QUESTIONS FOR CLASS DISCUSSION:

14. One author has called the Atomic Energy Act "America's Most Radical Law." Why do you think it was so called?
15. Why is the development of atomic energy not being left to private companies, as was done for radio, aviation, etc.?
16. Why should every citizen know something about and be concerned with the policy and activities of the A. E. C.?

NOTES:

TEACHER LESSON PLAN—8th Day

Problem 7. What are the physical, social, and economic effects of atomic bombs?

CONTENT OUTLINE:

I. Comparison with other destructive explosives (1) 16-19; (11); (9b):
   A. Ordinary bombs vs. atomic bombs
   B. Bikini experiments—results

II. Actual destructive effects (2) 11-13, 24-31; (11); (12); (18) 47-50; (19); (9a):
   A. Physical effects on cities
   B. Physical effects on people: heat, radiation, blast
   C. Effect on cities as a social and economic unit

III. Future military uses and the limitations of the atomic and hydrogen bombs (1) 16-19; (9b):
   A. Comparison between A-Bombs and H-Bombs:
      1. Potentialities
      2. Limitations
   B. Stockpiling of more powerful atomic bombs

IV. Lack of adequate defense against atomic bombs (1) 16-19; (2) 32-41; (18) 50-53; (11); (9a):
   A. Difficulty of attaining total defense
   B. What the individual can do to survive

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Show either film, "Tale of Two Cities," or "One World or None," if available.
2. Show film strip, "One World or None."
3. Have reading reports by students from **Hiroshima** by John Hersey and **The Challenge of Atomic Energy** by Crary, Evans, Gotlieb, Light.
4. Have a class discussion on the physical effects of heat, radiation, and blast on people.
5. Discuss specific reasons why there can never be an adequate defense against an atomic bomb attack.
6. Have the report on the effect of an atomic bomb assigned the previous day. Allow sufficient time for the class to discuss the report.
7. Consider the thought questions in the student assignment.
8. Make assignment for the following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. A 5-minute report on the wartime Manhattan Project. (Reference: An encyclopedia; or if available: Smyth, **Atomic Energy for Military Purposes; Secret,** Chrysler Corp.; Campbell, **The Atomic Story.**)
2. Make a large poster for class use showing the organization of the U. S. Atomic Energy Commission. See **Scientific American,** July 1949, p. 33.
3. Have a committee find out who the present members of the U. S. Atomic Energy Commission are; who the present Chairman of the Congressional Atomic Energy Committee is.
4. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 13, 15, 24.
5. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 13-15, 55-63.
6. **The Atomic Energy Act of 1946**—Brief for Action Pamphlet (Reproduction).
7. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 6-7.
8. **Domestic Control of Atomic Energy,** Commissioner Sumner T. Pike, pp. 1-5 (Reproduction).
9. **Remarks by Commissioner Lewis L. Strauss at the Town Hall,** Los Angeles, California, Nov. 9, 1949, pp. 1-5 (Reproduction).

NOTES:

STUDENT ASSIGNMENT—10th Day

Problem 9. What are some problems of Federal control of atomic energy?

ASSIGNMENT:

1. **Remarks by Commissioner Lewis L. Strauss at the Town Hall,** Los Angeles, California, Nov. 9, 1949, pp. 6-7 (Reproduction).
2. **Domestic Control of Atomic Energy,** Commissioner Sumner T. Pike, pp. 5-10 (Reproduction).
3. **Operation Atomic Vision,** Evans, Crary, Hass, p. 15.
4. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 6-7.
5. Read about current problems of the A. E. C. in (a) recent encyclopedia; (b) current magazines.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What are some reasons why our atomic energy program has been difficult to administer?
2. How does the A. E. C. work with private companies? Is this arrangement always satisfactory? Why or why not?
3. Why is much of the work of the A. E. C. kept secret?
4. Does Congress have the right and duty to check on the activities of the A. E. C.?
5. Who pays for the huge expenditures of the A. E. C.? Does the A. E. C. have any income?
6. What is the main activity of the A. E. C. at the present time?

THOUGHT QUESTIONS FOR CLASS DISCUSSION:

7. What are some possible reasons why the government is having difficulty attracting top-ranking scientists for work with the A. E. C.?
8. Some authorities have said that the U. S. is more likely to obtain security through achievement than through secrecy. What did they mean?
9. What dangers are there to the development of science, and to democracy itself, in secrecy, loyalty checks, and FBI investigations of scientific workers? Is any of this necessary under present conditions?

NOTES:

TEACHER LESSON PLAN—9th Day

Problem 8. How are we controlling atomic energy in the United States?

CONTENT OUTLINE:

I. Control of atomic energy development during World War II: the Manhattan Project (1) 13, 15; (25); Smyth, **Atomic Energy for Military Purposes;** Campbell, **The Atomic Story:**
   A. Cost
   B. Oak Ridge, Hanford, Los Alamos:
      1. Reason for these sites
      2. Present status
   C. The Smyth Report—nature and significance

II. Why was continued public control of atomic energy considered necessary after World War II? (10) 6-7; (18) 34-36:
   A. Civilian or military control?
   B. Private or public control?

III. The Atomic Energy Act of 1946 (13); (18) 34-35; (21):
   A. Purpose
   B. Main provisions
   C. Revolutionary nature of the act

IV. The U. S. Atomic Energy Commission (A. E. C.) (1) 13, 15, 24; (2) 13-15, 55-63; (14 a, b); (18) 35-36; (20) 5:
   A. Organization and personnel
   B. Functions
   C. Magnitude of its operations and budget

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Have a 5-minute report on the Manhattan Project.
2. Use map of U. S. to locate Oak Ridge, Hanford, Los Alamos.
3. Discuss need for domestic atomic control.
4. Develop on the board a list of the main provisions of the Atomic Energy Act.
5. Use student-prepared poster when discussing the A. E. C.
6. Have committee report on present members of the Commission, names later to be placed on poster.
7. Develop on the board a list of functions of the A. E. C. Emphasize widespread activities and cost.
8. Make assignment for the following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **Remarks by Commissioner Lewis L. Strauss at the Town Hall,** Los Angeles, California, Nov. 9, 1949, pp. 6-7 (Reproduction).
2. **Domestic Control of Atomic Energy,** Commissioner Sumner T. Pike, pp. 5-10 (Reproduction).
3. **Operation Atomic Vision,** Evans, Crary, Hass, p. 15.
4. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 6-7.
5. Read about problems of the A. E. C. in (a) recent encyclopedia; (b) current magazines.

NOTES:

STUDENT ASSIGNMENT—11th Day

Problem 10. How are we attempting to secure international control of atomic energy?

ASSIGNMENT:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 25-28.
2. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 32-41, 63-68.
3. **U. S. Atomic Energy Proposals** (Baruch Report), Dept. of State Publication 2560.
4. **Comparison of the UN Plan of Atomic Energy Control with Soviet Control Proposals,** Dept. of State (Reproduction).

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What facts about atomic energy and the atomic bomb make it necessary that some form of international control be worked out?
2. Would outlawing atomic bombs by international agreement be enough? Why or why not?
3. What seem to be some basic requirements of any **effective** system of international control of atomic energy?
4. Where do the raw materials for the atomic bomb come from? Does the United States have a monopoly on these materials?
5. Make a time line listing in chronological order the major steps that have been taken toward international control of atomic energy.
6. What is the purpose of the United Nations Atomic Energy Commission? What countries have membership on the Commission?
7. What is the Acheson-Lilienthal Report? The Baruch Report?
8. What are the main provisions of the Majority Plan for international control of atomic energy? (This plan is essentially that proposed by the U. S.)
9. What are the main proposals of the Russian Plan?
10. Make out a chart to show the areas of agreement and disagreement between the Majority Plan and Russia's plan for international control. Arrange the following questions in a column and indicate after each one whether the Majority and Russia would answer "yes" or "no" to the question.
    1) Is control possible? 2) Should an international control authority be set up? 3) Should such an authority be given power to carry on production activities, i.e. own and manage mines, plants, etc.? 4) Should there be complete, continuous inspection of all atomic energy activities? 5) Should inspection be subject to veto in the Security Council? 6) Should enforcement of the agreement, such as punishment for violations, be subject to veto? 7) Should atomic bombs be outlawed as a weapon of war? 8) Should existing atomic bombs be retained until **after** controls have been set up?

NOTES:

TEACHER LESSON PLAN—10th Day

Problem 9. What are some problems of Federal control of atomic energy?

CONTENT OUTLINE:

I. Administrative problems of the A. E. C. (14a) 8-15:
  A. Gigantic new venture
  B. Policy
  C. Getting first-class personnel
  D. Relations with contractors

II. The problem of public vs. private enterprise (10) 6-7.

III. The problem of security (18) 36-41; (14b) 8:
  A. How much secrecy is necessary?
  B. Loyalty checks and FBI investigations—effect on personnel
  C. Dangers of extreme security measures in peacetime to freedom of scientific inquiry and to democracy.

IV. Other problems (2) 15.

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Use teacher presentation to help point up problems; questions and discussion to bring out opinions and develop proper attitudes.
2. Develop on the board a list of the major problems.
3. Make assignment for the following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. If a panel is to be used in the next lesson, explain briefly the problem to be discussed, and ask for volunteers (3 students).
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 25-28.
3. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 32-41, 63-68.
4. **U. S. Atomic Energy Proposals** (Baruch Report), Dept. of State Publication 2560.
5. **Comparison of the UN Plan of Atomic Energy Control with Soviet Control Proposals,** Dept. of State (Reproduction).

NOTES:

STUDENT ASSIGNMENT—12th Day

Problem 11. Are we achieving international control of atomic energy?

ASSIGNMENT:

1. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 66-76.
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 28-30, 16-17.
3. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 7-8.
4. **Comparison of the UN Plan of Control with the Soviet Control Proposals,** Dept. of State (Reproduction).
5. **The Hydrogen Bomb,** DES MOINES REGISTER Reprint.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. Why will the U. S. not accept the Russian Plan for international control of atomic energy?
2. What are some possible reasons why Russia does not want to accept the Majority Plan for atomic control?
3. What other world problems are related to the problem of atomic energy control?
4. Because of the failure of the Western nations and Russia to reach agreement on atomic control and other problems, what is now happening?
5. Make a list of present barriers to international understanding. For each barrier suggest a possible means of overcoming it.

THOUGHT QUESTIONS FOR CLASS DISCUSSION:

6. Should the U. S. keep on making more and bigger atomic bombs while trying to reach an agreement on control of atomic energy?
7. Russia now has the atomic bomb. Do you see any possible effect that this might have on negotiations for control?
8. If and when some form of international control is established, will our domestic control act have to be changed?
9. What do you think of the idea, expressed by some people, that weapons of war (atomic bombs, rockets, guided missiles, bacteria, etc.) are getting so terrible that nations will never start another war?
10. Many scientists, statesmen, and other thinkers believe that the only answer to the atomic bomb is an effective world government in place of our present United Nations. Can you give any arguments to support this belief? What is meant by world government? What are some important differences between world government and the present United Nations?

NOTES:

TEACHER LESSON PLAN—11th Day

Problem 10. How are we attempting to secure international control of atomic energy?

CONTENT OUTLINE:

I. Why is some form of international control of atomic energy considered necessary? (1) 18-19; (2) 32-41, 63-65; (18) 36-46, 51-53; (22) 9-10, 22.

II. Is international control **technically** possible? (1) 25; (18) 53-54; (22) 25-26.

III. What major steps (in chronological order) have been taken toward international control? (1) 26-27.

IV. What is the United Nations Atomic Energy Commission (UNAEC) and what is its purpose? (1) 26; (22) 23-24.

V. What was the Acheson-Lilienthal Report? (22) 26-39.

VI. What are the main provisions of the Majority Plan (essentially the American, or Baruch, Plan) for international control? (1) 26-27; (2) 65; (15); (18) 54-64; (22) 43-86.

