TEACHERS' MANUAL

FOR

MODERN SCIENCE SERIES — BOOK III

OUR ENVIRONMENT

HOW WE USE AND CONTROL IT

BY

GEORGE C. WOOD

AND

HARRY A. CARPENTER

ALLYN AND BACON

BOSTON NEW YORK CHICAGO
ATLANTA SAN FRANCISCO DALLAS

TEACHERS' MANUAL

FOR

MODERN SCIENCE SERIES — BOOK III

OUR ENVIRONMENT

HOW WE USE AND CONTROL IT

BY

GEORGE C. WOOD

AND

HARRY A. CARPENTER

ALLYN AND BACON

BOSTON NEW YORK CHICAGO
ATLANTA SAN FRANCISCO DALLAS

Norwood Press
J. S. Cushing Co. — Berwick & Smith Co.
Norwood, Mass., U.S.A.

GENERAL INTRODUCTION

Three of the outstanding characteristics of the average pupil are (1) an overpowering curiosity; (2) dynamic activity; and (3) an inability to organize his experiences so that he may generalize upon them and make them useful.

With these characteristics in mind, the problem of the teacher of general science is (1) to center the curiosity of the pupil upon things worth while; (2) to guide his activity along proper channels; and (3) to direct his curiosity and his activity in such a way as to secure real mental growth and practical achievement. Every picture, diagram, question, special problem, key word, introductory chat, home and field problem, review outline, summary, demonstration, and suggested experiment in *Our Environment: How We Use and Control It* is directly aimed at the solution of this threefold problem.

The text sets out to teach the pupil and not the subject; to develop his mental capacity, not merely to strengthen his memory; and to help him fit intelligently into his environment. In short, it aims to correlate the facts of the pupil's environment in such a way as to give them an irresistible appeal to his natural instincts and interests and so develop in him a definite appreciation of his environment and of his place in the work of the world.

This guide suggests a method of attack for each chapter, presents some details of the technique in the handling of demonstrations, suggested experiments, and special problems, and supplies answers to every important question in the text. The answers to questions are not by any means the only ones possible. The problem of the pupils will be to secure as many different acceptable answers as they can. The answers here given will be of value chiefly in showing the teacher whether or not he is on the right track in handling the problems which these questions involve.

The time allotments at the heads of chapters are purely suggestive. Many teachers will wish to establish their own time schedules in the development of the text. The teacher who finds himself in a particular environment well fitted for the extended study of a special field (water power, industry, transportation, etc.) will specialize on the material of greatest local interest to the pupils.

PREVIEW OF PART I

ENVIRONMENT, ENERGY, AND WORK

The first 68 pages of the text are devoted to the development of some very important ideas both for the teacher and for the pupils. It is most important that the teacher obtain the viewpoint of the authors here, if the greatest benefit is to be derived from the pages to follow. Many textbooks would naturally begin with the subject matter of page 71, — the mechanics of air. That would be an obvious method of attack. Not so in this book, whose cardinal principle is that the pupil shall proceed from the known to the unknown without abrupt contacts with principles and facts far removed from his everyday life. These three introductory chapters make for just that. Furthermore they develop a set of mind and a method of procedure on the part of the pupil which will make the rest of the text more easily comprehended and increasingly interesting.

Specifically these three chapters:

1. Form a gradual and logical approach to the fundamentals of the subject.

2. Make the pupil aware of the meaning, significance, and relationships of the factors of his environment (Chapter I).

3. Give new meanings and significance to the commonplace (Chapter I).

4. Show that the activities of man — his work — have much to do with the factors of his environment (Chapter I).

5. Show that science has much to do with finding out the proper methods of using this environment (Chapter II).

6. Show how one may study the science of common things by the scientific method (Chapter II).

7. Give the child some fundamental laws of matter and energy and show how the factors of the environment may actually do work (Chapter III).

8. Teach the child to organize his common but disassociated everyday experiences into a useful whole (general laws) (Chapters I, II, and III).

CHAPTER I

SCIENCE AND LIFE

Time Allotment

In Chapter I the equivalent of one whole period should be spent in the study of the pictures alone. Two periods should be used on the general discussion of the subject matter of the chapter; two periods may well be spent upon the questions bearing upon the *Frontispiece* and *Key Picture 1;* one period on how and why we study science (include the science stories) and two periods on the *Key Words, Review Outline, Summary,* and *Thought Questions.*

This chapter is best begun by a general discussion of the interesting things which the pupils noted on their way to school. Have the pupils analyze some of these experiences, telling what they heard, saw, smelled, touched, and perhaps tasted. From this, turn to their homes and have them list a few of the things which seem important to the occupants of the home. Then come back to the school and discuss some of the important elements of school surroundings (books, chalk, blackboards, fellow pupils, games, teachers, sports, and so on). Bring out the conclusion that (1) our life activities are linked up with our surroundings; (2) the things we learn are products of our surroundings; and (3) what we think is related to our environment.

A second method of approach is to have five pupils each list five things about them in which they are interested. Note how many are alike and how many are different. Determine why many are alike. Make in this connection a careful study of *Key Picture 1* as showing an indoor and an immediate environment. List every factor here of importance. Add any others not seen here but which may be inferred.

The purpose of the above discussion should be primarily: (1) to develop a mass of facts from the pupils' own experiences as a basis for further discussion; (2) really to acquaint the pupil with many new concepts about commonplace experiences; and (3) to quicken his appreciation of the things at his very door.

Page 4. — 1.[1] *Food* builds up the body; *water* quenches thirst and, for example, is found in all vegetable foods; *clothing* gives protection to the body; *air* supports life; *cattle* furnish us with milk and meat.

2. *Air* is used in automobile tires. *Water* is used to float ships. *Food* is used by workmen so that they may lift heavy loads. *Electricity* drives the trolley car which carries men to work. The *earth* gives " food " to growing plants. *Steel* is used in engines, cars, and rails to transport people and goods. *Wood* is used in lead pencils, houses, etc. *Rubber* is used in fountain pens. *Trees* are made into paper which

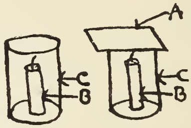
[1] Numbered questions are all identified as here; unnumbered questions are located by page and section references.

NOTE: Develop one point only under each question and hold the pupils responsible for the others. The answers to be expected should be very simple. You cannot treat the beginning of this subject in a too elementary manner. Remember that the answers included here for such exercises are purely suggestive and are not necessarily to be made by the pupils.

March 27, 1928. Oxidation. Harold Jones

Problem: Is air necessary to make things burn?

Materials: Two battery jars (C); two short pieces of candle (B); and a piece of sheet tin (A).



Method: A candle was placed in each battery jar. Each candle was then lighted. While they were burning the sheet tin was placed over the top of one of the battery jars.

Observations: After a few moments the candle in the covered jar went out. The candle in the open jar continued to burn.

Conclusion: Since the air was cut off from the covered jar and the candle went out and in the uncovered jar the candle still burned, I conclude that air is necessary to make things burn!

Practical Applications: A fire burns best when it has plenty of air. To put out a fire cut the air off from it.

is put into textbooks. *Cattle* produce leather which is made into shoes to protect the feet.

3. The answer to this question will depend upon the ability of the pupils actually to see all the parts of the picture. This work must be stimulated by the teacher. As the search proceeds the interest and enthusiasm will increase, resulting in a real game. Specimen answers would be: Water, airplane, flowers, dog, automobile, etc. There are many others here.

4. *Specimen answers:* Water is heavy or water weighs 62½ pounds per cubic foot. An airplane is partly held up by the air below it. Flowers are visited by bees, etc.

5. These answers should parallel those in **4**, but, for the most part should add new facts to those already cited.

6. Air is very light (weighing 1¼ ounces per cubic foot), is a mixture of gases, and supports fire. Water is a colorless liquid, is comparatively heavy, is necessary to life, and is found in most foods, etc.

The answers to the questions on *Figure 1* are self-evident to the teacher. They are veiled enough to the pupil to challenge his interest in searching them out. The picture will develop considerable meaning once the exercises of section 1 have been accomplished.

The use of the Science Discovery Book, suggested on *page 5*, is self-explanatory. This type of book has been found most useful in the classroom. The pupil develops the idea that he is writing his own book. This stimulates greater interest in the work as a whole. But it should be kept in mind that all such work must be constantly checked up and frequently discussed.

Drawings and clippings are especially helpful; see, now, the reference (page 18) to *page 35* of the text.

Page 6. *Figure 2.* The answer to the question is obvious. This answer will, however, form a basis for further questions on the care of house plants and the garden.

1. (*a*) Air, water, food, clothing, light, automobile; (*b*) air, water, food, shelter; (*c*) air, water, food, insects, light; (*d*) air, water, food; (*e*) air, water, food.

2. (*a*) Air, water, food; (*b*) air, water, food; (*c*) air, water, food (raw materials), light; (*d*) air, water, food.

NOTE: Bring out here clearly the factors which are common to all the living things in the frontispiece. Why and how are they alike? Here the *relation* of the living thing to its environment comes in. Since so many living things depend for life upon the same factors, the sympathy of the pupil for other living things can be emphasized with profit.

A very careful use of the pronouncing key on *page 7* should be encouraged. Fifteen minutes assigned to understanding its easy application will get the pupils into the habit of using it.

On **page 8** we come to the new idea of adaptations. Use the pupils' experiences to talk about the clever adaptations shown in animals with which they are familiar.

Page 8. *Figure 3.* It is obvious that light is necessary for plant growth because plants grow towards it and become colorless without it.

Page 9. *Figure 4.* **1.** The first picture suggests icebergs, snow, etc.; the second, a sandy shore or sand dunes; the third, desert stretches; and the fourth, a water environment.

2. White or polar bears are found only in the arctic regions. Palm trees live in the tropics along the seashore or in the deserts. Camels are desert beasts of burden. Alligators are reptiles adapted to live in the water.

3. The polar bear needs cold temperatures; the camel, warm. The palms need sun and sandy soil; the alligator, a water home.

All need air, water, and food (the trees making it from raw materials). The polar bear does not need the ice; nor the camel the sand of the desert; the palm trees need not live close to a body of water. The factors differ in respect to the kind of food used, the amount of water used and the temperature of the air, water, and food used by each living thing. These differences are due to marked differences in climate.

Figure 5.

	Adaptation	*Environmental Factor*	*Use of Adaptation*
A.	Fins	Water	For swimming
B.	Long, pointed bill	Water	For spearing fish
C.	Overhanging bill	Water	To prevent escape of fish
D.	Twisting of stem	Sunlight	To support stem to get light
E.	Bud scales	Rain, ice, cold	Protection
F.	Air (aërial) roots	Wall, sunlight	To secure protection and sunlight
G.	Grasping claws	Branch of tree	Support
H.	Broad foot	The earth	For walking and scratching
I.	Webbed foot	Water	For swimming
J.	Variously colored feathers on head	May match environment colors	Protection from enemies

Page 10. *Figure 6.* The large leaves expose a greater surface to the sunlight where the vegetation is luxuriant and much shading occurs. Heat and moisture in abundance favor such growth. Such leaves are easily torn and destroyed by high winds.

Page 11. *Figure 7.* Moisture is lacking here. Intense heat and little or no rain are the cause of such vegetation. Real leaves are lacking here. They are reduced to spines.

Page 12. *Figure 8.* The advantages are: The cutting furnishes man with fine wood, lumber, increases land areas for farming, etc. The disadvantages are noted on this page. Others may be added, such as the production of an ugly landscape.

NOTE: On this page there is a newspaper reference. It is used to bring home to the pupils the very important fact that their science is intimately related to the affairs of the world about them. The pupils should be encouraged to look for clippings bearing on their daily work and to place them in their *Science Discovery Book.*

Plate II. One phase of man's control of his environment is significantly illustrated by this picture. The extinct albatross, great auk, and other disappearing species of birds should be mentioned. The near extinction of the bison should be touched upon. Also speak of the quail, partridge, lady's slipper, mountain laurel, trailing arbutus, black walnut, white pine, etc. Mention laws which forbid destruction of various forms of wild life and call attention to the present campaign against rats, mosquitoes, wild horses, and gophers. This plate should teach a big lesson in conservation.

Page 13.

Frontispiece. **1.** The dog may kill a woodchuck. The cattle may eat the grain. The picnickers may destroy rare plant life. The flowers may furnish food for the butterflies. The waterfall may cut completely through the hill. (Many other answers may be given.)

2. The hot weather influenced the people in the picture to go out to this spot for their lunch. Signs of a thunderstorm cause the farmer to hurry in his hay. The stream of water makes a convenient boundary for the farm and also enriches it. The mountains protect the farm from high winds. The sunshine invites the insects to the flowers. The sunlight causes the plants to grow. The airplane excites the little girl.

Note: The answers given above illustrate an important point which should be kept in mind throughout the book. Many of these questions admit of many answers. Some of them admit of no definite answer. Debatable questions are intentionally included. If you can get the pupils to debate the relative values of several answers, you have secured interest and stimulated thought. If the pupil is taught that in some questions we have to suspend our judgment for the time being, you have inculcated in him a vital factor in learning. The big thing is to get a decided reaction, — to stir the imagination and the emotions.

Section 6. **1.** Man may dam a stream, build a railroad, cut down forests, destroy wild life, etc.

2. Changes in his environment (seasons) make man dress differently for different seasons. He is forced to build strong, high bridges to cross streams; heat forces him to work more slowly in summer than in winter: he is forced to live for the most part in those sections of the earth where food is plentiful and easy to secure.

3. By noticing what happens about you and how it happens. By use of the five senses and common sense.

Page 14. **1.** Easy travel, better mail service, better selection of foods, fruits, and vegetables all the year round, purer water and more of it, etc.

2. Accidents are more frequent, epidemics are less easily controlled, the air is more likely to be bad, crime is greater, living conditions are crowded, etc.

3. How to distribute food at a lower cost and more expeditiously; how to protect property; how to dispose of sewage; how to reduce crime; how better to control traffic, etc.

Figure 9. The trees are natural; the road is artificial. No, because the plants are evergreen trees adapted to a cold climate, while the plants in Figures 6 and 7 are adapted to a hot, moist climate or hot and dry climate.

Page 15. *Figure 10.* Air, water, and the essentials of the food and clothing of the living things in each picture are alike.

No automobiles, paved streets, business buildings, etc., are found in the environment of the native. The differences are primarily due to a better knowledge of the environment, methods of work, and of science by civilized man.

Frontispiece. **1.** Where does the stream seem to rise? Is it deep or shallow? Of what is the bridge built? What propels the trolley car? What time of the year is it? What kind of an airplane is the one seen in the sky? etc., etc.

2. Horses, cattle, automobile, water, etc.

Page 16.

Frontispiece. **1.** Mountains, grass, flowers, water, air, etc., are natural. Food, bridge, trolley car, automobile, train, airplane, etc., are artificial.

2. All of the foregoing can be known by use of the eyes; all by touch (except air); the automobile, airplane by hearing; the flowers by smell; the food by tasting.

3. Automobile, house, barns, airplane, train, bridge, etc.

Page 17. *Figure 11.* Franklin is using electricity and air in this experiment. His materials are a kite, string, key, and large bottle. We know that he is experimenting because he is using the factors of his environment in a way to produce a natural result. Franklin did not believe in signs. He was a scientist because he studied very carefully the relations between cause and effect. He discovered here that the lightning in the clouds is static electricity. He made this discovery by causing this lightning to travel down the wet kite string to the key and then jump in small sparks from the key to a conductor. From this idea he invented the lightning conductor.

Page 18. *Section 11.* A discovery is the *finding out* of something previously unknown or unrecognized, while an invention is the *construction* of something which has not before existed.

Frontispiece. **1.** The bridge is built of concrete, which possesses great strength. Flowers depend upon insects for seed production. The airplane depends upon air resistance to keep it up in the air. The energy of expanding steam makes it possible for the engine to draw the heavy train. The automobile uses gasoline as its motive power. (Many others may be added.)

2. The cattle depend upon plants for food. The fish in the stream feed upon insects which fall into the water. The farmer secures food from his cows and work from his horses. The party gets its food from both plants and animals (meat and bread), etc.

NOTE: The teacher should use the stories on pages 19 to 22 of the text as a basis for the construction of similar stories by the pupils from their own experiences.

Page 20. *Figure 12.* Some factors are snow, trees, earth, fences, water, mountains, sky, etc. The great altitude of Mt. Washington results in little heat being absorbed from the sun during the summer and it is, therefore, very cold at its top.

The *Key Words*, *Review Outlines*, and all other supplementary features at the ends of chapters may be made a very powerful aid in the development of correct concepts. *Key Words*, for example, should be correctly used by the pupils in sentences, then built up into short stories. The pupils will like this and in it will recognize and feel their own growth in the command of language.

A similar adaptation may occasionally be made of the *Review Outlines*. The topical headings of the outlines will serve as the story titles. The chapter *Summaries* are the logical cumulation of the topical reviews presented by the *Key Words* and the *Review Outlines*, — first the word, then the phrase, and finally the complete statement.

The teacher is urged to give adequate attention to these several types of supplementary review. They have been very carefully developed and are the best possible insurance against superficial work on the part of the pupil. They " blaze " the memory trail and will prove decidedly effective in securing satisfactory retention of the subject by the pupil.

In all the chapters the *Remember that* items must necessarily be memorized if used at all. They are important pegs upon which hang the whole content of the chapter. Use them also as story themes to be written out or discussed orally in the class.

Page 26. *Thought Questions.* **1.** The farmer grows crops, plows soil, cuts forests, etc.; the business man builds a store, a saw-mill, or a factory, controls the amount of raw or finished product of a kind coming into or going out of his town; the city dweller keeps a cat which catches birds, keeps a dog, keeps a garden or pigeons; the miner mines coal and controls fuel supply.

2. Weather may ruin crops; the sailor may be shipwrecked; the town dweller may hold an auction out-of-doors on a fine day and make a wonderful sale or the weather may entirely spoil this venture.

3. All who depend directly upon the soil or are affected by the weather in pursuit of their occupations have little control over their environment. This is especially true of seamen and farmers. Manufacturers who use raw materials and work them over under cover control the effort and time of thousands of persons and thus control the activities of whole towns full of people.

4. This answer will vary greatly, depending upon the environment.

5. A few of each will be named here: Solids: wood, iron, rock, glass, paper, clay, soil, sulphur, carbon, slate, copper, etc. Liquids: water, alcohol, vinegar, cider, milk, ink, etc.

6. Elephants uproot trees and carry immense burdens; cattle enrich the soil; sheep eat off much of the vegetation; vultures clean up dead animal matter; weeds drive out useful plants; birds keep down insects.

7. He makes water turn wheels; he drives engines by steam; uses air to stop trains; uses light to produce photographs; air to compress cotton into bales; electricity to drive his motors, etc.

8. Sight has taught you color, size, shape, length, and thickness of objects. Touch has taught you roughness and smoothness of things; weight of things; etc. Hearing has taught you the differences between bells, whistles, voices, horns, and vibrations of different kinds. Taste has taught you sourness, saltiness, bitterness, sweetness, flavors of things you eat. Smell has taught you to identify different odors; odors of solids, odors of gases, and of liquids.

9. (*a*) By lifting a quantity of it one finds this out. (*b*) It is not possible to connect the one act with the unlucky result. Every cause has its effect, but here in this case one thing cannot cause the other because they are not in any way related. One answer is based upon experience, the other upon superstition rather than science. Common sense will tell one that superstition is not science. Science is organized common sense and superstition is not based upon common sense.

CHAPTER II

HOW SHALL YOU STUDY YOUR ENVIRONMENT?

Time Allotment

In this chapter two full periods should be used in developing the (*Key*) *Demonstration* and the form of an experiment. One period may be spent upon the use of the experimental method in dealing with yellow fever; one period is to be spent upon the subject matter of the chapter and two periods upon *Key Words, Review Outline, Summary,* and *Thought Questions.* The *Home and Field Problems,* and special reports on experiments indicated on page 40 are to be done in an extra period.

During the study of Chapter I you have attempted to place the pupils in close contact with the appreciation of their everyday environment — an experience which may be new to many of them. Chapter II is primarily planned to present the rational method of studying this environment. Your pupils may never be able to explain this method to your entire satisfaction, but if you can get them to sense its character and apply its processes, you will have accomplished all that is really necessary for pupils of this age.

Page 28. *Key Picture 2* is a study in contrasts. Bring out that the method of true science is always the same, but the people using it and the materials at their disposal differ. In the picture the same method is followed for both experiments, but the persons involved and the equipment used are radically different. Have the pupils account for this fact.

Page 29.

The heat of the sun causes evaporation of water. The water vapor rises due to its comparative lightness and to the rising columns of warmed air which carry it up. Condensation causes the fog blanket.

Rain comes from masses of water vapor which have cooled and condensed into droplets heavy enough to fall.

The leaf is green because it contains chlorophyll which helps make starch in the presence of sunlight. Its flatness allows it to catch the rays of the sun at right angles to its surface and its thinness allows the light rays to pass completely through it. Dew is formed by the condensation of water vapor in contact with a cold surface such as rock. The pupils will not, for the most part, know these facts, but they have had experiences which will tie up to the new information supplied by the chapter.

Page 30.

A feature which will bear much emphasis is that of *Home and Field Problems*. Lay stress upon the boxed matter. Discuss it fully. Try to show the pupils that the science they are studying is not confined to the classroom but is to be studied (1) in the home and (2) on their way to and from school. Thus you connect the pupils' instruction with their immediate environment and they cannot help but see the practical side of it and its value in their everyday lives. But you must be the inspirer of their work along this line and their real guide. The pupils must be made to see that these problems set for them are real problems, no matter how simple they appear to be. It is the spirit of investigation which must be developed in your pupils. When assigning these first *Home and Field Problems*, take time to discuss their solutions and to tell the pupils how you (or the class — a fine opportunity for socialization) propose to evaluate the observations submitted.

Home Problem: Self-explanatory.

Page 31. *Field Problem:* Self-explanatory.

Section 17. Right here you begin the most important activity of the whole book. You are approaching the method of work of the scientist, that of experimentation. He uses other methods, to be sure, but this is his principal method of work. So your young scientists will work. Begin discussion of this feature by having the pupils tell you things they have actually tried to find out. Then show them how these things they found out may have been real experiments.

Figure 13. Self-explanatory.

Page 32. — Develop the definition of an experiment and then proceed to prove that the definition is right. The answers to the questions in *section 19* are self-evident.

Page 33. — Here is the first (*Key*) *Demonstration.* It is extremely important. If more convenient, substitute equal amounts of boiling (or very hot water) and iced water for the comparison. Bear in mind that the steps in the experiment are not to be memorized merely for the sake of having the pupils learn what is known as the scientific method of procedure. Rather you are to show them that these steps are inevitable in the satisfactory solution of any problem. Show them that they have used the steps already scores of times, in fact every time they have solved a problem. What you want to do is to get them to recognize the individual steps in an experiment when that experiment is presented to them (pages 36 and 37). In time your pupils will subconsciously identify these steps, after which the steps themselves will become a guide in attacking new problems. Then the pupils will habitually use the principles indicated on page 35, even though the experiment may not be presented in the orthodox form outlined on pages 33 and 34.

Figure 14A. This picture will be easily explained in connection with the experiment.

Page 34. *Figure 14B.* This girl is depending upon written authority for her information. A better way (Figure 14*C*) is to study, at first hand, a bird in the bush or a leaf on the twig. Do not let the pupils lose sight, however, of the fact that the former method is very valuable in verifying observations.

Page 35. In determining the form and appearance of the pupil's notebook page when demonstrations are "written up," the specimen sheet on page 6 may be of some help. The notebook may be of the loose-leaf or of the bound variety. Particular care should be taken by the pupils to make their sketches tell the exact truth. Labels should be pointed out with arrows. This method makes less work for the teacher and insures greater accuracy on the part of the pupil.

Page 37. *Section 23*, third paragraph. The *Problem* was: Do Aëdes mosquitoes which have never bitten a person suffering from yellow fever carry this disease? The *Materials* were: Hatched Aëdes mosquitoes and persons who had never had yellow fever. The *Method* was to allow the non-infected people to be bitten by the mosquitoes. In the *Observation* nothing happened. The *Conclusion* was that the Aëdes mosquito will not carry yellow fever if it has not bitten a person suffering from it. The valuable information from this conclusion is that the disease is not contagious.

The next *Problem* was: Do Aëdes mosquitoes which have bitten people suffering from yellow fever carry yellow fever? The *Materials* were: Aëdes mosquitoes, sick persons (suffering from yellow fever), well persons. The *Method:* The Aëdes mosquitoes were allowed to bite a sick person first and then a well person. *Observations:* The well person became sick with yellow fever. The *Conclusion:* The Aëdes mosquito carries yellow fever. *Practical Application:* Destroy the Aëdes mosquito and thus get rid of yellow fever. This has now been done.

Page 38. *Figure 15.* This hotel is now possible because the Aëdes mosquito has been brought under control with a consequent elimination of yellow fever in the Canal Zone.

Page 39. *Figure 16.* Self-explanatory.

Page 40. **1.** Here the finger at one end cuts off the direct atmospheric pressure. The atmospheric pressure on the other end keeps the water in the tube. Removing the finger allows the atmospheric pressure to exert itself on both ends equally and the weight of the water carries it out of the tube.

2. Oil passes from particle to particle of the wick by capillary action. That is, it passes from particle to particle through minute paths or spaces. Have the pupils dip a towel in water or a blotter in ink and explain what happens.

3. An acid causes the baking soda to bubble or effervesce. This is due to the readjustment of the particles composing the acid and the soda. Test this by actual experimentation.

4. Light induces the leaves of a plant to turn towards it. Test this by an actual experiment.

5. Cut two small shoots from a woody plant (willow) with the leaves attached. From one shoot cut a band of the bark about one inch wide down to the wood all the way around the stem. Set both shoots in water. In a few days roots will grow from the outer edge of the bark *above* the cut, showing that the upper portion has received food. Obviously the liquids must pass up through the wood.

Page 42. *Thought Questions:* **1.** They are all alike as far as the factors necessary to life are concerned. They differ in the factors which fit living things to live in the particular environment in which they are found. For example: Water surrounds fishes, free air surrounds men, and soil surrounds earthworms. Again, the minor factors differ; for example, rocks surround the Rocky Mountain goats; sand and alkali deserts surround the cactus and jack rabbits.

2. Most work is done in the Temperate Zones. The least work is done in the Tropical Zones. The cool air and lack of high and constant humidity in the Temperate Zones is invigorating and the comparative scarcity of natural foods requires much work to get it. In the tropics humidity and heat make work difficult and food is abundant and easy to procure.

3. Excavating, transporting matter, building, molding iron, cutting steel, cultivating the soil, laying brick, cutting stone, building automobiles, etc. They all move matter from one place to another. Any number of answers may be secured. Ask each pupil to give the occupation of his father, and the material will develop rapidly.

4. It is more than 3000 miles from New York to Paris. Mount Washington is about 6000 feet high. A cubic foot of water weighs $62\frac{1}{2}$ pounds. Our environment is our surroundings, etc. We accept these facts because someone has proved them to be true by actual experiment or by careful observations.

5. A hot stove or steam pipe burns when touched. A sharp jack-knife cuts the fingers unless handled with great care. Water will not run up hill of its own accord. Iron is heavy. Cork is light, etc. These facts have been learned by coming into contact with a stove or steam pipes which were hot, by being cut with a sharp knife, by handling the objects mentioned, and by noting that water normally runs down hill.

6. (*a*) It is hard to make a nickel stand up on its edge. (*b*) A piece of metal will not float in water. (*c*) What is learned by this method is generally right because we can at once see errors in our methods of work and we must obey the laws of Nature in working out these things.

7. China, Russia, India, and Africa are rich in superstitions. France, Germany, England, and the United States are rich in science. Science and superstition are both to be found in France, Germany, England, and the United States, with science exercising the greater control. Education and science walk hand in hand to overcome the superstitions of ignorance.

CHAPTER III

THE WORK OF MAN IN HIS ENVIRONMENT

Time Allotment

The equivalent of one period should be used in discussing the pictures of the chapter. *Home and Field Problems* and *Suggested Experiments* are to be assigned as outside work and one period or its equivalent should be spent in their discussion. Two periods should be used in discussing the subject matter of the chapter. One period will cover the two *Demonstrations.* One period is to be used on *Key Words, Review Outline,* and *Summary* and one period on *Thought Questions.* Two periods may be spent on the questions throughout the chapter.

In this chapter the pupil turns from the generalized discussion of his environment as a whole to the scientific fundamentals underlying the activities of the environmental factors. He should now begin to think of his environment as matter and energy, interacting upon one another. He should learn that the work of man involves the use of matter and energy; that there are obstacles to the proper use of effort by man; that man has discovered many simple machines to lighten his effort; and that the factors of man's environment, when energized, can do work. Later, it will be discovered that these factors can and have been harnessed by man to do his work for him. Finally, a general law is reached that everything which possesses energy can move or cause things to move and this results in work. This truth is fundamental in the study of general science.

Page 44. *Key Picture 3.* Considering these pictures from left to right, each shows matter in the form of solids while the third and ninth also show liquids. In the third and ninth, potential or stored energy is being transformed into kinetic or active energy. In all of the other pictures work is being done through the muscles which change potential energy to active or kinetic energy.

Page 45. *Home Problem:* Vacuum cleaner, electric washer, electric dishwasher, hammer, screw driver, tack puller, automobile jack, etc. Lifting or moving objects from one place to another is probably the most common form of work about the home.

Field Problem: Here the answers will differ widely. These should all be pooled in the class and thus become the common property of the class as a whole.

Page 46. *Section 27.* With reference to the Key Picture this list of different materials should consist of well over 20 items, all plainly shown in the pictures. Live factors are to be found in six of the nine pictures; in all nine are to be found non-living things and work is being done in every picture because matter is being moved through space by some force.

Page 47.

> **The teacher should not by any means be limited to *Suggested Experiments* indicated in the text. The pupils may evolve many by themselves which may be the results of discussions in class or may arise as real problems in connection with a step in the working out of some (Key) Demonstration. Every encouragement possible should be given to such experiments.**

Suggested Experiment. Problem: Do all substances burn (do all substances contain organic matter)? *Method:* Each material is tested in a flame. Results: Some burn and some do not. Those that burn turn black in the process. *Conclusion:* Not all substances burn.

Page 48. *Suggested Experiment. Problem:* Do some substances assume different forms? *Materials:* Ice, hammer, beaker, Bunsen burner. *Method:* Break the ice into pieces with the hammer and melt it in the beaker. Boil the resulting water. *Observations:* The ice changes from a solid to a liquid and from a liquid to a gas which disappears. *Conclusion:* Some substances are able to change their form.

Figure 17. Environmental factors here shown: Air, water, soil, heat, light. The plants are alive. Everything but the stone, the bottle, and most of the box was once alive. The stone, bottle, and soil were never alive. All but the stone, bottle, and soil are organic. The stone, bottle, and most of the soil are inorganic. All but the stone, soil, and plants are artificial. These alone are natural.

1. Solids are hard, occupy space, and have weight. Liquids may be poured, fit the container in which they are placed, and can be formed from some solids. A gas can not be seen, is light, and in some cases may be formed from a liquid by heating.

2. Answers will vary here, but the dictionary will be the authority. Simple definitions may be made in the class, based upon discussion of those submitted by the pupils.

3. Cheese, paper, cloth, meat, bread, etc., are all organic. Sulphur, glass, porcelain, iron, etc., are all inorganic. Shoes, knives, bread are solids. Ink, acids, milk, water are liquids. Oxygen, carbon dioxide, nitrogen are gases.

4. All are matter because they occupy space.

Page 50. *Demonstration 2. Observations:* The ball when placed on the table remains still because of inertia. The ball rolled because some force acted upon it. Friction and air resistance finally stopped it. Things tend to stay where placed until moved. Unless stopped by some resistance to it, a ball when once set in motion would never stop. The water rises in the graduate because two bodies cannot occupy the same space at the same time. Water is matter. All matter takes up space. No two bodies can occupy the same space at the same time. Two general properties of matter are: Matter occupies space; inertia is a characteristic of all matter.

Suggested Experiment: All points in this experiment are self-explanatory.

Page 51. Five elastic substances: A rubber band, steel spring, air, marbles, and hickory (wood). Inelastic: Rock, leather, putty, solder, wax, lead, zinc, etc. Transparent: mica, glass, celluloid, air, diamonds, etc. Ductile: hot glass, copper, platinum, steel, silver, etc. Malleable: tin, copper, brass, gold, zinc. Hard: steel, iron, quartz, glass, ebony (wood). Brittle: Dry clay, cold glass, cast iron, slate, bricks. The answers regarding usefulness and uselessness will vary according to the items named.

Page 52. *Section 34.* When the bell is not ringing, the energy is stored in a dry cell. The stored energy in coal will be available only when the coal is burned. Coal is bought to burn to release heat to warm our homes, etc.