VII. What are the main provisions of the Russian Plan? (1) 27; (2) 66; (18) 54-64; (22) 87-100.

VIII. What are the areas of agreement and disagreement in the two plans? (1) 27-28; (2) 66; (16); (18) 64-67; (22) 101-113, 123-124.

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss the **need** for international control.
2. List cooperatively on the board, in chronological order, the major steps that have been taken toward international control.
3. Have a panel of three students present the essentials of the Majority Plan, the Russian Plan, and the areas of agreement and disagreement.
4. As alternative to 3, develop on the board an outline (#10 in Student Study Guide Questions) showing areas of agreement and disagreement between the Majority Plan and the Russian Plan for international control.
5. Make assignment for following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 66-76.
2. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 28-30, 16-17.
3. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 7-8.
4. **Comparison of the UN Plan of Control with the Soviet Control Proposals,** Dept. of State (Reproduction).
5. **The Hydrogen Bomb,** DES MOINES REGISTER Reprint.

NOTES:

STUDENT ASSIGNMENT—13th Day

Problem 12. What are the social implications of the atomic age? Part I.

ASSIGNMENT:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 18-24.
2. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 11-13, 32-41, 63-65, 68-76.
3. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 6, 8.
4. **The Hydrogen Bomb,** DES MOINES REGISTER Reprint.
5. **U. S. Atomic Energy Proposals,** (Baruch Report) Dept. of State Pub. 2560, pp. 1-3.
6. **Farm People and the Atom,** David E. Lilienthal (Reproduction).
7. **The Challenge of Atomic Energy,** Crary, Evans, Gotlieb, Light, pp. 36-46.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What are the civil rights enjoyed by Americans today?
2. How may our civil rights be jeopardized if international control of atomic energy fails?
3. How have armaments races in the past affected the American public?
4. How would an atomic armaments race compare with armaments races of the past?
5. What might be the results of mass fear on the part of peoples throughout the world, other than an armaments race, if atomic energy is not internationally controlled?
6. Do we have a moral responsibility to lead in the control of atomic energy?
7. What is social lag?
8. How serious is the social lag? What evidence is there?
9. What social changes are likely to come about through peacetime uses of atomic energy?

THOUGHT QUESTIONS FOR CLASS DISCUSSION:

10. Be prepared to challenge or defend both statements:
    "Why not outlaw the bomb as poison gas was outlawed?"
    "The bomb won't be used in war. It's just like poison gas, all sides were afraid to use it."
11. Be prepared to discuss: "The atomic bomb ended one civilization and created a new one."

NOTES:

TEACHER LESSON PLAN—12th Day

Problem 11. Are we achieving international control of atomic energy?

CONTENT OUTLINE:

I. What are the areas of agreement and disagreement between the Majority Plan and the Russian Plan for international control? (Review).

II. What are some probable reasons for the deadlock? (2) 66-67; (10) 7-8; (18) 64-68;
   A. From the American viewpoint
   B. From the Russian viewpoint

III. What are some of the effects of the deadlock? (1) 16-19; (18) 36-41.

IV. What is the outlook? (2) 67-76; (1) 16-19, 28-30; (18) 67-68; (22) 101-128; "The H-Bomb," **Scientific American,** March, April, May, June, 1950; current magazines and newspapers:
   A. What approach is needed?
   B. What is the effect of Russia's atomic explosion; of the U. S. decision to make the H-Bomb?
   C. Are weapons getting so terrible that nations will be deterred from using them?
   D. Who should determine our policy, e.g., on deciding to make the H-Bomb?
   E. Is world government a part of this problem?

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss content outline. (The situation may change greatly in a short time. Consult current newspapers and magazines.)
2. Try by calm discussion to develop optimism and understanding of the problems rather than fear, hysteria, and a fatalistic attitude.
3. Plan a panel discussion for the following day dealing with the gap between worldwide scientific and social developments.
4. Make assignment for the following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 18-24.
2. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 11-13, 32-41, 63-65, 68-76.
3. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 6, 8.
4. **The Hydrogen Bomb,** DES MOINES REGISTER Reprint.
5. **U. S. Atomic Energy Proposals** (Baruch Report) Dept. of State Pub. 2560, pp. 1-3.
6. **Farm People and the Atom,** David E. Lilienthal (Reproduction).
7. **The Challenge of Atomic Energy,** Crary, Evans, Gotlieb, Light, pp. 36-46. (Must be furnished from Teacher's Kit A.)

NOTES:

STUDENT ASSIGNMENT—14th Day

Problem 13. What are the social implications of the atomic age? Part II.

ASSIGNMENT:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 2, 28-30.
2. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 13-23, 77-83.
3. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 2, 8.
4. **Youth in the Atomic Age,** David E. Lilienthal (Reproduction).
5. **Opportunity and Responsibility in the Atomic Age,** Dr. Robert Bacher (Reproduction), especially the last few pages.

STUDY GUIDE QUESTIONS AND ACTIVITIES:

1. What are the responsibilities of individual citizens in regard to atomic energy?
2. How can citizens become better informed?
3. Why must each citizen do independent thinking concerning atomic energy?
4. Why is open-mindedness especially important in regard to the problems of atomic energy? What are the dangers from lack of open-mindedness?
5. What can we as individuals and as a class do to inform the people of our community about atomic energy?
6. How can we better understand the problems of this atomic age?
7. Why must we continue to keep informed?
8. Make a list of the present and future opportunities in this new field of atomic energy which could affect your future employment.

THOUGHT QUESTIONS FOR CLASS DISCUSSION:

9. Be prepared to challenge or defend: "It's not our business. Leave it to the experts to solve this problem"; "I guess the answer is for all of us to move to the country."
10. What are the implications of the following statement? "Science, which gave us this dread power, shows that it can be made a giant help to humanity, but science does not show us how to prevent its baleful use. So, we have been appointed to obviate that peril by finding a meeting of the minds and hearts of our peoples. Only in the will of mankind lies the answer."—Bernard M. Baruch.
11. How does the following statement apply to the atomic age? "Circumstances are beyond the control of man, but his conduct is in his own power." —Disraeli.

NOTES:

TEACHER LESSON PLAN—13th Day

Problem 12. What are the social implications of the atomic age? Part I.

CONTENT OUTLINE:

I. What will be the results if atomic energy is not internationally controlled? (1) 18-19; (2) 11-13, 32-41, 63-65; (9b); (18) 36-41:
   A. Fear
   B. Armaments race—cost
   C. Effects of secrecy on civil rights

II. What are some of the prospects for the future if atomic energy is controlled? (1) 20-24; (2) 6-11; (17); (18) 41-46.

III. Do we have a moral responsibility to control atomic energy? (2) 63-65, 68-76; (15); (22) 16-18.

IV. How serious is the social lag? (10) 8; (18) 1-11; (20) 1:
   A. What is social lag?
   B. What are some evidences of social lag?

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss the possible social and economic effects of peacetime uses of atomic energy.
2. Compare the World War II armaments race with an atomic armaments race.
3. Discuss the civil rights which may suffer harm from inadequate control of atomic energy.
4. By means of a talk, point out to the students both sides of our moral responsibility to control atomic energy.
5. Following the above talk, call on two students to present the case for and two students to present the case against the proposition, "The U. S. has a moral responsibility to control atomic energy."
6. Have the panel discussion on the gap between scientific and social development, assigned the previous day.
7. Make assignment for the following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. **Atomic Energy, Double-Edged Sword of Science,** Burnett, pp. 2, 28-30.
2. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 13-23, 77-83.
3. **Atomic Energy Education,** SCHOOL LIFE Reprint, pp. 2, 8.
4. **Youth in the Atomic Age,** David E. Lilienthal (Reproduction).
5. **Opportunity and Responsibility in the Atomic Age,** Dr. Robert Bacher (Reproduction), especially the last few pages.

NOTES:

TEACHER LESSON PLAN—15th Day

Problem 14. How can we evaluate this unit?

CONTENT OUTLINE: High Points of the Unit:

I. Scientific fundamentals of atomic energy:
 A. Characteristics and property of matter
 B. Structure of the atom
 C. Relationship of atoms and elements
 D. Relationship of atoms and energy
 E. Significance of nuclear fission
 F. Peacetime applications of atomic energy—agriculture, industry, medicine

II. Fundamental social issues of the Atomic Age:
 A. The destructiveness of the bomb raises the problem of atomic energy control
 B. Present day control of atomic energy in the United States
 C. Problems of government control in the United States
 D. Issues of international control of atomic energy
 E. Significance of atomic energy for the individual

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Develop a cooperative review with the students over the high points of the unit.
2. Administer an examination over the unit. For suggestions on evaluation and suggested test items, see section VII, page 37, of this Teaching Manual.
3. It may be desirable, if time permits, to have the students exchange test papers and correct them in class. This should be accompanied by class discussion.
4. It would be of great value to make a group evaluation of the unit. The discussion should include such questions as:
 a. Do you think a study of atomic energy in high school is worth-while? Is this the right class in which to teach it? What suggestions do you have as to problems to be omitted or added?
 b. Were the materials used interesting, adequate, and readable? How can we systematically collect additional materials?
 c. Did the class activities and procedures work well? What suggestions can we make for teaching this unit to next year's class?
5. If at all possible, an additional day should be devoted to planning specific follow-up activities which your class can organize and carry out. Some suggestions are made in the lesson plan for the 14th day. Additional suggestions are made in section V, page 35, of this Teaching Manual.

NOTES:

TEACHER LESSON PLAN—14th Day

Problem 13. What are the social implications of the atomic age? Part II.

CONTENT OUTLINE:

I. What are the responsibilities of individual citizens? (1) 28-30; (1) 2, 8; (18) 1-11; (20) 1-2, 4:
 A. Be informed
 B. Do independent thinking
 C. Be open-minded

II. What can youth do? (1) 2, 29-30; (2) 13-23, 77-83; (10) 2, 8; (18) 69-78; (20) 11; (23a); (23b):
 A. Understand problems
 B. Interest others in the problems and issues of atomic energy
 C. Keep informed
 D. Be active in discussions and programs
 E. Be aware of opportunities in this new field

TEACHING PROCEDURES AND SUGGESTED ACTIVITIES:

1. Discuss content outline:
 a. Discuss all available sources people can use to become informed and to keep informed about matters pertaining to atomic energy.
 b. Discuss open-mindedness and independent thinking (what they are, how we achieve them, how we recognize people who are open-minded and who think).
 c. Discuss how understanding of the problems of atomic energy can be increased.
 d. Discuss recent information on opportunities in the atomic field for graduating high school students.
2. Have a short written assignment on "Why Individual Action?" or "What Can I Do?".
3. Discuss ways and means of carrying out community projects as part of a follow-up program. Make plans, such as appointing committees, for actually carrying out such projects.
 a. Individual student talks before community organizations.
 b. Panel discussion for parents and other groups during school assemblies and at evening P. T. A. meetings.
 c. Present plays or skits.
 d. Enlist the cooperation of local radio facilities in presenting information to the public.
 e. Write articles (features or editorials) for school publication and local newspapers.
 f. Write to and converse with public officials.
 g. Enlist the services of guest speakers who are qualified authorities, for group meetings.
4. Make assignment for following day.

STUDENT ASSIGNMENT FOR FOLLOWING DAY:

1. Review materials covered in previous fourteen days.

NOTES:

V. SUPPLEMENTARY AND FOLLOW-UP ACTIVITIES

(Some of these activities may be carried out while the unit is being studied, others after the unit is completed.)