1. Automobiles, water, air, locomotives, man. All can also make other things move.

2. Motion, electrical currents, heat, light, sound, all may act upon the factors of environment.

3. Dredging, navigation, railroading, mining, steel construction, stone cutting, excavation, trucking, aviation, painting, carpentry, etc.

Page 53. **1.** Yes. A boy works when he plays ball because he moves matter through space or overcomes resistance.

2. No, no work is done even though effort is used, since no movement of matter through space results.

3. Ride a bicycle, play ball, play tennis, run, skate, dig potatoes, etc.

4. Iron, wash dishes, sew, play tennis, play field hockey, cook, etc.

5. Steam (heat) runs an engine, an engine runs a machine, an automobile carries passengers, water in floods washes away homes or runs water wheels, wind blows down a tree, etc.

Figure 18. Because $D \times W$ equals F or foot-pounds of work done. Had he raised to the one-foot mark, he would have done 3 foot-pounds of work.

Page 54. **1.** Since W equals $F \times D$, the force required to raise 100 pounds a distance of 10 feet is 1000 pounds.

2. 1000 foot-pounds of work must be done, if 100 pounds is to be moved through 10 feet of space. This problem paraphrases problem **1** to show that a foot-pound is the work done by a pound of force working through a space of one foot.

Figure 19. In the movement of **A** over **B** there are no marked projections to catch against one another. There are marked projections on the under surface of **C** and the upper surface of **D.** As movement begins friction begins and as movement increases the friction increases with a corresponding increase in the heat generated between the two surfaces. The two conditions for friction, then, are two surfaces *moving* against one another. The rougher the surface, the greater the friction.

Suggested Experiment: Gravity causes the bricks to have weight. They are heavy. Inertia makes it hard to start moving the box along the table. Once the box starts moving, less force is required to keep it moving. Work was done here because the object was moved through space by the use of force.

Page 55. The question near the bottom of the page, on *Key Picture 3,* is answered as follows: Friction is evident in every unit of the picture. On the log; on the men's feet; on the rope over the top center man's shoulder and on the rope in his hands; on the moving parts of the steam shovel; on the shovel as it picks up the rocks and earth; on the ten-pins; on the ball as it rolls; on the man's hands and feet as he pushes the wheelbarrow; on the wheels where they touch the ground and at their axles; on the horse's hoofs and in all moving parts of its harness. Friction even holds the man on the seat. The man batting is held in place by friction and friction helps him get a grip on the bat. The man who is pushing the rock gets a grip on the rock by friction and his feet hold to the ground by friction. The rock is hard to move, partly because of friction. Friction holds the tennis player in place at a given spot, it gives him his grip on the racket, and helps send the ball from the racket. Friction acts on the moving ball. It acts in the bearings of the water wheel; on the water as it falls over the spillway, etc.

Page 56. *Figure 20.* Gravity causes the sled to go down the hill. Friction causes it to stop when it strikes the bare spot. Inertia causes the boy to leave the sled. Friction helped send the mud up from the revolving wheel. Inertia caused the mud to leave the wheel and fly in a straight line until gravity began to bring it down to the earth. The revolving rim of the wheel moves away from the mud, separating it from the tire, and the mud moving in a straight line tends to keep moving in that line because of inertia. Gravity finally overcomes the inertia and most of the mud comes to rest on the ground.

Page 57. *Figure 21.* Every unit of the picture involves movement for some definite purpose. Each illustrates one or more of the simple machines. Four of them illustrate compound machines. If the fundamental idea of a simple machine is thoroughly taught, there should be no trouble in the identification of the kind of machine shown in each picture and of the effort arm, resistance arm, and the fulcrum in each lever shown. The list here indicated may be added to by naming many other household utensils.

Page 58. *Figure 22A.* All machines here indicated have a fulcrum, an effort arm, and a resistance arm. They are all used in different ways, though the principle is the same in each. The force is applied at the end of the effort arm in each case. The resistance is at **R** in the tack puller; the rock is the resistance in the second picture; and the 20-lb. weight is the resistance in the lower picture. The fulcrum is at **F** in the upper and lower pictures and at **1** in the middle picture. **1** and **2** represent the fulcrum and resistance distance (**RD**). The 4-foot distance is the effort arm. The application of the terms of the tack puller to the moving of the rock is easy and obvious. If **x** were raised to **y, 1** would be moved nearer the rock. Less effort would be required to move the rock than before because the weight distance is reduced and the effort distance is increased. The dotted lines indicate the new position of the rock.

Page 59. *Figure 22B.* The log is forced up on both sides of the inclined plane of the wedge. This finally splits the log.

Figure 22C. Just enough effort to overcome inertia and friction would be required to pull the cart along a table. To lift it would require enough effort or force to equal the weight of the car. The inclined plane takes care of or bears most of the weight of the car and, therefore, less effort is required to move the car to the top of the inclined plane than would be necessary, if the car were raised bodily to that position.

Page 61. *Section 43.* The hammer, when it falls or when it is sent down upon the board by the muscles of the arm, raises the weight at the other end of the board. Muscular and gravitational force are used here. The kind of energy used here is kinetic. *Figure 23.* The machine as here used is a lever of the first class because the fulcrum is between the effort and the resistance.

Section 44. The falling water (*Figure 24A*) hits the paddles of the water wheel and its weight and momentum pushes them down, thus revolving the spool and lifting the weight. Work is thus done.

Page 62. The fan in *Figure 24B* causes air motion (wind). This causes the windmill to revolve, turning the spool and lifting the weight. In *Figure 24C* the hole is for the purpose of lighting the contained gas; the wire on the handle forces the cover back into place when it rises. The tubing carries illuminating gas to the pot; the arrow shows the direction of the upward movement of the pot cover.

Page 63. *Demonstration 3. Observations:* An explosion will take place. The pot top is forced up. Work is thus done. The expanding gases due to the heat do the work by exerting pressure on the top. The form of energy is that of heat; the kind is kinetic.

Practical Applications: The lever is the simple machine shown here. A thermostat on the wall affected by heat may open or shut drafts in your furnace. One should always open the oven door when lighting the oven. Otherwise the sudden heating and expansion of the air and gas in the oven, due to the presence of heat, may cause a dangerous explosion. The explosion might blow out the oven door, causing injury, or the flame might badly burn a person near the door.

NOTE: The table on page 64 will be found valuable in review work. The items included in it may be discussed with profit from the standpoint of the individual factor of the environment or from that of the general law. Use of both approaches will give the pupils an excellent working knowledge of the relations between the factors of the environment, energy, matter, force — and the general laws based upon these factors.

Page 66. *Thought Questions:* **1.** Reduction of friction reduces wear and less effort is needed to do the required work.

2. The " hot-box " is caused by too much friction between the wheel axle and its bearing. More grease is used to reduce the friction.

3. Particles of the wire are moved over one another, resulting in great friction and heat.

4. The boys at the end of the line going in one direction tend to keep that direction through inertia, and when the line is suddenly turned, the centrifugal force is so great as to tear the line apart.

5. By placing sand upon the track, thus increasing the friction.

6. Brakes produce great friction on the wheel rim. In locomotives, etc., compressed air is forced against the end of a piston attached to the brake and this piston pushes the brake against the wheel.

7. If there were no *force of gravity*, nothing would have weight; nothing could be held in place; if a ball could be thrown, it would never fall to the earth, but if there were no gravity, it could not be thrown anyway; if things could roll, they would roll uphill as well as downhill; water would not flow; it would never rain, etc. Were there no *inertia* it would be very easy to start an automobile but hard to keep it in motion; a bowling ball would stop rolling the instant it left the hand; nothing would stay where we placed it; mud would stick to the tires of an automobile and prevent its proper running; etc. Were there no *friction* you could not pick up objects with ease; you would have difficulty in walking; you could not stand up at all on the ice; you could not climb a tree; an automobile could not move on the level, much less climb a hill; no brakes would work; you could not use a ladder without nailing it down; etc. (Many others may be added here by the pupils.)

8. Gravity is used in weighing meat and groceries.

9. Inertia of motion helps keep the bicycle in balance. A moving body tends to keep moving in a straight line.

10. The inertia of the head moving down sends it on down the handle when the handle stops moving.

11. The inertia of the apples breaks them from the limbs before they can be made to move with the limbs.

12. The tallow or paraffine of the candle due to inertia will not crumble before it has passed through the board.

13. All occupy space and possess the property of inertia. *Cork* is soft, flexible, and light in weight; *glass* is transparent, smooth, and brittle; *rubber* is soft, impervious to water, and elastic; *air* is invisible, light in weight, and odorless; *coal* is black, hard or soft, and heavy; *asbestos* is fibrous, soft, and will not burn; *granite* is hard, heavy, and brittle; *aluminum* is light in weight, ductile, and a good heat conductor; *gold* is soft, heavy, and malleable; *quicksilver* is very heavy, pours like water, and silver-colored; *iron* is heavy, hard, and will rust; *lead* is heavy, soft, and malleable; a *sponge* is soft, light, and absorbent; *copper* is soft, ductile, and malleable; *bricks* are hard, porous, and brittle; *diamonds* are hard, translucent, and crystalline; *platinum* is ductile, heavy, and malleable.

Page 67. *Home Experiments:* **1.** The coin remains on the tumbler because the inertia of the coin does not allow it to be moved before the cardboard is knocked out.

2. All the named substances are more or less malleable except glass and stone. The most malleable are often used where the substance must take the shape of substances near it, such as rivets and pipe fittings. Others are used not because of their slight malleability, but because they are hard enough to withstand pressure without breaking.

3. The machines here developed will depend entirely upon the directions which go with the outfits and upon the ingenuity of the pupils.

PREVIEW OF PART II

THE WORK OF THE FACTORS OF OUR ENVIRONMENT

The pupil should now be ready to proceed with the study of the ways man is putting the leading factors of his environment to work. Air, fire, water, heat, light, electricity are all potential servants of man and the work of the scientist is to devise both new and better ways of using them.

Your problem will be to get the pupil into the spirit of making discoveries about his environment, scientific discoveries like those which he reads about in his text. Develop the right mental set on his part by constantly holding before him the idea that all of the interesting things he is now studying were found out by men who were once boys like himself.

From page 71 to page 427 the text focuses attention on the contributions which science has made in the field of mechanics. This should be a rich mine of information for the youthful scientist. Your problem will be to arouse his latent powers to concrete and useful accomplishment.

CHAPTER IV

PUTTING AIR TO WORK

Time Allotment

One period should be used on the introductory questions, *Suggested Experiments* (page 73), and reports on the *Home and Field Problems*. The equivalent of two periods may be spent on the problems in the pictures. If this is well done as the work proceeds, the text proper will need no more than two periods as it merely supplements the pictures. One period should be spent upon each of the *Key Demonstrations* in the chapter. One period for the *Key Words, Review Outline,* and *Summary;* one period for the *Thought Questions and Special Problem.* One period may be used for reports on *Suggested Experiments* assigned as *Special Problems* and one period for emphasis upon the hygiene of the ear.

The most important idea to develop in the minds of the pupils during the first ten pages of this chapter is that air is a real substance although it cannot be seen; that it is just as much a substance as iron or rocks are substances. This is to be conclusively proved by the *Suggested Experiments* on page 73. By these experiments the pupil discovers that the air satisfies the conditions which characterize a substance; namely, that a substance takes up space.

Next develop the fact that air has weight. This will be fully brought out in *Demonstration 4.* Each of the steps in this demonstration is spectacular and well worth showing. Individually and collectively, they have a most dramatic effect upon the pupil. Experience has shown that *Step A* gives the best results and is the one which should be written up in the Science Discovery Book. The others should be tried and discussed in the light of the first step.

Having established the fact that air weighs something, the material from pages 77 to 92 is easily comprehended by the pupil. There is absolutely no difficulty here. In Chapter III the pupil has already been impressed with the idea that moving things (water, air, falling bodies) can do work and that heat can cause motion. He is interested in motion, in action, in the dynamics of the environment. Now he sees for the first time that the inert air can do work in the barometer, in the pump, the siphon, vacuum cleaner, fountain pen, etc.

Then comes compressed air made plain in its principle by *Demonstration 7*. When the pupil has made the knowledge of atmospheric pressure and its applications in the world of work a part of his equipment, he has passed one of the important milestones in his journey into the field of science.

Demonstration 8 will give the pupil a concept of the cause of sound and of the air as the carrier of sound. Differences in sounds and their use and control in musical instruments are discussed in pages 99 to 104. Then comes the important discussion of sound and air in their relation to hearing. The hygiene of the ear cannot be overemphasized. Be sure to rationalize every rule, if you desire it to be of any value as a rule of conduct on the part of the pupil.

Page 70. *Key Picture 4.* The atmosphere becomes lighter as one ascends because there is less weight of air above any given mass of air. The balloon will rise higher than the airplane because it is a lighter apparatus and thus offers less resistance to an increasingly lighter pressure. The molecules of air are forced together because made to occupy a smaller space as the piston is pushed down. Since the air in the tire is greatly compressed and an elastic substance, the air forces the car off the ground and the weight of the car is carried on this mass of air. In a " blow-out " the air is allowed to come out with great force and in large masses. The sudden displacement of the surrounding air followed by its return to its original position causes the " slap " or report. The friction of the air against the tire edges intensifies the report.

NOTE: No balloon has been known to go over 42,000 feet so far.

Page 71. *Practical Questions:* **1.** The ball returns to its original shape because the air within is under greater pressure when its side is pressed in and this increased pressure tends to force the side out at once.

2. The air inside of the bottle is forced out by the heavier water entering the bottle.

3. A slight vacuum is formed between the palms, and the atmospheric pressure on the backs of the hands tends to hold them together.

4. Answers to this question will vary according to conditions.

5. Air under great compression can hold up the weight of an automobile because the tires are strong enough to hold the air in place, even though the weight of the car is upon this mass of air. In other words, the weight of the car is not great enough to cause the inclosed air to burst through the sides of the tires. Thus the car rides upon this cushion of air.

Page 72. *Home Problem:* The heated air inside the glass cools and contracts. This results in a partial vacuum, and the atmospheric pressure on the outside being greater keeps the glass tightly in place.

Field Problem: The report comes after the bag is burst. Light travels much faster than sound, therefore we can *see* the bag burst before we can *hear* the report.

Practical Questions are chiefly suggestive but by no means exhaust the field along this line. Their primary purpose is to establish a frame-work for the exposition of the chapter. They also recognize that the pupil may have something to contribute to the story of the chapter. The pupils, themselves, may be encouraged to make up many others all bearing on the chapter topic. Every encouragement should be given to such original work because of its great value in developing thought power.

Page 73. The first *Suggested Experiment* demonstrates that the water will rise but slightly in the tumbler, because the air in the tumbler keeps the water out. This air is invisible, but being a substance, it occupies space, else the cork would have risen to the top of the space in the tumbler. In the second *Suggested Experiment* the arm to which the bladder is attached will rise. There must be less weight suspended from this arm than before. Since the only substance lost was the air which was allowed to escape from the bladder, the air must weigh something. Therefore, air is a substance because it has weight and takes up space.

Page 74. *Figure 25.* Self-explanatory.

Page 75.

> **Great care should be taken with all *Key Demonstrations.* They are the keys which will unlock the main problems of the chapter in which they are found. Insistence upon the very best work on these problems will impress the pupils with the great importance of these keys. Constant reference to them as the work proceeds will convince the pupils of their value as keys.**

(*Key*) *Demonstration 4. Method A.* Be sure that the stopper exactly fits the can, making it airtight. Be sure to remove the can from the flame immediately after inserting the stopper. In *Method B* be sure that the cardboard is quite stiff and not too rough, else the seal will not be perfect.

Page 76. *Observations.* Note that the atmospheric pressure is equal from all sides on the surface of the varnish can. But in the case of the inverted tumbler, the glass bottom of the tumbler shuts out the pressure from the top. The water in the tumbler exerts less pressure on the cardboard than does the air which is pressing up from below against that part of the cardboard covering the open end of the tumbler. The directed atmospheric pressure keeps the cardboard in place.

Page 78. *Figure 27.* Hot air expands so that, volume for volume, cold air is heavier than hot air. The air particles are closer together outside the house because it is colder there.

Inside, the air is being warmed and this causes the air particles to separate. They are farther apart in the chimney than in the room because there is a greater amount of heat there. They rise through the register and elsewhere because their mass is relatively lighter than that of the cold air which surrounds it. They go out the window at **y** and enter at **x** for the same reason, because they are closer together than at **y** and therefore relatively heavier. They are closer together at the walls than in the center of the room because the area near the walls is cooler.