1. Demonstrations that may be given by either the students or the teacher:
   a. Physical change—dissolve a salt such as copper sulphate in water.
   b. Physical change—melting of some substance like paraffin.
   c. Physical change—crystal formation from a super-saturated solution.
   d. Chemical change—heat intensely equal parts of powdered zinc and sulfur.
   e. Chemical change—burn a small strip of magnesium ribbon.
   f. Chemical change—the action of an acid on metallic zinc, copper, etc.
   g. Law of electric charges—charge pith balls on an electroscope to show attractive or repulsive forces.
   h. Chemical activity—place a very small piece of metallic sodium in a pan or dish of water. HANDLE WITH CARE!
   i. Chain reaction—the mousetrap demonstration as pictured on page fifteen (15) of **Atomic Energy, Double-Edged Sword of Science,** Burnett.
   j. Chain reaction—the match demonstration as pictured on page ten (10) of **Adventures Inside the Atom,** General Electric Co., Pamphlet.
2. Make a collection of elements for display either to the class or for a bulletin board.
3. Make posters showing the structure of some of the simple atoms.
4. Construct plastocene models of atomic nuclei.
5. Prepare a bulletin board display showing the relationships between Einstein's formula $E = mc^2$ and the release of energy from a small amount of matter. Draw the pictorial concepts.
6. Have a committee collect news items and editorials about atomic energy and post them on the bulletin board or keep a clipping file.
7. Consult one or two newspapers daily for three weeks and read every article concerning atomic energy. Make a list of the "atomic terms" needed to understand these articles. Make a similar list for radio news reports.
8. Have a committee make a systematic check of magazines in the school and public libraries and report to the class as to articles available concerning current developments in atomic energy.
9. Build a model or make a chart illustrating some basic fact or principle about atomic energy. Display it in the hall.
10. Prepare brief biographies of famous people who have been associated with atomic energy development, such as Einstein, Fermi, Urey, Oppenheimer, Compton, Groves, Baruch, Lilienthal, etc.
11. Prepare brief biographies of famous people associated with the scientific discoveries leading up to the development of atomic energy, such as the Curies, Roentgen, Thompson, Chadwick, Rutherford, Soddy, Becquerel, etc.
12. Write an article for the school newspaper on some aspect of atomic energy.
13. Prepare news articles for the local paper, reporting on class activities in learning about atomic energy.
14. Read in an interesting book on some aspect of atomic energy, such as **Hiroshima** by Hersey; **Modern Man is Obsolete** by Cousins; **No Place to Hide** by Bradley; **Must Destruction Be Our Destiny?** by Brown; **Atomic Energy in the Coming Era** by Dietz; **The Atomic Story** by Campbell. Give a brief report or write a brief review of the book.
15. Prepare an oral or written report on one of the following topics:
   a. The Prospects of Power from Atomic Energy.
   b. The Effects of Atomic Radiation on the Human Body.
   c. How Atomic Energy Workers are Protected While Working with Radioactive Elements.
   d. A Brief History of the Atom.
   e. The Cyclotron, Betatron, and Other Modern Atom Smashers.
   f. The Geiger Counter and Its Uses.
   g. The Use of Radioactive Isotopes in one of the following:
      1) Agriculture, 2) Industry, 3) Medicine.
   h. Opportunities for Youth in Atomic Energy.
   i. The Activities of the Atomic Energy Commission.
   j. The Necessity for International Control of Atomic Energy.
   k. Some Suggestions for Improving International Understanding.
   l. Current Events in Atomic Energy.
   m. What Every Citizen Should Know About Atomic Energy.
   n. The Construction and Working of an Atomic Pile.
   o. The Story of Radium.
   p. The Release of Energy by Fusion, or the H-Bomb.
   q. Mining and Processing of Uranium Ore.
   r. Transuranic Elements, or the Work of Glenn Seaborg at the University of California.
16. Arrange with the librarian of the public library to display a collection of readable books on atomic energy, and to have an annotated bibliography available for distribution in mimeographed form. (Perhaps a permanent shelf for atomic energy material can be provided.)
17. Present one or more assembly programs on some phase of atomic energy. This might be a science lecture-demonstration, a panel discussion on peace-time uses of atomic energy or on the problem of atomic control, a debate, a skit, or a series of films on atomic energy. Invite parents to attend this assembly.
18. Present panel discussions, debates, or other kinds of programs on various aspects of atomic energy to adult groups in the community (or over a radio station, if available). Groups which might be interested in such programs include: PTA, League of Women Voters, Kiwanis, Rotary, Lions, church clubs, study clubs, and veterans' organizations.
19. If there is an Adult Evening School in your community, try to work out with them a joint program for presenting some of the facts and implications of atomic energy to adults.
20. Appoint a committee responsible for collecting new materials on atomic energy such as books, pamphlets, magazine articles, films, film strips, exhibits, charts, and recordings. When such materials are free of charge, have the committee write letters and add the materials to the school library.
21. Carry out any other activities, such as those listed in:
   a. **Atomic Energy Here to Stay,** SCHOOL LIFE Supplement, p. 10.
   b. **Atomic Energy, Double-Edged Sword of Science,** Burnett, p. 32.
   c. **Operation Atomic Vision,** Evans, Crary, Hass, pp. 77-81.
   d. **The Challenge of Atomic Energy,** Crary, Evans, Gotlieb, Light, pp. 69-78.

VII. EVALUATION AND TEST SUGGESTIONS

Suggestions for Evaluation

Evaluation of a unit should consist of evaluating both the unit itself and the work of the pupils in the unit. Evaluation cannot consist entirely of tests nor can it be confined to the last day of the unit. It is a continuous process, some part of it being done each day. In evaluating the unit itself, the teacher must consider to what degree the materials, activities, and procedures contributed to the accomplishment of the objectives. One factor affecting this, which should be considered, is the student reaction to the materials, activities, procedures, and problems of the unit. In evaluating the pupil's work, the teacher should consider oral and written reports, participation in class discussion, panel discussions, library reading reports (oral and written), and contributions in those culminating activities that lend themselves to evaluation. Some suggestions which may be helpful in evaluation follow:

1. The teacher should keep anecdotal records as an evaluating device. He should note and retain relevant information about each pupil's study habits, contributions to class discussions, and quality of performance in special assignments.
2. Library readings are perhaps best evaluated by oral reports to the class or teacher, although some form of card report can be used.
3. The teacher may gain additional insight as a basis for making his evaluation by letting the student evaluate the unit. Discuss with the students the following points:
   a. What parts of the unit did you think most worthwhile?
   b. What parts of the unit did you think least successful?
   c. What activities did you like the best? The least?
   d. What changes would you suggest in this unit for another year?
4. On the teacher lesson plans and student assignment sheets you use, write in comments about the success of different procedures. Make notations of possible changes another year. Write in comments of your own about the materials used.
5. File the test items which have proved useful. Try to reword faulty test items while you are still aware of the student reactions.

The tests used in the evaluation of this unit should be based on the objectives of the unit. Several types of tests may be used. Essay tests may effectively be used to evaluate the ability of the student to organize material within a given time; to evaluate the ability to interpret materials and facts and draw conclusions from them; to evaluate the ability to summarize and to express himself clearly. Objective tests are adaptable to testing basic understandings, skills, and attitudes. These tests may be of the true-false, multiple-choice, or matching variety. As a method of combined evaluation, review, and test preparation, the class may be asked to prepare test items to turn in. The value of this procedure is more for review and evaluation, but may be helpful in test construction.

Sample Multiple-Choice Items for a Test Over

THE ATOM AND YOU

Directions: To answer each question, first decide which is the best answer, then place the letter that corresponds with the best answer in the blank preceding the question.

.... 1. What is the major obstacle in developing atomic power for commercial use?
   a) Unsolved technical and engineering problems
   b) Lack of sufficient raw materials
   c) Inability to dispose of radioactive wastes
   d) High cost of atomic fuel

.... 2. What are the most important products of nuclear fission in maintaining a chain reaction?
   a) Electrons
   b) Neutrons
   c) Protons
   d) Alpha particles

.... 3. Why is uranium 238 important in atomic energy production?
   a) It undergoes fission and emits protons
   b) It may be changed into U-235 in an atomic pile
   c) It may be used in place of graphite in constructing an atomic pile
   d) It may be changed into plutonium

.... 4. Which best illustrates the most important knowledge we have obtained by using atomic energy in agricultural research?
   a) Plant growth is greatly stimulated by radioactive fertilizers
   b) Certain methods using fertilizers are more efficient than others
   c) Radioactive fertilizers are damaging to all plant life
   d) Twenty per cent of the phosphorus which a plant utilizes is furnished by commercial fertilizers

.... 5. In what way has atomic energy contributed most to medicine?
   a) It has enabled physicians to cure cancer
   b) It has provided remedies for tuberculosis and heart disease
   c) It has greatly stimulated medical research
   d) It has been effective in diagnosing diseases of the endocrine glands

.... 6. Which is the best description of a molecule?
   a) Two or more atoms physically united to form a mixture
   b) Two or more atoms united to form a chemical compound
   c) Several atoms chemically united in a chain to form a compound
   d) More than one atom bound together to form a new material

.... 7. Which statement about electrons is most nearly correct?
   a) They exist only in the shells of atoms.
   b) They have a charge equal in magnitude to that of a proton
   c) They are negative units of matter having no weight
   d) They are small, light, positive charges of matter

.... 8. Which of the following statements is **least related** to the others?
   a) Atomic weights are average weights
   b) Some atoms weigh more than others of the same element
   c) Atoms combine in ratio to their atomic weights
   d) Atoms of hydrogen with different weights are called isotopes

VI. SUGGESTED AUDIO-VISUAL AIDS

Films

1. **The Molecular Theory of Matter,** Encyclopedia Britannica Films, Inc.
   The film shows molecular activity in gases, liquids, and solids, and explains diffusion of gases, evaporation of liquids, and transformation of liquids into solids. Presented in the film is a microscopic view of Brownian movement. (One reel—11 minutes)
2. **Atomic Energy,** Encyclopedia Britannica Films, Inc.
   The film identifies atomic structure, outlines mass-energy relationships, and defines chemical and atomic energy. Explanations for the forms of atomic energy release are presented as are illustrations of atomic fission and the chain reaction. (One reel—11 minutes)
3. **Matter and Energy,** Coronet Productions
   The film pictures the different forms of matter, and discusses pictorially—elements, compounds, physical and chemical change. A brief discussion of atomic energy is included in the film. (One reel—11 minutes)
4. **Atomic Power,** March of Time
   The film provides a good description of the historical events leading to atomic fission and atomic bomb development. Included is a discussion of atomic fission and the resulting energy release. (One reel—17 minutes)
5. **Report on the Atom,** March of Time
   Although the film gives little attention to the destructive aspects of atomic energy, it provides an excellent treatment of the problems concerned with man's attempt to harness the atom for peacetime uses, and it pictures effectively the different uses of radioactive materials in medicine, industry, agriculture and biology. (One reel—20 minutes)
6. **One World or None,** Film Publishers
   Emphasized in this film are the needs for international control, lack of defense against the atomic bomb, and the horrors of modern warfare. The highlights of the film are centered around world government. (One reel—9 minutes)
7. **Tale of Two Cities,** Army Signal Corps
   This film presents the destructive results of the bombing of Hiroshima and Nagasaki. Many close-up shots that show the effect of the blast and radiation on buildings and materials are included. (Free rental—one reel—20 minutes)
   Available from Signal Corps Film Libraries at Governor's Island, N. Y.; Post Office Building, Baltimore, Md. and Atlanta, Ga.; Fort Sam Houston, San Antonio, Texas; Civic Operations Building, Chicago, Ill.; Presidio of San Francisco, Calif.; Fort Meyer, Va.; and Fort Riley, Kansas.
8. **The Church in the Atomic Age,** Produced by RKO Pathe for the Federal Council of Churches of Christ in America. (New title: **The Atom Bomb—Right or Wrong?**)
   This is one of the two best films available (along with **One World or None**). Factually and unemotionally, it develops its conclusion that any future war will bring not a solution to a problem but only incomparably greater problems; that modern techniques as never before make war itself impossible to condone; and that the individual's responsibility for working to prevent war is inescapable. It is fast-paced, interest-holding, with a strong appeal to any general audience and not merely to church groups. Motion Picture Association of America, 28 W. 44th St., New York, N. Y. (One reel—19 minutes)

Filmstrips and Charts

1. **Atomic Energy**
   A general overview of the scientific principles of atomic energy, the bomb, isotopes, atomic control, and peacetime uses. Useful as a review. Available from **The New York Times,** School Service, Times Square, New York. $2.00. (including script).
2. **The Atom at Work** (color)
   Summarizes the peacetime uses of atomic energy in industry, agriculture, medicine and biology, and power. 35 mm. Society of Visual Education, Inc., 1345 W. Diversey Ave., Chicago 14, Ill. $6.00. (including script).
3. **Let's Look at the Atom** (color)
   Presents the basic information on atoms and energy. Drawings and photographs and everyday analogies are used. 35 mm. Society of Visual Education, Inc., 1345 W. Diversey Ave., Chicago 14, Ill. $6.00. (including script).
4. **How to Live With the Atom**
   Excellent introductory filmstrip; amusing pointed cartoons. 35 mm. Comes with narrator's script and a good discussion outline. Film Publishers, Inc., 25 Broad St., New York 4, N. Y. $3.00. (including script).
5. **One World or None**
   Filmstrip version of motion film noted above. 35 mm. Film Publishers, Inc., 25 Broad St., New York 4, N. Y. $3.00. (with script).
6. **World Control of Atomic Energy**
   Cartoon filmstrip that discusses in more detail the setting up of an international atomic control agency. Included are the elements of the original United States and Russian positions (since somewhat modified), which discussion should bring up to date. Film Publishers, Inc., 25 Broad St., New York 4, N. Y. $3.00. (including script).
7. **The Atom**
   A simple and understandable explanation of the structure and behavior of the atom to accompany the LIFE Reprint. LIFE Filmstrips, 9 Rockefeller Plaza, New York 20, N. Y. $4.50. (including script).
8. **Nuclear Physics Charts**
   A set of six 25 x 37 inch wall charts in color, with accompanying booklet. Westinghouse School Service, Westinghouse Electric Corporation, 306 Fourth Ave., P. O. Box 1017, Pittsburgh 30, Pa. (1948) $1.00.

ADDITIONAL AUDIO-VISUAL AIDS are listed in:
   (a) **Atomic Energy Here to Stay,** SCHOOL LIFE Supplement, pp. 12-13.
   (b) **The Challenge of Atomic Energy,** Crary, Evans, Gotlieb, Light, pp. 79-85.
   (c) **Operation Atomic Vision,** Evans, Crary, Hass, pp. 92-94.

SOME SOURCES OF AUDIO-VISUAL AIDS:

1. Encyclopedia Britannica Films, Inc., 20 N. Wacker Drive, Chicago 6, Ill.
2. March of Time Forum Films, 369 Lexington Ave., New York 17, N. Y.
3. Bureau of Audio-Visual Instruction, Extension Division, S. U. I., Iowa City, Iowa.
4. Audio-Visual Aids Dept., Iowa State College, Ames, Iowa.
5. Film Publishers, Inc., 25 Broad Street, New York 4, N. Y.
6. Society for Visual Education, Inc., 1345 West Diversey Ave., Chicago 14, Ill.

...... 9. Which statement about atomic nuclei is correct?
  a) They always carry a positive charge
  b) They contribute very little to the weight of the atom
  c) They contain one or more neutrons
  d) They are mainly responsible for the chemical activity of the atom

...... 10. Which best describes the meaning of atomic weights?
  a) They are relative weights based on the weight of an oxygen atom
  b) They are the weights, expressed in grams, of equal volumes of the elements
  c) The weights of all atoms are based on the fact that the weight of helium is one (1)
  d) They indicate the different weights of the isotopes for any one element

...... 11. How does diffusion support the molecular theory of matter?
  a) It shows that molecules of one substance are unlike those of any other substance
  b) It shows that molecules have energy of motion
  c) It shows that matter is electrical in nature
  d) It shows that molecules are composed of atoms

...... 12. Which definition do you think **best describes** an atom?
  a) It is the basic unit of electricity
  b) It is one of the basic electrical units of matter
  c) It is a particle that cannot be divided into smaller units
  d) It is the smallest chemical unit of matter

...... 13. What is the significance of atomic numbers?
  a) They indicate the total electrical charge on an atom
  b) They show the negative charge on the nucleus of an atom
  c) They show the positive charge on the nucleus of an atom
  d) They show the electrical charge on the outer orbit

...... 14. Which statement about valence do you consider **least** appropriate?
  a) Any one valence indicates the pattern by which elements may combine
  b) Atoms have valence which indicates how they combine with other atoms
  c) Valence indicates the combining power of molecules
  d) Valence shows an electron transfer or partnership

...... 15. Which of the following pairs represents one and the same thing?
  a) Gamma rays and heat
  b) Proton and helium nucleus
  c) Alpha particles and protons
  d) Beta particles and electrons

...... 16. If an element has an atomic number of two (2) and an atomic weight of four (4), what would be its structure?
  a) Four nuclear protons and four orbital electrons
  b) Four nuclear neutrons and four orbital electrons
  c) Two nuclear protons, four nuclear neutrons and two orbital electrons
  d) Two nuclear protons, two nuclear neutrons and two orbital electrons

...... 17. In ordinary chemical reactions, what part of the atom is actively involved?
  a) All of the atom
  b) Only the outer electrons
  c) The outer electrons and the nuclear protons
  d) Only the nucleus

...... 18. Which of the following statements about electrons is true?
  a) All electrons are alike
  b) Electrons in one substance may differ from those in another substance
  c) The electrons found in any one atom are alike; those in different atoms are different
  d) Electrons are found in everything having mass

...... 19. What is the greatest disadvantage of using an alpha particle as a "bullet" for splitting an atom?
  a) Its speed and direction are too erratic
  b) It is repelled by positive charges
  c) It cannot be properly slowed down
  d) It is composed of two electrons and is therefore too light

...... 20. What happens to a radium atom when it decomposes spontaneously?
  a) The nucleus is split into equal parts and a comparatively large amount of energy is released
  b) Alpha and beta particles are given off and a comparatively small amount of energy is released
  c) Only small pieces of the nucleus are broken off and no energy is released
  d) The nucleus remains whole but alpha particles are given off

...... 21. What is the most revolutionary feature of the Atomic Energy Act of 1946?
  a) It gives to a governmental commission authority to let contracts without consulting Congress
  b) It provides for the manufacture of atomic bombs by civilians
  c) It provides for public ownership of a large industry
  d) It requires an independent governmental commission to make frequent reports on its activities to Congress

...... 22. What is the chief function of the Joint Congressional Committee on Atomic Energy?
  a) To give final approval to contracts let by the U. S. Atomic Energy Commission
  b) To submit to the President names of persons recommended for appointment to the U. S. Atomic Energy Commission
  c) To hold hearings and investigations on matters of security within the atomic energy program
  d) To make studies of the activities and problems of the U. S. Atomic Energy Commission

...... 23. What was the main reason why Congress decided on governmental control of atomic energy in the United States?
  a) Speed up basic atomic research
  b) Prevent private companies from making large profits in this new field
  c) Provide for our national security
  d) Prevent waste of scarce uranium supplies

...... 24. How many members are there on the United States Atomic Energy Commission?
  a) 3
  b) 5
  c) 9
  d) 18

...... 25. Which of the following represents most nearly the present annual budget, in dollars, of the U. S. Atomic Energy Commission?
  a) One million
  b) Ten million
  c) One hundred million
  d) One billion

...... 26. Where does the U. S. Atomic Energy Commission get the money to carry on its activities?
  a) From private companies working under contract with the Commission
  b) From the U. S. Department of Defense
  c) From appropriations made by Congress
  d) From companies, institutions, and individuals who purchase the materials produced in the Commission's plants

...... 27. What is the chief activity of the United States Atomic Energy Commission at the present time?
  a) Making atomic bombs
  b) Producing atomic power
  c) Doing basic research on the atom
  d) Manufacturing and distributing radioactive isotopes

...... 28. Radioactive isotopes are sold by the A. E. C. and shipped from the plant at:
  a) Oak Ridge
  b) Los Alamos
  c) Washington
  d) New York

...... 29. Concerning which of the following is secrecy about the atomic bomb most important to our national security?
  a) Basic principles only
  b) Engineering details only
  c) All matters concerning the bomb
  d) The location of our chief atomic energy plants

...... 30. What is the chief reason why secrecy is considered harmful to scientific progress?
  a) It prevents work on many projects which by their very nature cannot be kept secret
  b) It increases the cost of research because the laboratories must have many guards
  c) It discourages scientists from doing their best work because they will not receive publicity or credit for their achievements
  d) It prevents workers in the same field from making use of the discoveries of others

...... 31. Which of the following is most important for our national security, according to the U. S. Atomic Energy Commission?
  a) Greater scientific leadership and achievement than that of other countries
  b) Complete secrecy on all atomic matters
  c) Sharing of all atomic secrets with our World War II allies other than Russia
  d) Development of a powerful force of large planes for carrying the increased number of A-bombs now on hand

...... 32. Judging by present experiments with atomic power, which of the following seems **most likely** to occur?
  a) The cost of all other forms of power will be greatly reduced to meet competition
  b) Electricity and steam will, in time, be largely replaced by atomic power
  c) Atomic power will be used for many purposes by countries having no coal or oil, but for only certain major installations in other countries
  d) There will never be much use made of atomic power because it is too dangerous and expensive

...... 33. For what purpose was the United Nations Atomic Energy Commission established?
  a) To administer the international atomic control organization that was expected to be set up
  b) To study the atomic energy control problem and make reports to the Security Council
  c) To advise the Atomic Energy Commissions of the separate member nations on common atomic problems
  d) To supervise the international distribution of radioactive isotopes for research purposes

...... 34. Which of the following countries was made a member of the United Nations Atomic Energy Commission, principally because of its large uranium deposits?
  a) Canada
  b) Mexico
  c) Brazil
  d) Norway

...... 35. In which of the following will you find the United States proposals for international control of atomic energy?
  a) Acheson-Lilienthal Report
  b) Baruch Report
  c) Manhattan Project Report
  d) Smyth Report

...... 36. Which of the following is the **most important** reason why international control of atomic energy is needed?
  a) With international control, secrecy in atomic research will no longer be needed
  b) With international control, there will be a more rapid development of beneficial uses of atomic energy
  c) Without international control, nations will continue to make and stockpile atomic bombs
  d) Without international control, the cost of our domestic atomic energy program will continuously increase

...... 37. What has been an important effect of the failure of the Western nations and Russia to reach an agreement regarding control of atomic energy?
  a) An armaments race is occurring
  b) There has been complete suspension of atomic energy discussions among the United Nations
  c) Preparations are underway for a meeting of the chief executives of the United States, Great Britain, and Russia
  d) Atomic research is practically at a standstill

KEY TO TEST ITEMS

1. a
2. b
3. d
4. b
5. c
6. b
7. b
8. c
9. a
10. a
11. b
12. d
13. c
14. c
15. d
16. d
17. b
18. a
19. b
20. b
21. c
22. d
23. c
24. b
25. d
26. c
27. a
28. a
29. b
30. d
31. a
32. c
33. b
34. a
35. b
36. c
37. a
38. b
39. d
40. d
41. a
42. b
43. c
44. d
45. a

...... 38. In the United Nations discussions concerning international control of atomic energy, there has been **most** agreement on which of the following aspects of the problem?
- a) Regular inspection of all atomic energy activities in each country
- b) The need for international control of atomic energy
- c) Suspension of the veto power when discussing atomic energy matters
- d) A timetable for destroying existing atomic bombs