Page 80. (*Key*) *Demonstration 5.*

NOTE: The use of a paper funnel facilitates the filling of the tube with mercury.

Observations: The mercury column will fall until the atmospheric pressure on the surface of the mercury in the dish is exactly equal to the downward pressure of the column of mercury in the tube. The space above the mercury in the tube is largely devoid of air since it was at first full of mercury. It was formed by the falling of the mercury column. This space is named after the man who first caused it to be formed in his experiment (Torricelli). This column of mercury may be measured and it will be found to vary from day to day. Thus the atmospheric pressure may be measured. The greater the pressure the taller the column of mercury in the tube.

Page 81. *Section 56.* Air weighs less for any given volume on top of Mt. Everest and more on the shores of the Dead Sea. This is because there is less weight above the given mass of air on Mt. Everest than above the given mass of air at the Dead Sea.

Figure 28. The mercury column is the resistance; the effort is the weight of air above the mercury in the dish. The fulcrum is the lower edge of the glass tube in the mercury.

Page 82. *Figure 29.* The light hand registers the mean pressure; the dark, shows the actual pressure. The atmospheric pressure causes the drum to contract or to expand according as this pressure varies. **c** and **b** will be raised or lowered. This motion will be transmitted through the levers **d, d, d** to the chain **e**; the spool at **f** will revolve one way or the other; the hand at **h** will move to the right or left. Levers, an inclined plane, and a wheel and axle are machines shown here. Atmospheric pressure changes make them work.

Page 84. (*Key*) *Demonstration 6. Observations:* Air fills all of the tubes. The air is forced out or drawn out of the tubes and the water is forced in by the atmospheric pressure. The air pressure on the inside and outside of the tubes is unequal. The water rises to equalize the pressure in each case. This water in the tubes corresponds to the mercury in the Torricelli barometer. Water is more active than mercury because it weighs (volume for volume) only about $\frac{1}{13}$ as much as mercury. The valve in the pump allows water to pass upward when the piston is lowered. The piston forms a partial vacuum in the pump barrel and also raises the water above it when it is raised. The water will leave the pump through the spout.

Page 85. *Figure 31.* Active energy is used here.

Page 86. *Figure 32.* **1.** The atmospheric pressure is the same in the barrel, inlet pipe, and on the water in the well when the pump is not in use and the piston is down.

2. The air becomes rarefied in the barrel and the atmospheric pressure is thus much reduced.

3. A partial vacuum is formed in the inlet pipe and barrel.

4. Valve **g** is raised by the greater pressure of the atmosphere on the surface of the water in the well.

5. The atmospheric pressure above the valve **f** keeps it closed.

6. In **C** valve **f** opens because the compression of the air below it, due to the lowering of the piston, is greater than the atmospheric pressure above it. The compression of the air above valve **g** by the lowering piston shuts this valve.

7. The atmospheric pressure at **a** forces the water up the inlet pipe. The constant atmospheric pressure at **a** holds the water at this level. The pressure at **a** and in the inlet pipe is unequal, else the water would not stay in the pipe. The weight of the column of water in the pipe is less than the force exerted on the column of water by the atmosphere at **a**.

8. In **D** the rising column of water forces valve **g** open and the atmospheric pressure above **f** keeps it closed.

9. Valve **f** is opened by the pressure of the water below it. The water above valve **g** closes it, due to its weight.

10. Valve **g** is opened by the water pressure below it and valve **f** is closed by the weight of the water above it. Gravity causes water to run out of the spout **d**.

11. The rise of water in the barrel is caused by the piston raising it and the pressure of the water below. In the inlet pipe the water is raised by the atmospheric pressure at **a**.

12. Description will vary here. The column of water in the inlet pipe and barrel will exactly equal the atmospheric pressure at **a** as it flows from the spout.

Page 87. *Figure 33.* The upper arrows indicate atmospheric pressure on the surface of the liquid in the upper jar. Arrows could be correctly used over the lower jar as well. Once the flow has begun, gravity helps in the flow of the liquid through the two tubes since the atmospheric pressure in the two jars is equal.

Page 88. The laws of the siphon are: The receiving container must be lower than the discharging one. An external factor is necessary to start the operation.

Figure 34. A partial vacuum in the tube below the piston, due to the raising of the piston, causes a rapid flow of air into the suction spout and this fills out the muslin bag. The dust is carried through the spout into the bag and falls down upon the cork around the inside end of the spout.

Suggested Experiment: The dirt will rise through the spout and pass into the barrel of the cleaner where it drops to the surface of the cork because of its weight. The air passes on through the muslin and through the piston valve. The dirt cannot get out readily. On the upstroke of the piston the piston valve closes, due to the unequal atmospheric pressure on either side of the piston, but when the piston is lowered, the valve opens because the compression of the air in the barrel causes it to exert a greater pressure than that of the atmosphere on the upper surface of the piston.

Page 91. *Figure 35.* Air enters the bulb at **b** when the bulb is allowed to expand, forming a partial vacuum. Air enters at **e** because the atmospheric pressure is reduced at **c.** The spray is caused by the compressed air vaporizing the liquid from the bottle at **d.** The lever forces the air partly out of **a.** The atmospheric pressure forces the ink into **a** when the lever is released. The steam forces most of the air out of the jar. The rubber ring keeps the air out by sealing the can when the cap is screwed on. The cap keeps the air out of the can. The air is forced out of the holes in the sole of the shoes by the weight of the person wearing them and the atmospheric pressure on the outside of the shoe tends to keep the shoe in place on the floor, thus preventing slipping. By pressing down on the drain pump handle the air is forced out of the bell. Then on lifting the bell by pulling up on the handle the partial vacuum inside is increased and the atmospheric pressure below the stoppage in the pipe forces the obstruction up into the bell and the drain pipe is cleaned. The atmospheric pressure on the surface of the water in the glass tumbler at **y** forces the water up the tube **x** when the air is withdrawn from this tube by the mouth.

NOTE: The large brass bell used by the plumbers for cleaning out badly stopped pipes is a force pump which actually forces the obstruction down the pipe by compressed air.

Page 92. *Demonstration 7:* This is self-explanatory and the questions are easily answered by the pupils.

Page 93. *Figure 36.* Atmospheric pressure is used here exactly as it was used in *Figure 32.* It forces the water up into the air chamber and compresses the air in this chamber. The compressed air forces the water out of the spout in a steady stream. Without this constant pressure the water flow would almost stop from the spout while the piston was being raised in the lift pump part. The inlet valve rises when the piston is raised because of the greater pressure below the valve than above it. This pressure is due to the formation of a partial vacuum above the valve. When the piston is lowered, the weight and pressure of the water above the valve closes the valve. The outlet valve then opens because of the pressure of the water below it. When the piston is raised, the water above the outlet valve presses down on the valve, closing it immediately. This downward pressure is due both to the compressed air and to the weight of the water.

Page 94. *Figure 37.* A partial vacuum is formed below the piston when it is raised. The air above the piston will be forced below it by the greater pressure above it. As the piston descends it exerts pressure on the air below it. The compressed air pushes against the tire valve, opens it, and slides past it into the tire. The valve has a spring which closes it instantly as the piston rises again to repeat the process. The air enters the pump barrel through the small hole in the cap of the barrel and slides past the piston.

Page 95. *Figure 38.*

1. The different air chambers gradually prepare the bodies of the workers for the high air pressures below.

2. The coverings prevent the lowering of the pressure in the chambers below.

3. This allows the dirt to be carried from chamber **a** to **g** and then to **o** without losing the pressure in the chambers below.

4. This 50-pound pressure keeps the water and mud out of the excavating chamber.

5. The men can work but a few hours under such great pressure and have to be relieved.

6. They rest in each chamber to get used to the increased (or reduced) pressure in each.

7. The trap doors prevent the equalizing of pressure in all the chambers.

8. More sections are riveted on the top to increase the height.

9. Its weight carries it down deeper as the earth is removed from beneath it.

10. The great pressure of the air interferes with the circulation of the blood. If too long continued or too rapidly changed, it often causes a condition called "the bends," which sometimes is fatal.

11. **f** is a passageway for the men. **p** pumps air to the excavating chamber. **m** is a derrick which loads the excavated material on to a scow. **l** is a tug which tows the scow. **i** is the mud which is being excavated or the base of the body of water. **j** is the water and **k** is the scow into which the excavated material is being loaded.

Page 96. *Suggested Experiment:* The answers to all questions here will be obvious as the experiment proceeds.

Page 98. (*Key*) *Demonstration 8. Conclusions:*

1. Sound is caused by some vibrating substance.

2. All vibrating substances vary in their ability to produce sound.

3. The number of vibrations per second determine the intensity of sounds.

4. The air carries sound from one place to another.

5. A metal (steel) carries sound best.

6. The air carries vibrations of substances.

Page 99. *Suggested Experiment:* The answers to all questions here will be obvious as the experiment proceeds.

Page 100. *Figure 40.* In **A** sound is caused by the vibrating violin strings. In **B** a vibrating column of air causes the sound in the horn. In **C** a vibrating drum head next to a vibrating mass of air causes the sound. In **D** a vibrating column of air causes the sound. The pitch in **A** is caused by changing the lengths of the vibrating strings by application of the fingers at the neck of the instrument. In B the keys shorten or lengthen the columns of air in the horn. In D the stops do the same thing. A drum can be but partially tuned. This is because there is a very restricted limit to the stretching of the drum head. The hole in the side of the drum allows air to enter the drum, equalizing the pressure on both sides of the head and preventing its bursting when beaten by the drumsticks.

Page 102. *Figure 41.* Self-explanatory.

Page 103. *Figure 42.* The increased size of the resonator allows the vibrations of a larger volume of air and this increases the volume of sound. Vibrations from the end of the needle as it passes over uneven spots in the record are carried to the mica disk of the reproducer, which in turn is vibrated. The vibrations are magnified in the reproducer and again in the resonator.

Page 104. *Suggested Experiment:* The cause of sound in the can is due to the resin-coated cord which transmits the sound vibrations from one can to the other. The air chamber in the first can vibrates in unison with the vibrating cord because the bottom of the can is thin enough to repeat the cord vibrations. The air carried the vibrations to the ear, and the farther away the can was from the ear, the weaker the vibrations; the closer, the stronger. The outside flaring part of the ear catches these vibrations and centers them in the ear canal against the drum.

Page 105. *Figure 43A* is self-explanatory. *Figure 43B.* The ear interprets sound vibrations as sound. The vocal cords cause vibrations in the air which are recognized by the ear as sound. The tube from the ear to the throat allows air to pass through the mouth to the back of the ear drum, thus equalizing the atmospheric pressure on both sides of the drum and allowing the drum to vibrate easily. This also prevents its rupture. The tightening or relaxing of the vocal cords controls the rapidity or slowness of their vibrations and thus controls the pitch and tone of the voice.

Page 106. 1. "Boxing" the ears may burst the ear drum, permanently injuring the hearing. This is due to sudden unequal pressure on both sides of the ear drum.

2. Wax often prevents proper vibration of ear drum, thus affecting the hearing.

3. The sharp instrument may puncture the ear drum, permanently injuring the hearing.

4. The bathing cap will tend to prevent pressure upon the ear drum and keep water out of the ears.

5. Insects may enter the ears, causing great irritation and intense pain.

6. Nose and throat trouble may affect the hearing, due to congestion and partial closing up of the passageway from the throat to the ear.

Page 109. *Thought Questions:* **1.** The bag bursts because of the suddenly increased pressure at the point opposite to where the blow is struck. The wall of the bag cannot withstand this pressure and bursts. The noise is caused by the impact of the released air suddenly coming from the bag, which sets up violent vibrations in the air about the bag.

2. The illuminating gas particles are lighter than the air particles and so tend to separate, pass between, and mix with the air particles as in the case of the water vapor (page 83).

3. Greatly reduced atmospheric pressure allows the inside pressure in the body to exceed that on the outside and the blood is forced out through breaks in the capillaries in the thin lining of the nose.

Page 110. 4. Dust and papers follow after a fast-moving train because a partial vacuum is formed behind the train, due to its speed. The air rushes in behind the train to fill the vacuum, picking up dust and papers and forcing them after the moving train.

5. The lifting of the feet in the mud tends to form a vacuum beneath them and the atmospheric pressure from above presses down upon the top of the feet with enough force to make it difficult to lift the feet out of the mud.

6. There is not much difference in weight, but the inflated tire is slightly heavier (page 73) and therefore one would prefer to carry the lighter tire (deflated one).

7. The sudden opening of a door outward reduces the atmospheric pressure in the room and any other door unlatched in the room will be forced open (if the door naturally opens inward), due to the greater pressure on its other side. Similarly, a door opening inward, if suddenly opened, will increase the atmospheric pressure in the room and any other door in that room which is unlatched will be closed or still further opened, depending upon whether it opens inward or outward.

8. The downward pressure of the atmosphere upon the surface of the mercury in the dish due to gravity keeps the mercury up in the tube because the weight of the mercury column exactly equals the atmospheric pressure on the mercury surface. In other words, the weight of the mercury column and the weight of the column of atmosphere of equal diameter above the mercury in the dish are exactly equal.

9. The atmospheric pressure is constantly reduced as the balloon rises until the outward pressure of the gas in the balloon exceeds the atmospheric pressure on the outside of the balloon and it will then burst.

10. The drummer strikes the cymbals, causing them to vibrate and the surrounding air to vibrate, emitting sound. He then touches them, stopping the vibration, and the sound ceases.

Special Problem: This problem should be self-explanatory. It may be added that normal hearing includes distances up to two feet, so that 18 inches may be said to be the very minimum of the normal hearing distance. To find it difficult to hear the watch ticking at 18 inches indicates abnormal hearing.

Page 111.

Special Problems: The *Appendix* will furnish many problems which can be assigned to the individual pupils for special work. Better, they may be assigned to groups of pupils with a pupil chairman. Reports by these committees to the class will be a great factor in the development of the socialized recitation period. Many new problems may be suggested and developed by the pupils themselves. Encouragement and guidance by the teacher is the big requisite here.

CHAPTER V

AIR, FIRE, AND LIVING THINGS

Time Allotment

One period will be used in developing the *Introductory Chat, Practical Questions, Home* and *Field Problems,* and *Key Picture.*

Four periods will be spent upon the *Key Demonstrations,* because once these have been performed, the text material itself becomes secondary and merely supplementary to them. The text itself will give the pupil a fund of material to read in order to enrich the concepts developed in he demonstrations.

The actual text will occupy the equivalent of three periods. One period may be devoted to reports on selected *Special Problems* or *Suggested Experiments.* One period may be devoted to the pictures; one period to the *Key Words, Review Outline,* and *Summary,* and one period to the *Thought Questions.*

There are four important topics in this chapter which need to be fully developed: (1) the composition of air and its relation to combustion; (2) the nature, effect, and control of oxidation; (3) the products of combustion; and (4) the interrelation of the human body and oxidation with life.

This is one of the most thought-provoking chapters in the whole book. It is a great accomplishment to have the child understand that he gets his energy to do work by oxidizing his body and that all living things do the same thing. It shows that man is part and parcel of his immediate environment and that he does work because he is made up of the very things that when burned in his environment make it possible for work to be done.

(*Key*) *Demonstrations 9* and *10* clear up the problems involved in developing the first major topic. The parts of air which do not support combustion are considered in *Suggested Experiments* on pages 117 and 118. (*Key*) *Demonstration 11* gives the groundwork for the second topic. Just here the *Key Picture* may be intensively studied with profit. Too much emphasis cannot be placed upon fire control (pages 121 to 127, also pages 243 to 248). It should also be clearly brought out that the rusting of iron filings (page 126), the oxidation in the plant and animal body, and the burning of coal in the furnace are one and the same process. They differ only in rate of oxidation. This is important.

(*Key*) *Demonstration 13* gives the foundation for the third topic. On this demonstration are based the discussion of "breathing" (in man, fish, insects, and plant), the *Special Problems* and *Suggested Experiment* directly relating to it (page 130), and the concept of cells and tissues in living things.

(*Key*) *Demonstration 14* is here brought in for its significance in relation to all aquatic life. The necessity and advantage of deep breathing logically follows, together with a study of artificial breathing for use in emergencies.

Finally, the most important problem of ventilation, the basis of the fourth topic, revolves about (*Key*) *Demonstration 16* with full explanation of the factors entering into the problem on pages 143 to 147.

Page 112. *Key Picture 5.* **A, B, C, D,** and **E** all represent physical changes. In **K** and **F** a chemical change is taking place. In **I** the melting ice is a physical change, but the rusting of the exposed shingle nails is a chemical change.