...... 39. In the United Nations discussions concerning international control of atomic energy, there has been **least** agreement on which of the following aspects of the problem?
- a) The need for international control of atomic energy
- b) Outlawing atomic bombs as a weapon of war
- c) Inspection of the atomic activities carried on by each country
- d) Provisions for punishment of violators of whatever control agreement is put into effect

...... 40. Which of the following is considered by most observers to be the **least** important reason for the failure of the United States and Russia to agree on the international control of atomic energy?
- a) Mutual fear and distrust
- b) Extreme nationalism
- c) Failure to agree on other major world problems
- d) The warlike nature of the Russian people

...... 41. In which instance would the explosion of an atomic bomb devastate the largest area of a city? If it were detonated:
- a) In the air
- b) On the ground
- c) In an adjacent body of water
- d) Underground

...... 42. What is the source of injury from an atomic bomb explosion, which is not found in a demolition bomb explosion?
- a) Heat
- b) Radiation
- c) Blast
- d) Flying fragments

...... 43. At the present time, what seems to be the best plan of defense against an atomic bomb attack for a city?
- a) Provide shelter for all the people outside the city limits
- b) Rebuild everything on the surface of the ground with reenforced steel and concrete
- c) Disperse important industries and offices of the city to outlying areas
- d) Set up powerful defensive weapons around the city to discourage attack

...... 44. What is the best clothing protection from flash burns of an atomic explosion?
- a) Dark cloth, loose clothing
- b) White cloth, tight clothing
- c) Dark cloth, tight clothing
- d) White cloth, loose clothing

...... 45. Which of the following body parts would probably suffer the heaviest damage from external radiation exposure?
- a) Lining of the small intestines
- b) Muscles
- c) Nerves
- d) Liver

VIII. RECOMMENDED BOOKS, PAMPHLETS, DOCUMENTS, AND MAGAZINES ON ATOMIC ENERGY FOR THE SCHOOL LIBRARY

The total cost of all materials listed is approximately $25.00, with school discount. All materials listed under #1 may be purchased for $5.00; the combined #1 and #2 lists for $10.00; and the combined #1, #2, and #3 lists for $15.00.

1. **Books, Pamphlets, and Documents ($5.00 purchase):**
   - Bradley, David, **No Place to Hide,** Bantam Book edition, 1948. 25¢
   - Dietz, David, **Atomic Energy in the Coming Era,** Pocket Book edition, 1945. 25¢
   - Stout, W. W., **Secret,** Detroit, Michigan: Chrysler Corp., 1947, 79 p. Free
   - Bush, Vannevar, **Modern Arms and Free Men,** New York: Simon and Schuster, 1950. $1.00 edition, paper
   - Gotlieb, Albert, **Achieving International Control of Atomic Energy—Critical Thinking for a New Age,** New York: Bureau of Publications, Teachers College, Columbia U., 1947, 66 p. 75¢
   - Higinbotham, W., and Lindley, E. K., **Atomic Challenge,** New York: Foreign Policy Association (Headline Series No. 63, May-June 1947), 63 p. 35c
   - Lerner, Max, **World of the Great Powers,** Foreign Policy Association, 22 E. 38th St., New York 16 (Headline Series No. 61, Jan.-Feb. 1947), 94 p. 35c
   - **The Politics of Atomic Energy,** Woodrow Wilson Foundation, 45 E. 65th St., New York 21, 1946, 56 p. 25¢
   - ***Sixth Semi-Annual Report of the AEC** (Atomic Energy and the Life Sciences) 45¢
   - ***Seventh Semi-Annual Report of the AEC** (Atomic Energy and the Physical Sciences) 50¢
   - ***Eighth Semi-Annual Report of the AEC** 50¢
   - ***Atomic Impasse,** 1948, 48 p. 15¢
   - *Smyth, Henry D., **Development of Methods for Using Atomic Energy for Military Purposes** (The Smyth Report), 1947, 182 p. 40c
   - ***Handling Radioactive Wastes in the Atomic Energy Program,** 1949, 30 p. 15¢
   - ***Medical Aspects of Atomic Weapons,** 1950, 24 p. 10¢

2. **Books, Pamphlets and Documents** (if purchased with #1, total $10.00):
   - Cousins, Norman, **Modern Man is Obsolete,** New York: Viking Press, 1946, 59 p. $1.00
   - Masters, Dexter, and Way, Katherine (eds.), **One World or None,** New York: McGraw-Hill, 1946, 79 p. $1.00
   - Potter, R. D., **Young People's Book of Atomic Energy,** New York: Robert M. McBride and Co., 1948. $2.50
   - Swing, Raymond, **In the Name of Sanity,** New York: Harper and Brothers, 1946, 116 p. $1.00

3. **Books, Pamphlets and Documents** (if purchased with #1 and #2, total $15.00):
   - Brown, Harrison, **Must Destruction Be Our Destiny?** New York: Simon and Schuster, Inc., 1946, 159 p. $2.00
   - Lapp, R. E., **Must We Hide?** Cambridge, Mass.: Addison-Wesley Press, 1949. $3.00
   - ***Atomic Energy Development,** 1947-1948. 45¢
   - ***Recent Scientific and Technical Developments in the Atomic Energy Program of the U. S.,** 1948, 192 p. 35¢
   - ***International Control of Atomic Energy—Growth of a Policy,** Dept. of State Publication #2702, 281 p. 45¢
   - ***International Control of Atomic Energy—Policy at the Crossroads,** Dept. of State Publication #3161, 251 p. 45¢

4. **Books, Pamphlets and Magazines** (which complete the total $25.00 purchase. Includes all listed materials in #1, #2, #3, #4)
   - Eidinoff, M. L. and Ruchlis H., **Atomics for the Millions,** New York: McGraw-Hill, 1947, 281 p. $3.50
   - Campbell, John W., **The Atomic Story,** New York: Henry Holt, 1947, 297 p. $3.00
   - Lang, Daniel, **Early Tales of the Atomic Age,** Garden City, New York: Doubleday and Co., 1948, 223 p. $2.75
   - Laurence, William L., **Dawn Over Zero,** New York: Knopf, 2nd ed., 1947. $3.00
   - **Bulletin of the Atomic Scientists,** 53 W. Jackson Blvd., Chicago 4, Ill. Monthly. $5.00 per year.

*Materials available from Superintendent of Public Documents, Government Printing Office, Washington 25, D. C.

IX. APPENDICES

APPENDIX A: SUMMARY OF THE KINETIC MOLECULAR THEORY OF MATTER

1. All matter is made up of extremely small particles called molecules.
2. Molecules have mass and weight.
3. Molecules are not packed close together; but rather, they have space between them.
4. The space between molecules is related to density and the states of matter. The more dense a substance is the less space there is between its molecules. Gases have the most space between their molecules, liquids less space and solids the least of all.
5. All the molecules of any one substance are alike while the molecules of different substances are different.
6. The molecules of all matter are constantly in rapid motion. In gases the speed of movement is tremendous, in liquids the speed is reduced, while in solids, the movement may best be described as a slight vibration.
7. The large molecules (those with the most mass) move more slowly than do the small ones. The speed of movement varies inversely with the mass. In other words, the molecules of a heavy gas travel more slowly than do those of a light gas.
8. Sometimes the speed of molecules in liquids and gases becomes great enough so that the molecules at the surface can overcome the cohesive forces holding them together and they fly off into space. This is represented by evaporation and boiling.
9. Since molecules are constantly moving they must run into each other and also the walls of any vessel in which they are contained. This striking force is what causes the pressure of an enclosed gas to be exerted on the sides of the container.
10. When any gas is compressed or made more dense there are more molecules per unit volume and therefore the number of collisions increases. In other words, when a gas is compressed, its pressure increases.
11. When any substance is heated, energy is added to it and this addition is evidenced by an increase in the speed of the moving molecules. When a body of matter is cooled, the speed of its component molecules is decreased.
12. When the molecules making up a substance are moving fast the temperature of that substance is high and when the molecules are slowed down the temperature of that substance decreases.
13. When molecules collide the motion of any one molecule may be transferred to another; however, the total kinetic energy after the collision is the same as the original.

APPENDIX B: DEMONSTRATIONS FOR PROBLEM NO. 1

1. **Demonstration of Diffusion:**
   a. Potassium permanganate ($K\ Mn\ O_4$) in water:
   Drop a few crystals of potassium permanganate ($K\ Mn\ O_4$) into a tall beaker or cylinder of water. (Drops of dye or India ink may be used in place of the potassium permanganate.) Let stand until the dye spreads throughout the liquid.

   b. Bromine vapors in air:
   Pour one or two drops of liquid bromine into a tall cylinder and observe what happens. The upward diffusion of the bromine vapor is accomplished even though the bromine is about five times as heavy as air.

2. **Demonstration of Space Between Molecules (Water and Alcohol Combined Volume):**
   a. First suggested method:
   Obtain a piece of glass tubing of about one-fourth (¼) inch inside diameter and one meter in length. Stopper one end tightly. Fill the tube to one-half (½) its length with water and then carefully pour in alcohol **without mixing** until the tube is filled. Close top of tube with finger. Invert tube several times, being careful not to spill any of the mixture. Compare total volumes of the two liquids **before** and **after** mixing.

   b. Second suggested method:
   Obtain a tall 1000 cc. glass graduated cylinder and pour in water to the 500 cc. level. Then add exactly 500 cc. of alcohol and mix the two liquids thoroughly. Read the combined volume level.

3. **Demonstration of Molecular Motion:**
   a. Materials:
   (1) Molecular demonstration apparatus, or—

   (2) Test tube (1 inch in diameter) with one-hole rubber stopper to fit. Mercury (small amount). Small fragments of colored glass. Vacuum pump. Bunsen burner. Rubber tubing (2 or 3 feet). Glass tubing (8 cm.)

   b. Directions:
   Warm over a Bunsen flame a test tube containing about ½ to 1 inch of mercury with the colored glass particles floating on top, the mercury and colored glass particles being sealed in or maintained under a partial vacuum.

4. **Demonstration of States of Matter:**
   a. First suggested method:
   The easiest method of showing the three basic states of matter is with solid ice, liquid water and gaseous steam. Any freezing mixture such as ice and salt or dry ice and acetone will freeze water in the laboratory. The dry ice and acetone gives a very low temperature and is the quickest method to use. For every 4 ounces of crushed dry ice in a beaker, pour in 2 ounces of acetone. **Avoid any personal contact with the mixture.** The presence of steam can readily be shown by holding a cold object above a container of boiling water.

   b. Second suggested method:
   Use mercury instead of water. The dry ice and acteone mixture will freeze mercury readily. Mercury vapor may be obtained by heating a **very small amount** of mercury in a test tube. The tube if heated only at the bottom will show the mercury condensing in small droplets near the mouth of the tube. **Avoid inhaling the mercury vapor as prolonged exposure causes mercury poisoning.**

5. **Demonstration of Brownian Movement:**
   a. First suggested method:
   Secure a standard Brownian movement apparatus and fill the smoke chamber with match or cigarette smoke. Place the chamber with the thin glass plate up so it can be viewed with the high power of a microscope. Shine a strong light (a pencil flashlight will do) through the lens on the side of the chamber. Each smoke particle will appear as a bright point source of light.

b. Second suggested method:

Another method is to place a small bit of titanium oxide (powder) on a drop of water on a slide. View with the high power of a microscope and observe the movements of the small particles of oxide.

APPENDIX C: ATOMIC WEIGHT SUPPLEMENT

The atomic weight of an element is a number that gives the weight of an atom of that element as compared to the weight of an oxygen atom which is 16.0000. Most non-technical accounts of atomic energy give hydrogen (symbol H) as being the standard on which our system of atomic weights is based. This is not exactly correct, but is an approximation.