The melting ice and broken window-pane are both physical, while the rotting shingles and rusting shingle nails are both chemical changes. In **F, G, H,** and **L** oxidation or a burning is taking place (though in some cases it is very slow). In **J** there is a physical change taking place. At **N** both a physical change (boiling water) and a chemical change (burning of gas) are taking place. In **M** we have a symbolic interpretation of the burning process, two atoms of oxygen (O_2) join with one atom of carbon (C), producing a molecule of three atoms (CO_2) — carbon dioxide. In the same way one atom of oxygen combines with two atoms of hydrogen to form a molecule of water (H_2O). This explains what actually happens in the burning of the carbon and hydrogen in the candle and in the wood.

Page 113. *Practical Questions:* **1.** A match lights by friction. The friction generates heat enough to ignite the oxidizable compounds in the head of the match and these in turn ignite the carbon in the match stick.

2. Just enough air gets in through small crevices in the stove to supply enough oxygen to keep the fire burning.

3. The steam filling the hold cuts off the air supply and the fire goes out for lack of oxygen.

4. The human body is like an engine. It uses fuel (food) and burns this to release heat energy. But it needs oxygen to burn this fuel.

5. Deep breathing gets in more oxygen because more air sacs are used and filled with air. More oxygen allows the burning of more fuel in the body, thus releasing more heat and giving more energy with which to do work.

Home Problems: In each problem (**1** and **2**) the supply of air (oxygen) is much reduced and the fire is checked or goes out altogether.

Page 114. *Field Problem:* The fire is " put out " because the water cools the burning material to a temperature below its kindling point. Or the water when striking the burning material is instantly formed into steam, which forms a blanket over and about the fire, cutting off the full supply of air, and the fire dies for lack of oxygen.

> ***Key Pictures:*** **Constant reference should be made to the *Key Pictures* as each chapter proceeds. They are a valuable aid in making a concrete presentation of concepts which would otherwise be difficult of acquisition by the pupil. Furthermore, they are the nuclei of the various chapters which they introduce. If time permits, it will be well to have the pupils design other *Key Pictures* in their *Science Discovery Books* or on special charts which can be hung up in the room and constantly used in the discussions of the chapter.**

Page 115. (*Key*) *Demonstration 9. Observations:* In both jars burning takes place. Air filled both jars at first. The candle in the covered jar burned out because the air supply was exhausted. The other continued to burn because the air supply was not cut off.

Practical Applications: A fire burns best when given a full supply of air. If too much air is given a fire in the form of a draft, the fire may be blown out. The easiest way to check a fire is to cut off its air supply. Cover up a small fire and it will " go out." Stepping on a burning match cuts off the air supply. Blowing on a smoldering fire forces air into all parts of the mass, thus providing additional flame.

Suggested Experiment: The jar was first full of air. The water rises in the jar because the atmospheric pressure outside forces it up to take the place of the air (oxygen) used up in the jar by the burning of the phosphorus. The water stopped rising when the oxygen was all used up. Something else in the jar must occupy the remaining space. The phosphorus " went out " when the oxygen was all used up. The water goes up about $\frac{1}{5}$ of the way in the jar, showing that oxygen comprises about 20% (20.9% to be accurate) of the atmosphere. This shows that the air is composed of more than one substance, since there is still something in the jar not yet burned or used up. The other substance or substances must occupy about $\frac{4}{5}$ of the atmosphere.

Page 116. *Figure 45.* The long rubber tubing makes an easy connection between the test tube and the shallow dish. The heat drives out the oxygen from the chemical compound. The bottle containing water permits the collection of the gas by displacement of the water. The atmospheric pressure on the surface of the water in the shallow dish keeps the water in the bottle until it is driven out by the gas.

Page 117. (*Key*) *Demonstration 10. Observations:* **1.** Air.

2. The air was driven out when the water went in.

3. A gas took the place of the water.

4. The gas forced the water out.

5. The splint burned brightly in the bottle.

6. A candle burns in the air because a gas in the air makes it burn.

7. Oxygen is a very active gas.

Practical Applications: The steel doors keep out much of the oxygen. More oxygen in the air would cause things to burn much more readily than at present. An oxygen-hydrogen flame is hot because the hydrogen burns very readily. The pure oxygen in direct contact with it causes it to burn rapidly and completely, releasing much heat.

Suggested Experiment: The heating of the nitrite produces nitrogen. The match should go out. Nitrogen will not support burning. Nitrogen in the air serves to control burning by mixing with the oxygen of the air. The diluted or " thinned out " oxygen is naturally less active.

Suggested Experiment: The limewater should turn milky. The lighted wood splint should be extinguished. The limewater will again turn milky. The candle flame will deposit soot (unburned carbon) on the glass with some moisture. The wood splint will cause a like deposit. Oxygen makes both the candle and the wood splint burn. Some hydrogen in both the wood and the candle must have burned to produce the water (H_2O). See *Key Picture 5.* The limewater in the bottle turned milky. Two products of burning wood, then, are CO_2 and H_2O.

Page 118. *Suggested Experiment:* Heat will be generated in the bottle. The contents of the bottle will bubble (effervesce). Chemical energy is here shown. The lighted match is extinguished. Carbon dioxide extinguishes a flame. This gas is odorless. It is colorless and it is invisible. Carbon dioxide, then, is a colorless, odorless, non-inflammable, invisible gas.

Page 120. (*Key*) *Demonstration 11. Observations:* The phosphorus first begins to burn, followed by sulphur, paper, and wood in the order named. The phosphorus has a very low kindling temperature. The other three substances have correspondingly higher kindling temperatures in the order named. Most substances which will burn have different kindling temperature from those of other substances.

Page 121. *Practical Application:* Water keeps the air away from the phosphorus, thus preventing it from kindling. The phosphorus might be sealed in an air-tight can. Different materials are used in building a fire because each has a different kindling temperature, those having the lowest (paper) being placed in first to start the fire. The phosphorus compounds on the match head ignite as the match is scratched and these in turn raise the paraffine on the match stick and the carbon of the match stick to their kindling temperature. The outer covering of the match head prevents its burning before struck. The safety match must, of course, come in contact with a specially prepared surface before it will ignite.

Page 121. *Section 94.* Nitrogen is a colorless, odorless gas. Air is a colorless, odorless gas. Carbon dioxide is a colorless, odorless gas. Both gases differ in one chemical property from oxygen — they will not support combustion.

Page 122. *Figure 47.* Some causes of forest fires are: Lightning, dropping a lighted match on the forest floor, leaving camp fires burning, self-ignition of dry leaves in extremely hot weather. Most fires may be prevented by exercise of care in extinguishing all fires before leaving them, by imposing heavy penalties for violation of forest fire laws, by use of fire towers and fire wardens, and by education of the people in the values of forests.

Page 124. *Section 98.* **1.** Physical changes: A rolling stone, breaking a stick, running water, melting butter, blowing out a tire, sharpening a pencil, sweeping a floor, chopping meat, batting a ball, lifting a chair, etc. Chemical changes: A burning building, burning coal, burning oil, an acid "eating" cloth, the sun "fading" or bleaching cloth, developing a photographic plate, changing cider to vinegar, raising bread by yeast, digesting food, etc. In **2** the answers will be based, usually, on **1.**

Section 99. Paper goes in first, then wood, and finally coal. The coal would not ignite from a match flame because it has a very high kindling temperature. It must be gradually warmed to its kindling temperature. Wood, paper, and coal all ignite at different temperatures. The particles are less closely joined in paper than in wood and less closely joined in wood than in coal. Besides, the paper is thinner and more easily heated. The damper in the pipe should be open. The front draft should also be open. One should always avoid having highly inflammable material near the stove and one should never use kerosene oil to make the fire start more easily.

Page 125. *Figure 48.* The text of *section 100* answers these questions adequately. The question at the end of this section is answered by draft and fuel regulation.

Page 126. *Demonstration 12. Observations:* The water did not rise farther because all the oxygen that could be possibly used up was consumed. The iron filings should become rusty in color. They have really been oxidized, the rust being the oxide of iron. The water came up into the tube to take the place of the oxygen used up in the oxidation process. Oxygen from the air went into the rusted iron to form the oxide of iron (rust). Oxidation took place here and it can go on without a flame. No flame is seen here or heat felt. The process was very slow.

Page 127. *Section 102.* If the surface is covered by a substance (paint) which cuts off oxygen and moisture, slow oxidation (decay) of wood or the rusting of iron cannot occur. **1.** This will include rotting fences, boards, rusting nails, iron, rails, iron work, tarnished copper and silver, etc.

2. This slow oxidation may be checked by the use of paint, oil, grease, wood veneers, concrete, etc.

3. Copper, nickel, brass, gold, bronze, and zinc will not easily oxidize.

Page 128. (*Key*) *Demonstration 13. Observations:* The limewater should turn milky in each case, indicating the presence of carbon dioxide. This gas is produced by the oxidization of carbon. It is the oxide of carbon. This same gas was produced in the *Suggested Experiment* with the burning candle on page 117. Oxidation.

Conclusion: Oxidation goes on in plants, fishes, and human beings. We know this because they all produce the same substance, carbon dioxide, which is generally a product of oxidation. Oxidation in living things is slow oxidation. All living things carry on this process, because all use oxygen and give off carbon dioxide and all release heat as a result of the process. Carbon and hydrogen must burn in the body to produce CO_2 and release heat. Water vapor is often noticed upon the window-pane. Water is also given off from the body. Oxidation produced this vapor (at least in part). Hydrogen must have been burned to produce it.

Figure 50. The limewater comes into direct contact with the air over the seeds. The stopper prevented the loss of the gas. The seeds, fish, and boy are all alike in that they all need oxygen and all give off carbon dioxide.

Page 129. *Section 104.* Exercise increases oxidation. One breathes faster to get more oxygen. This is done to burn up more body tissues to release more heat to do more exercising. The heart beats faster to get more food and oxygen to all parts of the body and to take the wastes away from these parts. The higher pulse is caused by a quickened beating of the heart. The higher temperature which is but momentary is caused by the sudden extra burning of the tissues.

Figure 51. The atmospheric pressure is reduced in the jar because the space in the jar is increased by lowering the rubber tissue. The air on the outside rushes into the balloons to fill up this partial vacuum, and all it can do is to expand the balloons. When the tissue is pushed up, the space in the bell jar is reduced and this causes the balloons to collapse, owing to increased pressure upon their sides. The air is thus forced out of the balloons. The air molecules are forced closer together in the right-hand jar due to greater pressure upon them. In the left-hand jar they are farther apart because the pressure is reduced.

Page 130. *Suggested Experiment:* **1.** The balloons fill with air.

2. They fill when the rubber tissue is pulled down.

3. They empty when the pushing up of the tissue reduces the space, thereby increasing the pressure in the jar.

4. The space is greater in the jar when tissue is pulled down and less when it is pushed up.

5. Atmospheric pressure forces air into the balloons and air pressure (compressed air) forces this air out of the balloons.

6. A partial vacuum is formed as the tissue is pulled down.

7. Muscles pull the diaphragm down.

8. This action enlarges the chest cavity.

9. Air rushes into the lungs to fill this partial vacuum.

10. We do not " suck " air into our lungs.

11. Atmospheric pressure makes our lungs expand.

12. The lungs collapse because of the pressure of the ribs above and the diaphragm below.

13. Muscles cause the ribs to rise and fall.

Science Discovery Book entries: **1.** A person breathes by increasing the lung cavity and allowing the air to rush into the lungs. By reducing the size of the chest cavity the lungs are caused to collapse and the carbon dioxide, water, and other substances are forced out of the lungs.

2. The larger the lung capacity, the larger the supply of oxygen for the body tissues.

3. Standing up straight gives the lungs a better chance to work properly.

4. Tight belts or other tight clothing about the body trunk prevent the proper action of the diaphragm.

Special Problems: **1.** Setting-up exercises will give the quickest results here.

2. Using a rubber tube, each boy can see how many times he must empty the air capacity of his lungs into the bottle before all the water is driven out. Find a bottle which will hold just as much water as you can expel by one exhalation. Then measure the contents of the bottle. This will be your lung capacity.

Page 131. *Figure 52.* Self-explanatory.

Page 133. *Figure 53A.* All are composed of units. Some are alive (cells in man's cheek and cells in leaf) and some are not alive (bricks in chimney). Parts of the cell: Cell wall, protoplasm, nucleus.

Page 134. *Laboratory Exercise:* The movement of the protoplasm in the Elodea is evidence that it is a living substance. The small oval green bodies are chloroplasts (protoplasmic bodies colored with chlorophyll) which are carried about the cell in the stream of protoplasm. In the observation of the onion or tulip leaf, a very thin surface tissue is to be used; and to see the stomata properly, the material must be covered at all times with water under a cover glass on a slide.

Figure 53B. A group of organs make up an organism.

Page 135. *Section 112.* Red corpuscles pick up oxygen in the walls of the air sacs of the lungs. This cargo is oxygen.

This cargo is exchanged for carbon dioxide in the capillaries all over the body.

(*Key*) *Demonstration 14. Observations:* The heat drives out some of the oxygen in solution in the water. These are oxygen bubbles. This is proved by the fact that the fish by its actions shows lack of air (oxygen) for respiration. It is uneasy in the boiled water but contented in the unboiled water. The first jar contained oxygen which the second jar largely lacked. We conclude that ordinary water contains oxygen. This same idea may be easily shown by connecting an exhaust pump to the top of a flask containing water and a fish. Much of the oxygen will be withdrawn from the water.

Page 136. *Figure 54.* Self-explanatory. Note that every living thing here contains the same elements and is composed of the same substance — protoplasm.

Page 137. *Figure 55.* Water in an aquarium which contains no plants must be changed often to give the fish a fresh supply of oxygenated water. Where plants are found they furnish the fish with this oxygen.

Page 138. *Figure 56.* Self-explanatory. The object of vigorous exercise, then, is to stir up the volume of residual air in the lungs and replace it with a new supply. A short-winded person is one whose breathing organs are not accustomed to having their supply of residual air stirred up. Getting your "second wind" means that you have completely changed the residual air and then have a reserve supply to use as you exercise (run).

Page 140. *Demonstration 15. Observations:* This method allows full, easy, and effective movements on the part of the rescuer. It also allows the patient to rest in a natural position and offers an easy outlet for the water.

Figure 57. Upper Picture: The patient is in such a position that water easily runs out of the lungs and mouth. The rescuer uses the force of gravity to aid him in his work. *Lower Picture:* The down thrust forces water from the lungs.

The release of pressure allows the lungs to expand partially and some air rushes into them.

Page 141. *Section 116.* Smoke tends to rise. Consequently there will be less smoke near the floor. *Section 117.* Ventilation is the exchange of impure air for pure air in a room through openings (windows and doors). Because living things must have oxygen. *Suggested Experiment:* The candles will be extinguished. The limewater should turn milky. Carbon dioxide from the burning candles accomplishes this. Generally, about two minutes elapse before the flames expire. With all holes open the candles will burn indefinitely, because fresh oxygen is allowed to come in and the carbon dioxide passes out, due to the setting up of a draft. Ventilation is the exchange of fresh air for air not so fresh, as in a room.

Page 142. (*Key*) *Demonstration 16. Observations:* In both the first and second tests the candles should sputter and burn unsteadily and nearly "go out." In the third test they should burn steadily and indefinitely. This latter result is due to the entrance of plenty of oxygen supplied by the air currents set up across the top of the box, down the side farthest from the windows, and across the bottom near the candle flames.

Conclusion: The best method of ventilating a room is to open one or more windows at the top and bottom on one side of the room. Applications of this principle to rooms of individual pupils will vary according to the conditions to be met.

Page 143. *Special Problems:* **1.** This problem is best worked out by the use of a textbook in zoölogy and by actual observations on specimens of the animals named.

2. All the cells will probably have cell walls, protoplasm, and nuclei. All may be shaped differently and may be differently colored.

3. The best results here will be accomplished by periodic practice.

4. Read A. Williams' *How It Works* and *A Book of the Sea*, Nelson Co., also *Book of Knowledge*, Grolier Society, for work of divers.

5. This organization work may be best done by communicating with the *Red Cross Society, Washington, D. C.*

6. All will probably be alike in having cell walls, protoplasm, and nuclei. The tulip cells will be oblong, greenish in color, and with relatively thick walls; these cells will be separated in some places by stomata (page 134), which allow an exchange of gases. The onion cells will show the same characteristics, but with no green color.

The mouth cells will be colorless, irregular, and thin-walled.

Page 146. *Figure 59A.* Cold air, being heavier, comes into the room at the lower opening of the window and drives the warm air up and out of the upper opening of the window. In *Figure 59B* a fan drives warmed, fresh air into the top of the room in order to avoid drafts and another fan draws the foul air out of the bottom of the room. The windows and doors are supposed to remain closed.

Page 148.

> ***The Summary:*** **To test out the use of these summaries assign one sentence to a pupil and have each orally explain the assigned sentence or tell a story about it in his own words. This practice will be most valuable in the enlargement of the pupil's stock of ideas and in the development of his ability to express himself regarding scientific concepts.**

Page 150. *Thought Questions:* **1.** The foot shuts off the air (oxygen) from the flame.

2. Using the bellows increases the supply of oxygen by forcing air into the mass.

3. The products of burning substances are always compounds because oxygen always enters into a chemical combination with the substance burned to produce a new substance.

4. First, a physical change took place in the breaking of the pencil. Secondly, a chemical change took place in the burning of the pencil. In the first change the form only of the substance was changed. In the second change both the form and the nature of the wood was changed (wood to gases and ashes).

5. The warm air is forced up to the top of the room by the colder air below.

6. Gasoline quickly evaporates and fills the whole room with a gas which is very easily ignited because of its low kindling temperature.

7. The oil and wick contain hydrogen which when burned forms H_2O, the oxide of hydrogen.

8. Burning gas grates or heaters in a living room use up a large proportion of the oxygen which should be used by persons in the room.

9. The insect uses spiracles situated on the abdomen and mesothorax and which open into branching trachea running through the body. The movements of the body wall of the insect cause an exchange of gases in these organs. In the fish, thin-walled gills are richly supplied with blood vessels which are near the surface and almost come into contact with water forced over these gills by the movements of the fish's mouth and the opercular flaps at the side of the head. Here the exchange of gases takes place. In man, a full respiratory apparatus is found, consisting of lungs, air sacs, bronchial tubes, windpipe, mouth, and nasal passages. The diaphragm and the ribs control the increase and decrease of the chest cavity capacity and the air rushes into the lungs or is forced out as the ribs and diaphragm act.

10. The sleeping room should be ventilated in order to maintain an adequate supply of oxygen with a corresponding removal of the carbon dioxide and a circulation of air in the room.

11. The draft will be outward at the top and inward at the bottom. This is due to the warm air being forced out by the heavier cold air which enters at the bottom. Rising particles of warm air are replaced by the cold air, thus maintaining the equilibrium of atmospheric pressure.

12. Covering the burning clothing with a blanket cuts off the oxygen and the fire is generally extinguished.

13. The gas from the fire extinguisher, being noninflammable, forms a blanket over the fire and cuts off the oxygen from it.

14. Giving a furnace fire plenty of oxygen insures a good fire, provided the fuel is good. This means putting on limited amounts of fuel and keeping the ashpit free of ashes.

15. Dust, bacteria, odors, too much water vapor, or too much carbon dioxide will all make air impure.

Page 151.

Books Which Will Help You: **The books listed throughout the text are not supposed to form an exhaustive list. The teacher should add to the list as occasion and opportunity offer. The pupils also should be encouraged to be on the lookout for books bearing upon the topics under discussion. Reports upon various phases of these books should occasionally be called for.**

CHAPTER VI

THE USE OF WATER IN THE HOME

Time Allotment

Three periods will be used on the (*Key*) *Demonstrations.* Two periods will be spent on the text proper. The equivalent of one period on the *Introductory Chat, Practical Questions, Home* and *Field Problems,* and on the pictures and their explanation will be needed. One period may be used on the *Thought Questions* and one period on *Key Words* made up by the pupils or on the *Review Outline* and *Summary.*

Page 152. *Key Picture 6.* Equal volumes of air and of water differ in weight because there are more molecules in the body of water than in the body of air. As molecules are composed of matter and weigh something, the water must weigh, volume for volume, much more than the air. (Of course, it is impossible to show in the cut the relative differences in the number of molecules in air and water.) The pressure at the bottom of the column of water is due to the fact that every cube of water added above means $62\frac{1}{2}$ pounds added to the total weight of any body of water. The opening of the pipe is $\frac{1}{144}$ as large as the area of the tank bottom. The pressure in this small pipe is less (144th as much) than in a pipe one foot square.

Page 153. *Practical Questions:* **1.** Artesian well water comes from a great depth and from low rock strata which pollution can seldom reach.

2. Waters differ in taste and odor because they often pass through different materials (sulphur, lime, iron, etc.) which are dissolved in them.

3. In both cases water pressure, due to the weight of water stored at some point and connected with the system, causes the flow.

4. A fire near at hand requires large amounts of water to put it out; clogged pipes; or many families drawing water at the same time, something that happens daily at about 6 P.M.

5. People use more water now because it is easier to secure, costs little, and people are as a whole more cleanly than they used to be.

Page 154. *Home Problem:* **1.** The pressure in the upper faucets will at once be reduced because the flow of the water from the lower faucet reduces it.

2. There will be a reduction of flow at both times, but the greater reduction will be at night since more water is used for cooking a larger meal and washing more dishes. Again, people arise at different hours and eat breakfast at different hours, but most people eat dinner at about the same time at night.

3. The milky appearance of the water is due to the presence of air bubbles. The water from which the bubbles are driven out will be tasteless. Air in water makes it palatable and pleasant to the taste.

Field Problem: The answers to this problem will vary greatly. The water might soak into the ground, be absorbed by roots and then pass into the air as vapor from the plant leaves; it might go into the gutter and then into the sewer; it might evaporate and become a cloud and fall as rain; it might run down into a small rivulet, thence into a larger stream and run a turbine which generated electricity. It might finally reach the ocean only to be evaporated again to form clouds and rain.

Page 154.

> ***The Pictures in This Book:*** **The problem pictures are a special feature of this book. Every picture is a question put to the pupil. These pictures should be used to the fullest possible extent because they are specifically developed as an integral part of the text. The pupils should be encouraged to do two things with the pictures: (1) to see other values in the pictures besides those indicated and to make out additional questions upon them; (2) to select other pictures from newspapers and magazines which will illustrate as well or even better, perhaps, the topic under discussion. Picture study cannot be overemphasized.**

Page 155. *Figure 60.* Low temperatures change water from a liquid to a solid (ice). High temperatures turn ice to the liquid form and the liquid to a gas (steam). Changing water from one form to another is simply a physical change.

NOTE: Live steam is, of course, invisible, but on reaching the atmosphere it condenses into mist. The illustration makes graphic the process of condensation.

Page 156. *Figure 61.* The discoloration is caused by the multitude of soil and vegetable particles which the waters have torn away from the stream bed. The weight of the rushing waters exerts a powerful force against the stream bed. The current through sheer momentum carries the particles along until a cove or the lowlands stop the rapid flow, whereupon the heavier particles settle to the bottom.

Page 157. *Figure 62.* The cutting off of the forests, land erosion, and lack of reservoirs and dams to control stream flow are the chief causes of such floods. The remedy is more forest planting at the headwaters of flooding rivers and the building of dams to impound stream overflows.

Page 158. (*Key*) *Demonstration 17. Observations:* As the bell of the thistle tube is lowered the right-hand column of ink rises. Air is in the tube between the rubber tissue and the ink. The pressure of water on the rubber tissue is relayed to the column of air, which in turn presses up the tube against the ink. The weight of the water in the jar causes this pressure. This pressure differs as the depth of the bell varies. This is due to the fact that the pressure in the water increases as the bottom of its container is approached. This pressure will be the same from all sides at any stated depth. This proves that water exerts pressure upon objects in it and that the deeper an object goes in the water the greater will be the pressure upon all sides of that object.

Practical Applications: As a caisson descends, the internal air pressure in the excavating chamber must be correspondingly increased so that it will continually more than equal the increasing pressure from without. If submarines go below a certain depth, the pressure of the water becomes so great as to crush in their sides. The diver's air-lines are strengthened with steel wire so that the water pressure will not cause the air-pipes to collapse, thus cutting off the supply of oxygen to the diver.

Page 159. *Figure 64.* Water rises from the surface of the lake, **C,** by evaporation due to the sun's heat. This water vapor in due course condenses and falls as rain. Then it soaks through the soil, **E,** is carried along the rock strata **G** by gravity, and finally, due to water pressure above and behind, comes up as springs or as artesian wells, **A** and **B.**

Page 160. *Figure 65.* **A,** toilet; **B,** washbowl; **C,** bathtub; **D,** hot-water heater; **E,** stove; **F,** kitchen sink; **G,** compressed air or pneumatic tank; **H,** wash tubs; **I,** pump; **J,** cistern; **K,** water supply pipe. The water is pumped into **G** by the pump **I** from the tank or cistern **J**. Compressed air in the top of the pneumatic tank at **L** forces the water up the pipes and into all parts of the house.

Page 161. *Figure 66.* The screw type of faucet is undoubtedly better because this type has a less number of moving parts, there is less play in these parts, and so less wear. The function of each part may be developed from a study of the pictures.

Page 162. *Section 135.* A stop and waste cock on outside could not be easily controlled, or the pipe emptied. The branch to the heating system has a wheel valve to control supply of water to boiler. This second wheel valve allows shutting off of water in upper floors to fix faucets or leaks. The inner cock prevents freezing in winter. *Figure 67.* Self-explanatory.

Page 163. *Figure 68.* The water separates the particles of sugar, thus dissolving the lump. The individual particles are too small to be seen, but they distribute themselves evenly through the water, producing the solution.

Page 165. (*Key*) *Demonstration 18. Observations:* Soft water makes soap lather easily. Suds appear in hard water with difficulty. Boiling precipitates the minerals and leaves the water soft. (This is why the inside of teakettles is often encrusted with a layer of lime.) Borax softens hard water by precipitating the ingredients of the water which prevent the proper action of soap.

Conclusion: Hard water contains minerals (mostly lime). Anything that will separate the minerals from the hard water will make hard water soft. By boiling temporary hard water or by treating hard water with chemicals, the water becomes soft to the touch and readily makes suds.

Page 166. An interesting method of studying the washing powders is to have pupils write to different firms manufacturing these powders, asking them for information about the ingredients of their products and the reason for the use of each ingredient. With several sets of analyses before them, the pupils may be able to come to some decision as regards the good and poor qualities of each kind studied.

Page 168. (*Key*) *Demonstration 19. Observations:* The water becomes heated at first just above the flame and then circulates around the apparatus from right to left. The cylinder (heater) becomes heated near its top first because warm water from the smaller tube passes into it. The cold water in the lower part of the cylinder being heavier, displaces the warm water, forcing the lighter liquid to the top of the circuit. Soon the whole circuit of water is hot. In the house apparatus the gas heater takes the place of the Bunsen flame. The thistle tube provides for the escape of steam from the circuit. The cold-water pipes take the place of the thistle tube in the house circuit.

Page 169. *Figure 71.* Both the house apparatus and the model have a heater, tank, inlet pipe, and hot-water service pipe. The house system has a cold-water inlet pipe attached to the water mains in such a way as to give a constant supply of cold water to the heater. This system also has a drain faucet for the boiler. The arrows show the direction of the flow of water.

Page 170. *Figure 72.* Self-explanatory.

Page 171. *Demonstration 20. Observations:* Heat is transferred by the steam. This steam condenses in the beaker. Much heat is given up in this process because the reading on the thermometer in the beaker is very low as compared with that in the flask, which is 212° F.

Practical Applications: If connected so as to make a complete circuit, the water would circulate from flask to flask. As it left the first flask it would be steam and as it left the second flask it would be water. This is exactly what happens in a steam-heating plant.

Page 171. *Section 145.* The expansion apparatus (now attached to the system in the cellar) takes care of the overflow of water due to its expansion by heat. Otherwise the pipes might burst. The hot-water system costs less to operate than the steam system, but the initial cost of installation is greater. The hot-water system gives an even heat and though slow in reaching the required temperature is correspondingly slow in cooling. It is not so easily controlled and adapted to all kinds of weather. A leak in the system is likely to cause more damage. This topic is a good one for class debate.

Page 172. *Figure 73.* The piston of the compression pump forms a partial vacuum in the cylinder as it is driven to the left. The ammonia gas fills this vacuum through an inlet valve which opens as the piston moves to the left. This valve closes as the piston returns to the right and at the same time the lower valve opens. The condensed ammonia gas is thus forced down by the piston into the pipe leading through the cold-water tank, where it will be fully condensed. But the vacuum in the expansion coil allows the ammonia to be vaporized as it passes through the spraying valve. This vaporization absorbs much heat from the brine surrounding the fresh-water cans. The water is thus frozen into ice cakes. The valves in the circulating pump work in the same manner as those in the compression pump, only in the reverse order, the brine going up while the ammonia passes down. The storage plant is kept cool by its air coming into contact with the brine pipes and thus becoming cooled. Circulation of air, is, of course, set up here.

Suggested Experiment: The glass freezes to the cork. Ice is formed. The evaporation of the ether takes a large amount of heat out of the water, freezing the water on the cork. Evaporation of water takes heat with it and cools the pavements. Alcohol evaporates very quickly and takes much heat with it from the body, reducing the fevered condition.

Figure 74A. Bring out very clearly here the fact that the refrigerating unit in the upper right-hand part of the ice box (shown in the open compartment) is connected with the motor (usually placed in the cellar) by pipes so that there is a complete circuit of gas and liquids in the mechanism, as shown in *Figure 74B.* Food is stored in the other three compartments around the refrigerating unit and vegetables are stored in the ventilated lower compartment.

Page 172a. *Figure 74B.* Compare this picture with the one on the previous page. Note the use of each lettered part. Study the motor on the preceding page and have the pupils tell the uses of the parts without reference to the figure on this page.

Page 173. *Figure 74C.* The air circulates in the refrigerator because the warm food warms the air above it while the cold air around the ice in the left side, being heavier, forces the warm air up. The latter passes over the ice, where it is cooled. The air thus continually circulates, keeping the food cold.

Page 174. *Figure 75.* The metal can, being a good heat conductor, allows heat to leave the can easily, but the wooden tub, being a poor conductor of heat, allows little to enter the space between the can and the tub. The dash stirs the cream about, making its grain very fine. The crank turns both the dash and the can, but in opposite directions.

Page 175. *Figure 76.* The concrete shell holds the sewage. The stones catch and hold the solid contents of the sewage, and spread it out so that it will more fully decompose. The other parts are self-explanatory.

Figure 77. Self-explanatory.

Page 176. *Figure 78.* The siphon in **A** is the sharp curve in the toilet bowl leading to the sewer. In **B** the siphon is the sharp curve leading to the sewer. The water in each acts as a trap or seal to keep sewer gases out of the house.

Figure 79. The siphon works when the siphon valve opens and the downward rush of water tends to form a vacuum in the right-hand branch of the outlet pipe. The atmospheric pressure on the surface of the water in the tank forces the water up the left-hand branch of the outlet pipe to fill this partial vacuum and the water then flows until the tank is emptied. As the water runs out the float falls, finally opening an inlet valve through which fresh water enters. As this water fills the tank the float is raised until the valve is again closed. The siphon is now full of air and will not work until the siphon valve handle is again turned.

Page 177. *Figure 80.* Answers will vary here. The arrangement is good. There is too little sunlight in this bathroom. A towel rack might well be placed near the wash bowls.

Page 178. *Figure 81.* The slats keep the clothes together and at the same time allow the water to enter and leave the compartment. The holes in the slats provide passages for the water. Electricity runs the machine. The wringer is so attached that it can take four different positions.

Page 179. *Figure 82.* The traps prevent gases from entering the rooms. The outlet to the roof allows all odors to escape and prevents damage to fixtures should there be an explosion in the sewer itself.

Page 180.

Key Words: **It is suggested that in each of the succeeding chapters the key words of each period's lesson be entered in the** ***Science Discovery Book.*** **It is also suggested that all key words in every chapter which you actually use be entered in a special place in the** ***Discovery Book*** **so that at given times a rapid review of any of these words, taken at random, may be made. This will be an excellent rapid-fire review and a splendid test of the pupil's ability to correlate the different topics of his study.**

Page 181. *Thought Questions:* **1.** No. Clear water may be full of disease germs. On the other hand, dirty-looking water might be safe to drink. Only a chemical analysis makes it possible to know whether water is really pure or impure. That is why we have daily examinations of city water-supply systems. That is why drinking from country wells and even springs is unsafe unless the water has proved pure by test.

2. The ice, if it be natural ice, may contain disease germs.

3. Boiling the water at least 20 minutes should purify it sufficiently for drinking.

4. Hard water will not clean clothes readily. It also encrusts boilers with lime scale. Soft water, on the other hand, is not so palatable as hard water.