Oxygen was chosen as the standard upon which our system of weights is based because of its abundance in nature and willingness to react with other elements. The figure 16.0000 was arbitrarily selected as a matter of convenience so that the lightest element known (hydrogen, H) would be at least a whole number.

APPENDIX D: DEMONSTRATION FOR PROBLEM NO. 4

DEMONSTRATION OF SPONTANEOUS RADIOACTIVITY:

Observe a luminous clock or watch dial under a microscope or hand lens of sufficient power to see minute flashes of light. (There is a trace of radium mixed with a fluorescent material, such as zinc sulfide, in the paint used on such dials.)

Demonstrate Geiger counter if available.

APPENDIX E. THE PEACETIME APPLICATIONS OF ATOMIC ENERGY

More than five years have passed since Hiroshima and Nagasaki were reduced to ashes. Shortly after the world realized that modern science could release atomic energy, journalists, in imagination, had crowded the highways with automobiles powered by atomic energy, filled the air with planes similarly propelled, and envisioned entire cities deriving their power from a couple of ounces of uranium. Moreover, trips to the moon, in atomic powered rockets, were being planned by some adventurous science writers while others had visions of producing crops, with the aid of atomic fertilizer, that would make Jack's wondrous beanstalk look undernourished.

The time has most certainly come when well-informed Americans should be able to differentiate between fact and fancy with respect to the peacetime applications of atomic energy. Basically, the constructive uses of atomic energy appear most promising in two respects. One is the use of atomic radiation in finding out more about the physical world, about living organisms and the biological processes—those things upon which industry and human health are built. The other use is in the development of an entirely new source of energy.

—In Medicine:

In the course of unlocking the secrets of the atom, man has acquired new and powerful techniques with which to study disease, and to attack some of the plagues that have burdened mankind for many centuries. This important search began shortly after the discovery of X-rays and the isolation of radium. A recent invention known as the cyclotron has furnished us with a powerful source of high speed particles that can be applied to medical research, diagnosis and treatment.

The development of atomic piles has now provided us with a twofold supply of riches. Neutrons, in hitherto undreamed of number, will be available both for direct therapy and for the production of many different man-made radioactive atoms. With these great assets stemming from the harnessing of atomic energy, we may look forward hopefully to rewards that will far outweigh the unfortunate and destructive potential of atomic bombs.

Before we consider in some detail the role of atomic energy in modern medicine, let us review some important biological facts. All living things are composed of cells, and these cells vary enough in their size, shape and behavior to accomplish all the manifold functions of the living organisms that inhabit the earth. Regardless of their diverse functions, all cells are constructed according to pretty much the same plan. Within the body of man, the small, rapidly reproducing blood cells bear no external resemblance to the thread-like, long-lived nerve cells. Nor do they resemble the muscle cells that provide mechanical energy. Yet all these cells contain the same elemental materials, arranged in similar basic patterns.

In the rapid and continuous process of life—in the building up and breaking down of tissue, the replacement of nutrients and removal of wastes, the production of muscular energy, the reproduction of the whole organism—the complex, living molecules break up and recombine in a multitude of ways. Yet always, they combine in ways that preserve their electrical balance. To destroy that balance would be to damage or kill the living material. This is exactly what radiation does. Excessive amounts of radiation from radioactive materials attack, disrupt and destroy the delicate balance in the atoms, molecules and protein combinations within the bodies of living things. As a result, it damages and kills the cells of which those atoms and molecules are a part. If enough cells are destroyed, the whole organism is severely injured and dies.

Since all living things are made up of molecules, and since radiation apparently can damage any molecule, the effects of radiation on life are varied and extensive. Some injuries, such as skin burns, seem relatively simple, but repeated damage of this kind can result in cancer. Other radiation damage is much more subtle. Gamma rays or neutrons emitted by radioactive elements accidentally taken into the body may prevent the production of blood cells, or damage the intestine or the reproductive organs. Radiation most centainly can alter the functioning of the complex protein molecules called enzymes. Although not too much is known about them, enzymes probably govern and assist the many biochemical activities in our bodies.

High energy radiations, in addition to causing burns and radiation illness, may result in changes in the cellular material which governs heredity in people, animals and plants, and thus cause changes in the characteristics passed from one generation to the next. Not all of these effects are harmful—some, such as changes in corn for example, may be used to improve yields, food quality and disease resistance of hybrid varieties. At the present time, however, man does not know how to control the radiation so it will produce the effects he desires; he must take the bad with the good.

We know that higher plants and animals develop within the nuclei of their germ cells, tiny units (probably protein in nature) called **genes**, and these genes are arranged along rod-like bodies called chromosomes. Each kind of plant or animal has a set number of chromosomes in its cells. Geneticists believe that each of the 10,000 or more genes in a human cell is unique and that each performs a special job in the development of functions of the body. The precision with which

genes normally duplicate themselves during cell division is one of living matter's greatest achievements. Recognizable deviations from the normal occur less than one time in a million. However, such changes do occur, and they are known as **mutations**—be they favorable or unfavorable.

As a result of intensive research, it has been determined that high energy radiation may produce genetic effects in living cells in three ways:

(1) Indirectly through the production of substances that have secondary genetic effects. For example, X-rays produce hydrogen peroxide which is poisonous in living cells.

(2) Through direct effects on such organic molecules as the genes. Direct ionization of the molecules is probably the chief effect of radiation. This will result in breaking chemical bonds, which no doubt permanently alter genes.

(3) Through the breaking of chromosome threads.

A knowledge of these facts has necessitated the utmost precautions on the part of all persons who are concerned with any of the various aspects of atomic research.

However, not only has the atomic age brought with it new and urgent reasons for investigating the subtlest of life processes; it has also given us a new and powerful tool for their study—the radioactive isotope—an aid to medical research comparable to the discovery of the microscope.

The abnormal growth of tissue that we refer to as cancers or tumors have plagued man throughout the pages of recorded history. Today over 200,000 people die of cancer each year in our own United States. In other words, it accounts for almost ten percent of deaths. The cause of cancer as well as its very nature are still unknown. We do know that in cancerous tissues there appears to be an uncontrolled growth of cells causing serious interference with the normal processes and functions of the organ in question. The problem, therefore, is to find out exactly how the body builds cells normally, and then to detect when that process breaks down in cancerous formations. Radioactive tracers are the best tools yet found for this research.

Let's consider a specific example which illustrates the use of radioactive materials in attempting to get at the cause of cancer formations. Concerning cancer of the liver, the following facts have been known for sometime:

(1) When the liver is damaged it sometimes accumulates fat until it becomes considerably enlarged.

(2) A fatty liver is likely to develop cancer.

Armed with these facts, medical research men have induced liver damage in experimental animals and have then injected them with radioactive phosphorus. (Phosphorus plays an important role in the normal liver's conversion of fat into energy.) By comparing the use of phosphorus by normal and fatty livers, investigators hope to get down to the truth of the relationship between diet and the formation of liver cancer.

At the present time, radioactive tracer elements are being used to a limited extent in diagnosing cancerous conditions. The University of Minnesota has reported success in diagnosing brain tumors by combining radioactive iodine with a dye which tends to collect in cancer tissue. This dye combination is injected into the patient's veins. In a few minutes the blood has carried it to the brain. The Geiger counter, picking up the tell-tale radiation from the iodine, locates the dye. Any abnormally large concentration of the material is indicative of a brain tumor.

Radioactive iodine has also been used with success to find bits of thyroid cancer which have broken away from the original cancer mass. After a cancerous thyroid has been removed by surgery these scattered bits of cancer tissue sometimes begin to pick up large amounts of iodine from the blood. Radioactive iodine concentrated in them can be found with the Geiger counter, and these small growths removed. A similar technique involving the use of radioactive phosphorus has been used to diagnose cancer of the breast.

Unlike external cancers, deep-seated cancers such as those of lung, stomach, pancreas and intestine, are usually detected at such an advanced stage that only a small fraction of them have yielded to treatment. With increased supplies of radioactive materials available for medical research, it is hoped that some readily applied tests will be discovered that will give us suitable warning at an early stage so as to make early diagnosis and treatment of these cancers possible.

The value of radioactive material goes beyond its use in diagnosing cancerous conditions. When these materials will concentrate in cancer tissue we can use them for actual treatment as well as diagnosis. We know that the rays they produce will kill cancer cells. The problem in this connection is to have them absorbed by the abnormal tissues in order to attack them from within. Thus, there would be far less exposure of normal tissue to the atomic rays and much less chance of injuring the patient's general health than is involved in using X-rays or radium.

To date, only radioactive iodine has proved significant in the internal approach to cancer treatment. Because it naturally collects in the thyroid gland, its rays have effectively checked the growth of one form of thyroid cancer. This treatment has resulted in remarkable improvement in some of the cases. Since thyroid cancer is itself quite rare, this singular success makes but a little dent in the total problem, but it does show enough results to spur scientists on in their search for other tracers that will concentrate in the more common forms of cancerous tissues.

Radioactive phosphorus is being used in experiments with cancers of the breast, brain, bone marrow, stomach, kidneys, heart and liver. It first attracted attention as a treatment for leukemia, in which the body produces an oversupply of white blood cells; and in polycythemia vera, in which an oversupply of red blood cells is manufactured. Leukemia has often been called the cancer of the blood, since it too is caused by some strange upset in the body's ability to control cell manufacture. Both red and white blood cells are formed in the bone marrow. Scientists seeking remedies for these blood diseases have turned to radioactive phosphorus because it naturally concentrates in the bone marrow. Having collected in the marrow, its rays might kill the surplus blood cells at their source. Furthermore, such a localized treatment might be less rigorous than the steady dosage of X-rays now being used in an attempt to clear up the condition. Today, though no cures are claimed, radioactive phosphorus is the standard treatment for some types of leukemia. It reduces suffering and has prolonged the life of many patients.

If tracers will not naturally collect in cancer tissue, various other materials may be used to give them a "lift" to their chosen destination. They could be combined, for example, with certain colloids such as India ink—which concentrates in the liver and the spleen.

Besides iodine and phosphorus, radioactive gold is used in some cases where the material can be injected directly into the cancerous tissue. In some cases radioactive strontium is used in the treatment of bone cancer.

An effective radioactive treatment for two types of skin cancer has been developed at the University of California. Radioactive phosphorus in the form of a white crystalline salt is dissolved in water and absorbed by a piece of blotter. The blotter is then cut to fit over the cancer and is simply taped to the skin. Within a day or two the superficial cancer is wiped out by the rays from the phosphorus.

No scientist now would dare to predict where or when the final break will come in the struggle against cancer. We can be certain, however, that atomic energy will contribute greatly to the final victory.

The use of radioactive elements is certainly not confined to cancer research studies; rather we see evidence of its worth in nearly every aspect of medical research. Defective circulation in the body extremities can be studied by injecting radioactive sodium compounds into the patient's blood. A Geiger counter placed close to the patient's toe will show how fast the injected sodium has traveled to this extremity.

An important use of radioactive isotopes of iodine has recently been realized with the disclosure of successful experimentation in the treatment of non-cancerous thyroid conditions. A deficient functioning of this gland is called **hypothyroidism**, and frequently results in great loss of mental and physical vigor. **Hyperthyroidism**, excessive activity of this gland, leads to nervous and easily excitable state of mind, and accelerated heart activity. Hypothyroid cases can be diagnosed by noting that little radioactive iodine is taken up and used by the gland, whereas persons with overactive thyroids show a characteristic rapid iodine intake.

Iodine has likewise played a role in relieving pain and distress in two types of heart disease—**angina pectoris** and **congestive heart failure.** Previous studies showed that lessening of thyroid activity would so diminish the body's demands upon the heart as to reduce markedly the choking sensations and pain of angina pectoris and the shortness of breath and dropsy characteristic of congestive heart failure. Useful in a small percentage of cases that do not yield to other therapy, treatment to reduce activity of the thyroid by use of radioactive iodine has been tried on only a limited number of patients. Over half of this group experienced almost complete relief.