5. Both should be well covered to prevent pollution and well protected at the sides to prevent seepage of impurities from the surrounding soil. Both should be cleaned at regular intervals (3 or 4 years), the cistern more often than the well.

6. The water service pipes may accumulate sufficient rust and waste to offset the pressure and so stop the flow. Another cause of failure on upper floors is the use of lower faucets. The height of the building with reference to the reservoir may also seriously interfere with the flow at all times.

7. Spring water is generally cold and pure. It has little head and so cannot be sent to great heights in a home. Its volume is also generally small. It is generally poor for washing purposes because it is usually very hard.

8. Water requires soap to form emulsions by which to loosen up the dirt in fabrics.

9. The warm air over the food rises because pushed up by the cold air made cold by the ice. If the ice were at the bottom, the cold air would stay at the bottom and there would be little circulation of air and so the food would not be cooled.

10. Water pipes are most commonly stopped by rust; waste pipes by the accumulation of grease and lint. Powerful suction pumps attached to both kinds of pipes will generally clean them out. Strong soap suds and ammonia water together with lye are often used to keep waste pipes clean. Modern plumbing uses large, rustless pipes.

Special Problems: The three problems here outlined are self-explanatory.

CHAPTER VII

THE CONTROL OF WATER FOR USE IN THE COMMUNITY

Time Allotment

The equivalent of one period should be used upon the pictures, *Introductory Chat, Home* and *Field Problems.* Two periods will be occupied by the two important demonstrations. Two periods may well be used to cover the text matter. One period will be used on *Practical Questions, Problems,* etc. One period may be used on *Key Words* and *Thought Questions* or on *Thought Questions, Summary,* and *Review Outline.*

Page 184. *Key Picture 7.* The upper diagram represents a gravity system, the lower one a pumping and gravity system combined. The upper shows a system where a reservoir receives water from streams in a hilly country; the lower one pumps water from a lake into a reservoir. In both cases gravity carries the water into the city mains. In some places the water is pumped directly into the mains from a lake or other source.

Page 185. *Practical Questions:* **1.** A better head of water (force) is obtained by going to the mountains. Mountain water is also likely to be purer.

2. The force of moving water due to its weight runs water wheels and turbines and thus does the same work that heat from the burning of coal would do in turning dynamos by means of steam power.

3. The weight of water and its momentum while moving makes it powerful.

4. Water will be used more and more because coal is increasingly expensive and the upkeep of water-power plants is much less than for steam plants.

5. The planting of new forests helps to conserve the water supply and to regulate stream flow, thus preventing floods.

Page 186. *Home Problem:* The weight of the water here causes pressure in the inclosure and a fine but strong stream is sent out of the small holes because of the head of water behind them.

Field Problem: The principle is the same as in the *Home Problem* except that the water is under control in the sprinkler.

Page 187. *Figure 83.* In **A** the water is pumped from the lake to the city. In **B** the water comes by gravity from mountain lakes. The water sources are probably pure in both, but the Los Angeles sources are freer from possible contamination because they are farther away from thickly populated centers.

NOTE: This picture shows also a power plant which was present only during the construction of a water tunnel. The crib is the cylindrical structure.

Page 188. *Figure 84.* The smooth walls reduce the friction.

Page 190. *Demonstration 21. Observations:* The rubber squares are kept in place by the water pressure on their inner surfaces. When the pieces of rubber are removed, the lower stream will be the longest and shoot out in a line more nearly horizontal than the others because the pressure is greatest at the bottom (page 158). Water pressure is obtained and increased by building dams of great height. The front and any two sides of the can may be compared to a dam and its reservoir.

Practical Applications: The greater the height of these dams the larger the volume of water stored and the greater the head (pressure of water). The bases are very thick to give added strength and anchorage to hold back the enormous volume of water behind them.

Section 163. Dams must be built on bed rock so as to insure a firm foundation to withstand the enormous pressure of water against the dam.

Page 191. *Figure 86.* The top dam is the stronger because (1) it has added anchorage at the bottom and (2) its base is much thicker from top to bottom.

Page 192. *Figure 87* is explained in the following discussion of (*Key*) *Demonstration 22.*

Page 193. (*Key*) *Demonstration 22. Observations:* The water rises to different floors because the reservoir is much higher than the top of the building supplied with water. Water will rise almost to its own level. The greater force is shown at the lowest floor because the greatest pressure is exerted here. The force of water may be increased by raising the reservoir or lowering the house. The reservoir is kept filled with water by the pump. This pump opens its barrel valve when the piston is lifted partly because of the partial vacuum formed above the valve and partly because of the atmospheric pressure upon the surface of the water in the well. When the piston lowers, the barrel valve closes due to water pressure above it and the upper valve opens for the same reason. The upper valve closes because of the water pressure above it when the pressure behind it is reduced due to the upward movement of the piston. Pumping water directly into the water mains gives steady pressure in the service pipes and more of it. It makes necessary constant pumping, however, and if the pumps do not work, the whole system is out of commission.

Figure 88. The outside toilet, pig pen, manure pile, and cesspool may all drain into the well which supplies Farmer **B.** Farmer **A** will be more likely to get pure drinking water

because he receives water from a spring which lies above the contaminated area.

Page 195. *Figure 89.* The grading at 1 in **A** is wrong because it permits surface water to run directly into the well. In **B** at 1 the surface water runs away from the well. In **A,** 2 is wrong because the loose boards allow surface water to run directly into the well. In **B** at 2 the surface water runs away from the well. In **A** at 3 surface water seeps into well from the sides. In **B** all surface water must pass down to the bottom of the well before it can get into the well, by which time it will have been pretty well filtered by the soil.

Page 197. *Figure 90.* Aëration kills most of the bacteria in the water. This effect is due to the exposure to oxygen and sunlight, both of which are fatal to most bacteria. The air also makes the water sweet and palatable.

Page 198. *Figure 91.* Self-explanatory.

Page 199. *Figure 92.* The sewage from North Chelmsford was carried down the river, contaminating it for long distances. Lowell and Lawrence used the river water for drinking purposes. Typhoid fever germs were carried into the water mains of the two cities and the epidemic followed. The remedy was a better water filtration and purification system for these two cities. Still better was a change in the source of the supply.

Page 200. *Figure 93.* The gravel and sand catches most of the solid particles of the sewage and the sunlight, bacteria, and air do the work of decomposing this material into gases and harmless sludge.

Page 201. *Figure 94.* The dirt goes into the compartment above the rear wheel.

Page 202. *Figure 95.* Self-explanatory.

Page 203. *Figure 96.* These fires are caused by careless use of fire by campers and woodsmen, by lightning, etc. Fires destroy much timber and other valuable property, make soil infertile, destroy bird and animal homes, destroy much forest life, etc. These fires may be partially prevented by greater use of fire wardens, fire lanes, more efficient fire fighters, more care on the part of the public in control of fires, spark arresters on locomotives, careful lumbering, and through better enforcement of existing fire laws.

Page 204. *Figure 97A.* These towers through the use of the alidade enable a fire warden to locate a fire exactly and much time is saved in gathering men and getting them to the proper place to fight the fire.

Page 205. *Figures 97B* and *98* self-explanatory.

Page 206. *Figure 99.* Lower picture: Such deforestation is permissible when the cutting is done according to scientific methods and the forests so cut do not in any appreciable way affect the evenness of the water supply in that region throughout the year. Such scientific control is chiefly found only on government lands. Most private owners at the present day do not trouble to exercise such care.

Page 207. *Figure 100.* Self-explanatory.

Page 208. *Figure 101.* Self-explanatory.

Page 210.

> *Remember That* — **These items at the end of each chapter are the chief topics that should stand out in the pupil's mind at the close of the work on any chapter. They should be used constantly in review and each statement may well be assigned for class discussion or for composition work. A full elaboration of each statement will be possible and should be made by each pupil, if the subject matter preceding each set of statements has been fully developed.**

Page 211. *Thought Questions:* **1.** These bubbles get larger as they rise because the pressure above them and about them becomes less and less. Then, too, many of the smaller bubbles often combine to form larger and larger bubbles as they near the surface.

2. Less water is used at 3 A.M. than during all the rest of the twenty-four hours.

3. Answers to this question will vary according to local conditions. Some of these sources of pollution are: sewage, chemicals from manufacturing plants, dyes, oils, etc. Such pollution may be prevented by more stringent laws or ordinances, fully enforced.

4. This connection with the sewer system will materially reduce the chances of epidemics.

5. The sand filter by means of the sand particles separates the solids from the liquid, thus catching and holding filth and germs. Sand filters must be cleaned or changed frequently, however, to be effective.

6. The septic tank can be more readily and completely cleaned than a cesspool. It also requires less frequent cleaning because it disposes of sewage matter more quickly than a cesspool.

7. Forests insure an even flow of water during the whole year; they conserve plant and animal life; insure proper water-power supply; furnish health resorts and recreation centers; help keep the air pure in forest regions; and conserve moisture.

8. Coöperate by keeping your walks clean; by keeping your garbage pail free from overflow; by keeping your rubbish containers leak-tight; by forcing your tradesmen to heed the community practice of cleanliness; and by correcting infractions of the rules by others, that is, by removing litter such as carelessly dropped newspapers.

9. Storing city water in still-water reservoirs allows all foreign substances to sink to the bottom, at the same time permitting the sunlight a better chance to kill the germs.

10. These cities must get their water supply from lakes because they have no high mountains about them to furnish them water by a gravity system. The lakes are, then, the most convenient source of supply. These cities go far out into the lakes to get the water most free from all surface contaminations. Usually, too, this more remote water is colder.

CHAPTER VIII

THE SOURCES AND CONTROL OF HEAT

Time Allotment

Spend one period on the *Practical Questions, Home* and *Field Problems*. The equivalent of two periods may well be spent upon the pictures. Allow the equivalent of three periods for the text matter. Two periods should be used on the *Key Demonstrations*. One period should be used on the *Thought Questions, Review Outline*, or *Summary*, with a final period on the principle of the fire extinguisher and fire prevention.

Page 212. *Key Picture 8.* Oxygen goes into the fire; carbon dioxide comes out. The element, carbon, is common to most fuels. Hydrogen may also be added.

Page 213. *Practical Questions:* **1.** The kinetic energy is transformed into molecular energy which is heat.

2. Cold air in the fireplace chimney must be heated and then forced up by more cold air from the room until an upward current of air reaching to the top of the house is set up. Then the smoke can get out. Before this action is completed some smoke is forced into the room.

3. Coal will burn because it contains the fuel elements — carbon and hydrogen in abundance. Rocks do not contain these elements and so will not burn.

4. Gasoline evaporates more readily than kerosene and easily distributes itself through the air of the room. A match struck in the vapor-laden air may result in an explosion.

5. The upper part of the room is always warmer than the lower part because the heavier cold air at the bottom forces the warm air to the top.

Page 214. *Home Problems:* **1, 2,** and **3** are self-explanatory.

4. Some sources of heat are the sun, friction, gas, coal, oil, wood, and paper. Coal, gas, and oil give the most even and steady heat because they can be better controlled and contain more heat units per cubic foot than the others.

Field Problems: **1.** Answers will vary here according to local conditions. Examples would be: Checking and warping of wood due to the sun's heat; the burning of leaves or of a building or refuse; a moving automobile or a locomotive; a moving trolley car; welding, etc.

2. Answers will vary here also. Examples: Cooking foods, heating water, heating buildings, lighting tobacco in various forms, burning refuse, melting iron, etc.

Suggested Experiment: There is no change in weight due to heating, proving that heat at least is not matter. Heat is probably the result of molecular activities in matter and so a form of energy. The balloon will expand because of the air expansion due to the heat. Work is done because matter is moved. Heat did this work. Energy of heat was transformed from heat to motion (mechanical energy). The heat was released from the fuel by burning it. Heat is probably a form of molecular energy.

NOTE: Recent investigations into molecular activities may change our views concerning matter and energy, but for the present the accepted theories concerning these two ideas will be used here.

Page 215. *Figure 102.* Tinder, or some equally inflammable material, must be used to catch the spark.

Page 216. (*Key*) *Demonstration 23. Observations:* The heat causes the water to expand and thus rise in the tube. The amount of water in the tube is not changed. This water occupies more space because the molecules have widely separated due to the heat (increased molecular activity). The iron increased in length while being heated. The copper lengthened still more. There is no change in the amount of air in the balloon. The molecules of air separate farther apart than those in the water or iron or copper. The result for this reason is far more apparent.

Conclusion: Heat causes matter to expand.

Practical Applications: Heated air circulates in a room because not all of the air can be heated to the same temperature at once. This means uneven heating, with the result that the cooler air falls to the floor, pushing the warm air up and so maintaining a constant circulation. The expansion tank takes care of the expansion of water due to its increased molecular activity when heated. The space between the rails allows for the rail expansion in length in hot weather and prevents buckling of the rails. In the terrific heat of an automobile engine, pistons made of copper would expand so much that they would stick in the cylinders, thus causing failure of the engine.

Page 217. *Figure 103.* Self-explanatory.

Page 218. *Figure 104.* **a** corresponds to a modern furnace. **b** is the cellar pipe and riser. The cold air coming into the furnace at **a** forces the heat into the room above. Here it rises to the top of the room because of other cold air in the room. This was a poor system because the smoke came directly into the room along with carbon dioxide and other gases.

Figure 105. The cold air in the lower part of the room rushes towards the fire, forcing the warmed air to the top. There was some ventilation here. Much smoke left in the room and the production of strong drafts made it a poor system but better than the hypocaust.

Page 219. *Figure 106.* Here the gases and smoke were carried up the chimney and a good circulation of air was insured. The air currents are now easily explained. This type of heating did not heat the whole room very efficiently, however.

Figure 107A. Parts are easily identified. Note that the andirons are placed in front of the fire here in order to show their construction. The oxygen is brought to the fire from the room. This is due to the draft up the chimney. The water is produced by the burning of the hydrogen in the wood while the carbon dioxide is produced by the burning of the carbon in the wood.

Page 220. *Figure 107B.* The damper controls the draft up the chimney. The smoke chamber partly takes care of the smoke which accumulates in the chimney as the fire is getting under way. It also aids in preventing back drafts down the chimney as the fire burns. The back of the fireplace is curved to carry the draft up into the chimney better and to cause a proper deflection of the heat from the fire into the room.

Page 221. *Section 185.* Soft coal is dirty in handling, gives off much smoke, clogs up furnace and chimney, and must be burned with care to prevent explosions of gases coming from it. *Figure 107C.* This stove was better than the fireplace because the fire and the draft could be better controlled and much more heat came out through the sides of the stove into the room.

Page 223. *Figure 108.* Self-explanatory.

Demonstration 24. Observations: The size of the flame may be increased by further closing the vent, allowing less air to enter the mixing tube. The most heat is secured when the vent is fully opened. At the same time the least light is obtained. The least heat is obtained when the most light is obtained (when the vent is closed). The use of the vent is to regulate the supply of air entering the mixing tube. Here it separates the molecules of fuel so that the oxygen at the tip of the mixing tube can reach every molecule and oxidize it. The more molecules burned the more heat is released. The closing of the vent shuts off this separating gas (which by the way may be any kind of gas) and the molecules only glow, passing off in large part unburned. This gives the luminosity to the flame. The most carbon deposit will be made on the cardboard when the flame is most luminous. This means that much carbon is unburned. In *Figure 110B* the air shutter is the vent; in *Figure 112A* e is the vent (draft); in Figure *112B* the draft check is the vent. For answers to remaining questions study *Figures 110B* and *112B*.

Page 224. *Figure 109A.* The tank is placed outside for safety in case of an explosion. It is placed below the level of the cellar floor to prevent the flooding of the furnace with oil. The heat is intense because the oil contains much carbon and hydrogen, burned under a forced draft. This method gives an even heat during the day and requires no care or watching. It is clean. It is somewhat expensive to install as its cost is in addition to that of the furnace itself, but its cost of running is not much above that incurred in the use of coal.

Page 225. *Figure 109B.* The strainer strains out any impurities in the oil; the valves control the amount of oil going into the blower; the gauge shows the amount of the vacuum maintained in the machine while it is running; the blower vaporizes the oil; the pump pumps oil from the tank to the blower; the transformer adjusts the house current to the motor; the electrodes carry the electric spark; the jet is the exit for the vaporized oil into the furnace; the air adjustment plate determines the amount of air coming into the blower to be mixed with the vaporized oil.

Figure 109C. Study the functions of the parts of this kerosene stove on page 226 and then have the pupils describe the stove on page 225 without referring to page 226.

Page 226. *Figure 110A.* Self-explanatory.