This is not intended to represent any comprehensive report of the role which atomic energy has to play in modern medicine. It is hoped that this presentation will point up the fact that the use of radioactive isotopes as tools for medical research is one of the most important aspects of the rapid development of atomic energy.

If the combined efforts of many hundreds of chemists, physicists, biologists, engineers and mathematicians and the expenditure of two billion dollars could achieve the miracle of atomic energy, there is a possibility that similar expenditures can perform equal miracles in the prolongation of human life. If the coordinated scientific attack as exemplified in the atomic bomb project can be applied to medicine, there is every reason to expect that many of the ailments that afflict mankind may be cured or prevented. Such an attack should make substantial progress towards the elimination of the common cold, infantile paralysis, tuberculosis, heart disease, cancer and the other plagues besetting us.

Thus it appears that medicine stands on the threshold of a truly new era in its development and it is only a matter of time before man may fully enjoy the fruits of this peacetime application of atomic energy.

At the present time, quacks are attempting to exploit the creative powers of atomic energy. For example, they are making great claims for radioactive bath powders, U-235 drinking water, atomic skin plasters and other products which are either worthless or dangerous.

As we have pointed out, atomic energy—in the form of radioactive isotopes manufactured in the atomic pile—has made some amazing progress in the treatment and diagnosis of pathological conditions. But its powers are not yet thoroughly understood and it can be employed safely only by skilled doctors and technicians under rigidly controlled hospital conditions. In clinical research with patients, physicians must use radio isotopes with great caution and carefully select the element used according to the type of emission it radiates, the length of its radioactive life, the place to which it goes in the body and its toxicity as a chemical.

Among those whom the Food and Drug Administration has already caught and convicted in the federal courts is a woman who extolled the merits of radioactive drinking water. She offered it as a cure for polio, gout, rheumatism, cancer and some fifty other disorders. She also sponsored a penetrating healing balm whose atomic rays could build tissue, relax the nerves, relieve sinus congestion, clear up skin infections and correct chronic appendicitis. A third product she offered was radioactive bath powder for the treatment of diabetes and neuritis. There's not a speck of radioactive materials controlled by the A. E. C. in these products. The Commission guards its isotopes with zealous care, and releases them for research and treatment only under rigorous restrictions.

The uses and examples that we have already mentioned by no means cover all of the research being done at the present time. Many large medical centers and universities and more and more industrial laboratories have research programs using radioactive materials.

—In Agriculture:

In agriculture, as in medicine, scientists are finding new and varied applications of radioactive isotopes in their quest for more knowledge and more power. Once again, however, we must be able to differentiate between glowing predictions on the one hand, and actual accomplishments on the other.

A great deal of research has been carried out in an attempt to understand just how fertilizers help the growing plant. Unfortunately few of us realize just how important plant fertilizers are. It seldom occurs to us that, while in the growing stages, practically every food we eat is dependent on some form of fertilizer. Nor are we aware of the fact that the food we eat today can be higher in nutritional value than it was a century ago, partly as a result of improved fertilizers and a better understanding of their use. In 1948 alone the American farmer spent well over $700,000,000 on commercial fertilizers. This sum still represents only a part of what should be spent if all farming practices were to utilize to the fullest extent the fertilizers that are needed.

The usual way of testing a fertilizer is to apply a definite amount, and compare the change in crop yield that results with former yields. While this appears to be a simple method, it is complicated by crop response to soil fertility, weather, method of application and many other factors. Now, however, we are able to get a direct measure of a fertilizer's value. In the case of a phosphate "carrier" we can determine the actual amount of phosphorous that it supplies to the crop.

How can the phosphate supplied by the fertilizer be distinguished from that derived from the soil? The

answer is found by "marking" the fertilizer—a small amount of radioactive phosphorus will do the job.

Radioactive phosphorus is like the normal element except that one of its atoms decomposes occasionally. The rays which are discharged when this decomposition occurs can be easily detected; hence we can trace the phosphorus anywhere in the plant. (One-half of the radioactive phosphorus is destroyed in two weeks. Consequently, this marking can be followed for only about six months.)

The final evaluation is quite simple. If the phosphate separated from the crop is only one-eighth as radioactive as the applied fertilizer, then only one-eighth of it came from the fertilizer. The remainder must be unmarked phosphorus obtained from the soil. Plants or parts of plants can be harvested at any time to measure the response.

The radioactive isotopes are used in such experiments as tracers to determine how fertilizers act. It is purely a research tool and should not be confused with the claimed stimulative effect of radiations on plant growth. An extensive cooperative experiment carried on by the U. S. Department of Agriculture in fourteen states using uranium, radium and other sources of radiation on eighteen crops has shown no beneficial effect of such radiations upon either crop growth or quality.

The problem of photosynthesis is an old one. Ever since its recognition in 1840, chemists have been concerned with an attempt to understand it. As early as 1850, it was recognized that the overall process was just this—the conversion of water and carbon dioxide into sugar and starch. With the development of radioactive carbon, scientists are more hopeful than ever that they will be able to discover the complex processes by which carbon dioxide is converted in the plant from its initial state into its final state through the agency of light.

It was clear that the simplest kind of experiment would be to feed a plant in the light some labeled carbon dioxide and give the plant just a very short time in which to carry on photosynthesis. By examining the compounds present in the plant after exposures of various durations, it should be possible by reducing the period of exposure to eventually find only one compound formed by the labeled carbon. The beginning of the process—the first chemical reaction—would thus be known; and then by lengthening the period of exposure under careful control, it should be possible to follow the labeled carbon atom into each succeeding compound. It would thus be possible to understand the entire conversion process.

By using such methods, research workers have identified some fifteen compounds as having been formed in ninety seconds of photosynthesis. Not until the time of photosynthesis is reduced to five seconds do we have only four or five compounds formed. It would appear then, that these are the first compounds into which radioactive carbon is incorporated by the green plant. At the present time, there is evidence which suggests that the first compound to appear in the fixation of carbon dioxide by the green plant is phosphoglyceric acid. Furthermore, we are beginning to get some clues concerning the order of appearance of compounds in the photosynthetic process. The ability to duplicate this cycle in the laboratory could be applied in several directions: the production of foods and fuels in the laboratory; the farming of the seas which cover some seventy percent of the world's surface; and the improvement of the photosynthetic process itself.

Indeed we are far from realizing these goals at the present time. In fact, about all that can be said with certainty is that in research laboratories in our country, and in other nations as well, intensive research is slowly revealing some of Nature's highly guarded secrets concerning photosynthesis. Time alone will tell whether man will ever be able to set up industrial factories to artificially produce the carbohydrates, sugars, and proteins and fuels the world so badly needs.

It is true that such ideas as these are both dramatic and fanciful—but they may be no more fantastic than the atomic bomb. The bomb was successfully developed, first, because the basic principles were known, and second, because governments were ready to devote the necessary funds and scientific personnel to the task. It is not likely that the atomic bomb project would have been undertaken had there not been a crisis in human affairs—a threat of defeat for the western democracies. There may be approaching another crisis in human affairs: permanent large scale food shortages. Starvation and malnutrition are slow processes, and their threat may seem less urgent than sudden death from bombs and bullets. At what point in this crisis the social, economic and political barriers will be breached cannot be predicted. If such a crisis becomes a reality, let us hope that science will be ready with the knowledge needed to enable the waters of the earth to come to the rescue of the overburdened land.

—In Industry:

Long before scientists succeeded in splitting the atom, we realized that our supplies of coal and oil were limited, and that from a long range point of view, new sources of energy were essential for a continuation of the world's industrial pace. Before the smoke had cleared at Hiroshima, many scientists foresaw in the process of atomic fission a possible fulfillment of this need for a new source of industrial power.

Since Hiroshima, science has continued to forge ahead, and bit by bit scientists are solving the technical and theoretical problems which stand as the major obstacles to the realization of this peacetime application of atomic energy. As the world moves into the second half of the twentieth century, we can only speculate concerning the vast changes that may occur if the potential power of atomic fission becomes a world-wide reality. We need not speculate, however, concerning the knowledge we now possess which points the way to future ideas on atomic energy use; furthermore, we should recognize the nature of the problems for which science has yet to provide answers.

In our study of atomic fission we noted that several products result from the splitting of U-235. The list includes fission fragments such as barium and krypton, from one to three neutons, high energy gamma rays, and tremendous amounts of energy in the form of heat. All of these products figure in man's efforts to transform atomic energy into electrical power. The manner in which an atomic pile could be used to power an engine is not difficult to foresee. If the temperature of the pile is permitted to rise high enough to boil water and produce steam, then we can obtain our power by connecting the steam supply thus produced to a steam turbine. The most likely use for such power would be to operate a large generator for the production of electrical energy. Water is not the only material that might be used for circulating in the pile. Helium gas and molten metals are being experimented with as possible heat transfer media.

The production of useful power from atomic energy (and the possible production of new fissionable materials for use as fuel) is to be accomplished by means of nuclear reactors—structures similar to the atomic pile. A reactor is a very special assemblage of fissionable fuel containing: moderating material to control the energy of the neutrons, coolant to remove the heat, various structural materials to form the supporting framework, shielding to confine the intense radiation, and some means of controlling the rate at which the nuclear reaction proceeds.

What will a nuclear power plant look like? As yet there is not enough fundamental knowledge or experience to provide an accurate answer. There are at least four or five basic approaches to reactor design with many variations that must be tested before it can be said which one is best and for which specific applications. Presented on page twenty of **Atomic Energy, Double-Edged Sword of Science,** by R. Will Burnett, is a schematic nuclear power plant which uses U-235 as fuel, a solid moderator, molten metal as heat transfer medium, and steam as working fluid to operate conventional power equipment.

It is important for us to realize that installations of this kind must be practically foolproof, for the intense radiations within the reactor make the component parts so radioactive that adjustments and repairs are difficult if not impossible even after the reactor has been shut down. We can get some idea of the engineering problems involved in this undertaking when we realize also that the materials of the reactor are subject to corrosion by the gaseous or liquid coolant medium. Furthermore, the interior of the reactor is filled with intense radiations, particularly gamma rays and neutrons which have the ability to penetrate considerable thicknesses of the materials and cause displacements of the atoms composing these materials. These displacements may result in a kind of internal corrosion and decomposition of reactor materials, making them unfit for prolonged operation. For this reason, some of the best high-temperature alloys developed for ordinary power plants cannot be used in the construction of these reactors.

Future developments concerning the amount and cost of fissionable fuel available for use in the reactors will figure most importantly in the degree to which atomic energy will be used in power production. Uranium ore, the primary raw material of atomic energy, is distributed widely throughout the earth's crust, but most of the deposits are of such low grade that they are very expensive to refine. The U. S. at present obtains most of its uranium ore from the rich deposits of the Belgian Congo, while the relatively small production in this country has been from the low grade carnotite ore of the Colorado Plateau. An intensive search for new uranium deposits is going on in this country and throughout the world, and the search has progressed sufficiently for the Atomic Energy Commission to report that there is an adequate supply of uranium to permit the use of atomic energy on a "substantial scale."

Unless the theoretical possibility referred to as "breeding" becomes an engineering accomplishment, some method of introducing new fuel into the reactor must be devised. This breeding process consists of the production of fissionable material in a reactor in greater amounts than is used up in the fission process. You will recall that uranium happens to be found in nature in two forms which differ only in atomic weight—U-235 and U-238. In a pile of natural uranium containing 139 atoms of U-238 to each atom of U-235, the fission of a U-235 atom will provide one neutron to continue the chain reaction among other U-235 atoms, and another neutron to convert a U-238 atom into fissionable plutonium. Thus the reaction, besides releasing energy in the form of heat, will (as long as there is some U-238 present) continue to create new fissionable fuel. The new atomic power plant being constructed for the A. E. C. at the Oak Knolls atomic power laboratory in Schenectady, New York, is being designed to take advantage of this breeding reaction. Though theoretically attainable, the process of "breeding" has yet to be demonstrated.

Problems of waste removal and disposal serve to complicate further man's attempt to capitalize on the potential power of the atom. As the chain reaction proceeds in the reactor, and as more and more of the atomic fuel is used up, fission fragments in the form of barium and krypton collect and must be removed if these "ashes" are not to "smother the fire." The disposal of flue gases and ashes from a conventional furnace is a simple matter, but this is far from being true for the highly radioactive wastes from a nuclear reactor. While it is true that some of the "waste" materials can be put to useful purposes in medicine and other fields of science most of the fission products at present must be disposed of as waste.

What are the future possibilities for large scale utilization of nuclear power? This is a question we can't hope to answer adequately at this time because there is not enough data or experience available. We have a complex series of interdependent factors: raw material availability and costs, fissionable material production tasks, incomplete information concerning engineering problems on nuclear processes, materials of construction, engineering designs, capital investment, maintenance and operating costs.

David Lilienthal, in a report issued shortly before he resigned as chairman of the A. E. C., predicted real progress in the use of atomic energy for power in from ten to twenty-five years. Continuing, he suggested that nuclear power could find its greatest uses in areas where other fuels are scarce, and that nuclear energy was far more likely to supplement our existing power sources than to supplant them. Finally, he stated that atomic power plants for large ocean going vessels are a development that can be expected in the near future.

Though it appears that American industry will have to wait some time before nuclear power will be available for industrial uses, atomic energy is today playing a major role in our industrial program. As in medicine, radioactive tracers are adding tremendously to our knowledge of industrial processes. New industrial uses for these tracers are being found every day. Several firms have recently been established to further the use of radioactive atoms in industry. Tracerlab, Inc. of Boston became the nation's first firm with a business built entirely on the by-products of the atom bomb. Such firms make available to recognized businesses tracer elements to be used in industry. Tracerlab expects to develop new industrial applications for radioactivity and to expand its list of commercial products.

In industry, as in agriculture and medicine, scientific research in the field of atomic energy is contributing to our knowledge of processes and to our sources of available power. These hold great promise for the future of mankind. The extent to which future generations will benefit from the increasing knowledge and sources of power depends upon what use man decides to make of them.

APPENDIX F: DEFINITIONS

1. ALPHA PARTICLE:
   Same as the helium atom nucleus, containing two protons and two neutrons and produced by certain nuclear reactions or rearrangements such as the decomposition of radium.

2. ATOM:
   The fundamental or smallest unit of which a chemical element is made.

3. ATOMIC NUMBER:
   The measure of the electric charge on the nucleus of an atom or the number of protons in the nucleus or the number of electrons outside of the nucleus.

4. ATOMIC WEIGHT:
   The measure of the mass of an atom or, more simply, the weight of an atom based on a relative scale on which the weight of oxygen is fixed at 16.0000.

5. BETA PARTICLE:
   The same as an electron only possessing high speed as emitted from certain radioactive substances.

6. CHAIN REACTION:
   Any nuclear reaction which sustains itself by releasing neutrons, which in turn split other nuclei.

7. COMPOUND:
   Any substance which is made up of elements chemically united in definite proportions by weight.

8. CRITICAL MASS:
   The smallest amount or mass of fissionable material that will sustain a chain reaction.

9. ELECTRON:
   The simplest unit of negative electricity having a mass of approximately 1/1837 of a proton.

10. ELEMENT:
    Any one of the basic types of atoms from which all compounds are made and which in itself cannot be broken down into simpler units by chemical means.

11. ENERGY:
    The capacity to do work or the capacity to make a force act through a distance. Forms such as electrical, heat, chemical, light, sound, etc.

12. FISSION:
    A particular phenomenon describing the splitting into two nearly equal parts of certain atomic nuclei with an accompanying release of energy.

13. FUSION:
    A phenomenon describing the uniting of light nuclei or particles with an accompanying release of energy.

14. GAMMA RAY:
    A high energy group of waves like light waves. It is nonmaterial pure energy that constitutes a radiation of extreme intensity and penetrability coming from the atomic nuclei of some radioactive atoms.

15. ISOTOPE:
    Any type of atom differing from other atoms of the same element in weight, due to a difference in the number of neutrons in its nucleus; but, chemically identical with other atoms of the same element.

16. MASS:
    The material equivalent of energy—different from weight in that it neither increases nor decreases with gravitational force.

17. MATTER:
    Commonly defined as anything possessing weight and occupying space.

18. MOLECULE:
    A chemical combination of two or more atoms representing the basic unit (smallest quantity) of a compound that can exist.

19. NEUTRON:
    An electrically neutral particle of mass one (1), found in the nucleus of atoms, and simply described as a fundamental particle being composed of an electron and a proton.

20. NUCLEUS:
    The positively charged central part of an atom containing practically all of the weight of an atom, nearly all of the energy, and composed of protons and neutrons.

21. PROTON:
    The simplest unit of positive electricity, corresponding and equal in charge to the electron, and approximately 1837 times as heavy as an electron.

22. RADIOACTIVITY:
    The spontaneous nuclear breakdown of atoms whereby such atoms change themselves into others possessing different properties; occurring naturally in elements where atomic number is greater than that of lead and artificially (after bombardment) in all elements.

APPENDIX G: HISTORICAL DATA

400 B. C.—Democritus, a Greek philosopher, first described the smallest pieces of matter termed "atoms."

1774-1777—Joseph Priestley, English, and Antoine Laurent Lavoisier, French, laid the foundations for modern chemistry.

1807—John Dalton, British, advanced his "atomic theory" of matter.

1811—Omadeo Avogadro, Italian, gave meaning to the difference between atoms and molecules.

1864—James Clerk Maxwell, Scotch, published the electromagnetic wave theory for light and radio waves.

1871—Dmetri Ivanovich Mendelyeev, Russian, formulated the periodic relationships of the elements.

1879—J. J. Thompson, English, first determined the ratio of the charge of an electron to its mass.

1896—Henry Becquerel, French, found that uranium ore was radioactive.

1898-1899—Marie Curie, Polish, and Pierre Curie, French, discovered and isolated radioactive polonium and radium.

1905—Albert Einstein, Swiss, gave science the mathematical formula $E = mc^2$ for the mass equivalence of energy.

1907—J. J. Thompson, English, devised the first method of positive ray analysis and discovered isotopes.

1910—R. A. Millikan, American, determined the amount of electrical charge possessed by each electron. (For this discovery he was later awarded the Nobel Prize.)

1910—Frederick Soddy, English, invented the term isotopes for elements having the same atomic number, but different atomic weights.

1913—Niels Bohr, Danish, developed the Bohr theory of atomic structure (solar system model).

1913—Henry Moseley, British, used X-ray spectra analysis to classify the elements according to their atomic number.

1916—R. A. Millikan, American, by a single experiment, verified Einstein's photoelectric equation and made the first accurate determination of the value of Planck's constant.

1919—Ernest Rutherford, British, changed nitrogen into oxygen which represented the first artificial transmutation of an element.

1931—Ernest O. Lawrence, American, invented the first cyclotron at the University of California.

1932—James Chadwick, British, bombarded the element beryllium with alpha particles and identified the neutron.

1932—John Douglas Cockroft and Ernest T. S. Walton, British, broke up the lithium atom in the laboratory and gave experimental proof to Einstein's formula.

1934—Irene Curie Joliot and Frederic Joliot, French, discovered radioactive phosphorus.

1934-1938—Enrico Fermi, Italian, transmuted forty (40) of sixty (60) different elements.

1939—Otto Hahn and F. Strassmann, German, bombarded uranium with neutrons and formed the two elements barium and krypton.

1939—Lise Meitner, Austrian, and Otto Robert Frisch, English, described the process of Hahn and Strassmann scientifically and coined the term "fission."

1942—Enrico Fermi, Italian, produced first chain reaction in atomic pile at Chicago.

APPENDIX H: BASIC SCIENTIFIC FACTS AND PRINCIPLES AS APPLIED TO MATTER AND ENERGY

1. An **atom** is the smallest particle of an element that can exist by itself and still retain the properties of that element.
2. All matter is composed of **basic chemical elements** of which ninety-eight are known at present.
3. **Compounds** are chemical unions of atoms of the basic elements.
4. The force binding atoms together in compounds is electrical in nature.
5. The smallest quantity of a compound that can exist is a **molecule**, which is composed of two or more atoms chemically united.
6. Elements are represented by **symbols** such as hydrogen $_1H^1$ where the subscript number represents the atomic number and the superscript number represents the atomic weight.
7. All atoms possess weight and the relative weights of atoms based on the weight of oxygen as 16 is called the **atomic weight.**
8. The **atomic number** of an atom signifies the total number of positive nuclear charges or the total number of negative charges of the orbital electrons.
9. All atoms are composed of basic units of matter and energy, the three best known parts being the **electron, proton,** and **neutron.**
10. **Electrons** are the basic negative units of matter, very light in weight and found in the orbits of atoms.
11. **Protons** are the basic positive units of matter. They are very heavy and are found in the nuclei of atoms.
12. **Neutrons** are the basic electrically neutral units of matter. They weigh about the same as a proton, are commonly thought to be composed of a proton and electron and are found in the nuclei of atoms.
13. Atoms are often thought of as being like solar systems with a compact **nucleus** of protons and neutrons and **orbits** which are paths in which the electrons revolve around the nucleus.
14. The force which holds the electrons in their orbits is **electrical** in nature.
15. The **chemical properties** of an element are determined by the number of orbital electrons, which is equal to the atomic number.
16. The number of electrons in the outermost orbit or valence shell controls the **combining power** of atoms.
17. The sum of the weights of all the particles composing an atom represents the **atomic weight.**
18. Some atoms of an element called **isotopes** differ in weight from others of the same element due to a difference in the number of neutrons in the nucleus.
19. **Isotopes** of the same element have identical chemical properties.
20. **Hydrogen** is the simplest of all atoms with one proton in its nucleus and one electron revolving around the nucleus making the atomic number and the atomic weight each one (1).
21. Hydrogen (Symbol H) has an isotope known as deuterium (Symbol D) which contains one neutron and one proton in its nucleus and so the atomic weight of D is just twice that of H, but the atomic number of each is the same.
22. The electrons revolve around the nuclei of atoms at a great distance from them so the **space** taken up by an atom is large, but the total volume of the electrons, protons, and neutrons is small.
23. Even though an atom is mostly space it is quite **impenetrable** due to the high speed of the electrons in their orbits making them seem to be everywhere at once.
24. Under special conditions small particles of matter (fragments of other atoms such as electrons, protons, neutrons) can be made to **penetrate** atoms like bullets.
25. **Energy** is that which has the ability to cause the exerting of a force through a distance, or the capacity to do work.
26. All energy is classified as **stored (potential)** or **moving (kinetic).**
27. All atoms are constantly in **motion** and so possess kinetic energy.
28. The **kinetic energy** of any particle of matter depends upon its mass and the square of its velocity.
29. Chemicals possess **potential energy** due to the various arrangements of their atomic particles.
30. Energy resulting from nuclear forces is the kind referred to as **atomic energy.**
31. The spontaneous breaking up of an atom with the release of energy used to hold the units together is known as **radioactivity.**
32. The particles and energies released in radioactive decomposition are known as **alpha** and **beta particles** and **gamma rays.**
33. The loss of alpha and beta particles causes an element to change itself into an element of lower atomic weight, this change being known as **transmutation.**
34. Matter and energy used to be thought of as each an indestructible entity; but, now it is known that matter may be converted into energy and energy into matter.