Page 227. *Figure 110B.* The opening into the mixer corresponds to the air port in the Bunsen burner (*Figure 110A*); the air shutter corresponds to the sleeve; the feed pipe to the mixing tube; the burner to the top of the mixing tube. The other parts are obvious.

Figure 111A. This stove had a griddle which was adjustable, but it had no oven and its fire box was too small.

Suggested Experiment: The wire should become hot. The fine wire should become red hot because it offers a greater resistance to the electric current. The amount of heat given off by a wire when an electric current passes through it depends upon the size of the wire. The heat is given off from the wire because it offers resistance to the current. The smaller the wire the more resistance and the more heat given off. This may be explained by the fact that the electrons all try to pass over the small wire at once and the crowding is great, causing much friction and consequent heat.

Page 228. *Figure 111B.* This stove has an oven and a much larger surface exposed for the radiation of heat. Its fire box is large. It also has a good smoke pipe.

Figure 112A. This stove has an air inlet (vent or draft) **e,** near the base, and the coal burns inside a fire box **a,** or magazine (which is somewhat like the mixing tube of the Bunsen burner). It has a damper **b,** which controls the amount of heat going up the chimney.

Page 229. *Figure 112B.* Both have drafts, fire boxes, ash pits, smoke pipes, and pipe dampers. The range is shaped differently, has griddles where cooking may be done, and an oven where baking may be done. It also has circulating and cleaning flues, a smoke-pipe shelf, a stove damper, and temperature indicator. Uses of parts are obvious. The arrows pointing into the stove indicate entrance of oxygen. The other arrows show circulation of air about the stove and of gases in the stove and the smoke pipe.

Page 231. *Figure 113.* Self-explanatory.

Page 232. (*Key*) *Demonstration 25. Observations:* Heat comes from the burning wood splints through the side of the can. Tin conducts heat readily, even in the case of several thicknesses of the metal. The heat here would have come through iron also, but less rapidly. The heat got into the water by conduction and through it by circulation of the water. The cooler water, being the heavier, forced the warm water towards the top. The currents thus set up carried the sawdust with them. The course of the sawdust grains indicated the direction of the currents set up. Heat sets up convection currents when applied to liquids in a receptacle. Volume for volume, cold water is heavier than warm.

Conclusions: Though some heating of buildings is always due to radiation, most of it comes by convection. Heat is carried by water in the hot-water heater or steam-heating plant and this water is moved about by convection currents. In the steam-heating plant the steam rises by expansion or under pressure and the heat is carried with it. The proof of this, as far as the hot-water heater and hot-water plant is concerned, is the fact that one has a return pipe line to bring water back to the boiler and the other (hot-water heater) gets hot at the top first, which was proved by our experiment on page 167. In the steam-heating plant the steam gauge indicates pressure and shows that this pressure forces the steam up into the radiators. The average home, then, is heated by conduction, radiation, and convection currents.

Page 233. *Suggested Experiment:* The peas drop first from the copper rod because the copper conducts heat more readily than brass or iron. This is because the molecules in copper are very close together.

Page 235. *Figure 115A.* The arrows entering the cold-air feed represent fresh air entering the jacket of the furnace, where it is heated and sent up into the rooms through the cellar pipes and risers. The air also enters the ash door and passing over the fire, provides oxygen to burn the coal and waste gases. Smoke and unburned gases pass out through the smoke pipe.

Page 236. *Figure 115B.* This system gives the rooms plenty of fresh, warmed air. On the other hand, much dust reaches the rooms and the system is not always evenly controlled. The cold-air box slide needs frequent adjustment to get into the rooms just the right amount of air, heated to the right temperature. The arrows represent convection currents in the rooms, cold air passing into the furnace jacket and gases passing up the chimney.

Page 237. *Figure 116.* Carbon (C) and hydrogen (H) are the principal fuel elements in coal. Oxygen unites with carbon in the coal, producing carbon dioxide. The oxygen also unites with hydrogen, producing water. The nitrogen of the air passes through unburned.

Figure 117A. In **A, x** checks the fire and **y** hastens it. The opening of both means a " dead " fire. The upper door should be entirely closed and the lower one also closed with the draft partially open. Much of the heat is going up the chimney because the smoke-pipe draft is closed. The coal is not properly banked in the fire box to burn well and carry off the gases and the ashes are banked too high in the ash pit.

In **B** the conditions are about correct. The air entering the smoke pipe properly checks the fire to afford time for more complete combustion, and keeps the heat in the fire box, where it can readily heat the air in the jacket. No ashes in the ash pit makes for a good draft. The coal is banked well to carry off the hot gases.

Page 238. *Suggested Experiment:* The flask containing cold water will lower, showing that cold water is heavier than hot water. Heat expands matter so that it occupies more space than when cold. Volume for volume, then, there is less water in one flask than in the other. In a tube containing both hot and cold water the hot water would go to the top. Heat expands matter. In a heating plant it expands the heated element, setting up currents, and so passes through the pipes.

Figure 117B. Heat gets through the radiators by conduction. It passes into the room and to the person in the chair partly by radiation but chiefly by convection.

Page 239. *Figure 118.* The majority of the parts shown are self-explanatory. The expansion tank (now more often found in the cellar) takes care of the excess water due to expansion.

Section 203. This slow warming of the rooms is of advantage in mild weather and a disadvantage in cold weather;

the slow cooling of the rooms is an advantage in cold weather and a disadvantage in warm weather.

Page 240. *Figure 119A.* Self-explanatory.

Page 241. *Figure 119B.* In this system valves are necessary on the radiators, but no return pipe is necessary since the return water can pass the steam coming up in the same pipes. No expansion tank is necessary since a safety valve takes care of excess steam pressure.

Page 242. *Figure 120.* Paper, plaster, and the air back of the lath all being poor heat conductors keep the heat in. The sheathing and clapboards keep the cold out.

Figure 121A. The covers must be tight fitting to keep the heat in, thus maintaining the temperature necessary for cooking. The insulating material also helps to keep the heat in. The iron heating plate furnishes the heat to cook the food. It is heated and inserted in the cooker, where it slowly and evenly transmits its heat by radiation. The metal frame prevents scorching of food in the kettles through a too close contact with the metal plates.

Page 243. *Figure 121B.* The vacuum tends to keep the heat in; the spring allows for the expansion of the bottle and absorbs the shock if the whole apparatus is accidentally dropped; the double wall makes the vacuum possible; the cork keeps in the heat and liquids; the cover protects the cork and keeps it in place.

Page 244. *Figure 122.* The house owner cannot ordinarily get at the electric wires since they are protected in steel cables or pipe. Therefore, fires caused in the home by electricity are generally not due to carelessness on the part of the owner but rather to faulty construction or installation of the wires.

Page 245. *Figure 123A.* The acid, when spilled upon the soda, causes production of much carbon dioxide. The tubing allows the gas to escape and also directs it upon the fire.

Figure 123B. Self-explanatory once the companion cut is explained.

Suggested Experiment: The gas formed in the bottle envelops the fire, cutting off the air (oxygen), and the burning ceases.

Page 246. *Figure 124.* The coat is hanging too near the fire; the candle on the mantle is too near the curtains; the gas flame is too near the curtains; the lighted cigar is too near the tablecloth and the child; the child is playing too near the lamp; the rug is too near the fireplace; there is no fire screen; and the oil to clean the gun is easily ignited if exposed to extreme heat.

In the lower diagram live coals from the fireplace may be allowed to accumulate on the cellar floor; the hot ashes are placed in a wooden box; the barrel of kindling wood is too near the furnace. Finally the furnace door is left open, which, of course, is unsafe with combustible substance near by.

Page 247. *Figure 125.* Self-explanatory.

Page 250.

> **The lists of *Thought Questions* printed in the text at the end of each chapter are typical of many others that might have been used but have been omitted for want of room. They are productive of much thought and discussion. The practical thing for the teacher to do here is to develop others to be added to the lists contained in the text. Better still, have the pupils add to these lists others which they may be able to evolve. These should be written out in their *Science Discovery Books* as their own contribution to their study of science.**

Page 251. *Thought Questions:* **1.** A fireplace gives excellent ventilation and adds much cheer to a home.

2. More heat is produced by a stove and it can be better controlled and used to better advantage.

3. A draft is caused by the unequal heating of the air — the heavier cold air rushing in to take the place of the lighter warm air.

4. The column of cold air in the chimney holds the smoke down and it has no place to pass out until the air above it is well heated.

5. In the tropics, wood makes the best building material as it is a poor heat conductor — it keeps the heat out. In the cold climates wood would lead again for the same reason — it keeps the heat in.

NOTE: In both regions stone would be superior to wood, but it is not always available.

6. Wood, being a poor heat conductor, prevents burning of the hands.

7. The shiny surface will deflect the rays of the sun and this tends to keep the contents cooler.

8. The spring allows for expansion and sudden jars.

9. Rubbers keep the body heat in because rubber is a poor conductor of heat.

10. The inner edge or surface of the glass expands more rapidly than the outer surface and cracks before the two rates of expansion can be equalized.

11. The whole glass expands at nearly the same rate.

12. The bulb of the thermometer expands suddenly and gives more room to the mercury, but continued application of heat will cause the mercury to expand and it will rise in the tube.

13. Seasonal changes in temperature affect the metal of the pendulum so that adjustments must be made to correspond to these changes.

CHAPTER IX

OUR USE AND CONTROL OF LIGHT

Time Allotment

One period for orientation (pages 253, 254) and one period for the *Key Demonstration* should be allowed. Use one period for the study of the eye pictures and light refraction in the eye and the lens correction. One period should be allowed for the study of the other pictures. The equivalent of three periods should be given to study of the text proper. One period should be given over to the study of rules for the care of the eyes and proper lighting effects. One period is to be given to the *Special Problem* and *Thought Questions*.

Page 252. *Key Picture 9.* In **A** the essential parts of the eye are seen in cross section. No more parts than those shown here need be taught in order to understand the essential working of the eye. At the right the rods and cones, nerve endings in the retina, are shown greatly enlarged. In **B** certain of the light rays coming through the window are reflected from the letter "T" at **b** and are then sent into the eye where the image is inverted in the retina. This impression is sent to the brain and interpreted as the letter "T." In **C** the candle illuminates 1 sq. inch of space at 1 foot distance with some intensity. At 2 feet the light must cover 4 times as much area and the intensity is $\frac{1}{4}$ as great; at 3 feet the area is increased 9 times and the light intensity decreased accordingly. The greater the distance, the greater the area of illumination, and the less the intensity of light.

Page 253. *Practical Questions:* **1.** Light-colored walls are more cheerful than dark-colored walls because they reflect the light to all sides.

2. Opaque objects cast shadows because they exclude the light rays for a certain distance beyond their resting places.

3. Lights can be thrown from one object to another by reflection.

4. The image in the camera is inverted because the light rays are reflected from the object in every direction. Those from the lower part of the object enter the camera and strike the upper part of the ground glass, while those coming from the upper end of the object go through the lens and strike the lower part of the ground glass. Thus the image is upside down.

5. Incomplete oxidation of the carbon particles results in glowing carbon particles and hence the light of the candle.

Home Problem: Reports will greatly vary in this problem. The careful guidance of the teacher and a check up on the actual conditions described by the pupil is the only way of determining the correctness of the pupil's work here.

Page 254. *Field Problem:* Self-explanatory.

Figure 126. The light rays shine in all directions. The only rays that can pass through the holes are those that strike the center of the first hole (assuming that the holes are in line).

Page 255. *Key Demonstration 26. Observations:* The light rays travel in straight, not crooked lines. Since the cardboards are in a straight line, the light must travel in a straight line or it would not be seen through the three holes.

Page 255. *Figure 127.* Page 256 names the parts of the shadow. These parts appear because the source of the light covers a relatively large area and the opaque object cannot cut off all of the light from the surface directly behind it. If the source of the light is small, the shadow will have no penumbra, but an umbra only.

Page 256. *Figure 128.* Shade **A** shuts out practically all light and may be used in sick rooms or to diminish the amount of bright sunlight in a room. Shade **B** moderates the light coming into a room. **B** is translucent while **A** is opaque.

Page 257. *Figure 129.* Clear images are caused by reflections of sky, foliage, etc. The mirror or lake surface reflects the objects in the same relative order as that which would meet the eye were it looking directly at the objects. Reflection causes surfaces to shine, giving life and variety to the landscape. This is why a sunny day is more pleasant than a cloudy day.

Page 258. *Figure 130.* The even surface of **a** reflects all of the light rays at the same angle, but the uneven surface at **b** reflects the light rays at different angles. At **b** the softer light is given because but few of the rays of light strike directly into the eye.

Page 259. *Figure 131A.* The other rays do not pass in the right direction to enter the hole at **x**. Only a few of the rays may go through this hole. The image is inverted because some of the rays from the upper part of the picture pass through **x** and going straight must reach the bottom part of **y**. Similarly, the lower rays from the flame and candle pass through **x** and come to rest on the upper part of **y**. Hence the inverted image.

Section 218. Diamonds both refract and reflect light.

Page 260. *Suggested Experiment:* The image of the object toward which the camera is pointed will be seen on the tissue paper. This image will be inverted. A small opening makes the image sharper. The image is made by reflected light rays, but these reflected light rays are thrown directly into the camera through the pin-hole upon the tissue-paper back.

Suggestion : If the tissue paper is fastened to a cardboard frame which exactly fits the box and this frame attached to a slide, the image may be easily and exactly focused without moving the camera box.

Figures 131B and *131C.* The lens is added in *131B;* the retina is added in *131C.*

Suggested Experiment: The camera focuses by the action of the lens, which can be moved backward or forward. The eye model must be moved backward or forward as a whole to bring the object into focus. In the living eye the ciliary muscles flatten or thicken the lens **x**, which focuses the object on the retina. The image is inverted in both instances, because (1) light rays from all parts of an object travel in straight lines and (2) but a small number of these light rays may pass through the opening at **x**. Some of these rays meet and cross at the center of the lens.

Page 261. *Figure 132.* The thin lens at **x** does not bend or refract the light rays at a sharp angle so that they are brought to a focus on surface **d**, while the lens at **y**, being thicker, presents its surface to the light rays at a different angle. The result is a bending of the light rays at a sharp angle and the image is brought to a focus on the surface **dd.** The image is not thrown on **ab** because it could not be in focus on that surface. In other words, the lens **x** is slightly too thin to bring the object to a focus on **ab** and the lens **y** is slightly too thick to bring the object into focus on surface **ab.** Now if **ab** is considered as the ground glass of a camera or the retina of the eye, both lenses are wrongly set for getting a clear image. In the camera the lens **x** would have to be moved slightly forward and the lens **y** slightly backward. In the eye lens **x** would have to be thickened and lens **y** flattened by the ciliary muscles.

Page 262. *Figures 133A* and *133B* are self-explanatory.

Page 263. *Figure 134* is self-explanatory.

Page 264. *Figure 135A.* The thin lens causes the light rays to bend but slightly and they tend to come to a focus *behind* the retina. This means that the image is out of focus on the retina, for the light rays cannot come to a focus behind the retina.

Page 265. *Figure 135B.* The reverse condition of *135A* obtains. The thicker lens tends to bring the image in focus in *front* of the retina. Since there is no surface in front of the retina, the image is out of focus on the retina.

Section 225. The stop should be opened wide on a cloudy day and stopped down on a clear, sunny day. This action is accomplished in the eye by the ciliary muscles. The movements of the iris control the amount of light entering the eye. Without this accommodation the retina would be injured by the intense light and we could not see clearly.

Figure 135*C.* Most people have some astigmatism. The vertical lines will appear darker than the horizontal lines or vice versa.

Page 266. *Figure 135D.* The convex lens **x** tends to help the lens of the eye to focus the image on the retina by bending the light rays at a slightly sharper angle than that pictured in *Figure 135A.* As a result the image is brought to an exact focus on the retina.

Figure 135E. The concave lens y brings the light rays up nearer the ends of the eye lens, where they are bent at a less sharp angle, and they are then carried back to the retina, where they are exactly focused.

Page 267. 1. The "flicker" movement causes a constant refocusing of the eyes, which unduly tires the ciliary muscles.

2. In the front of the theater the distortion of the picture is greatest and the focusing is correspondingly more difficult.

3. The upper part of a line of print may be in focus and the lower part out of focus because of the angle in which the book is held. This strains the eyes.

4. The reflection of light from the glazed paper tires the retina.

5. The moving book or paper causes a constant refocusing of the eyes. This unduly tires them.

6. The light is refracted from the page into the eyes, causing words to be indistinct and straining the muscles in their attempt to focus to see these indistinct words.

7. The flickering light gives an uneven reflection from the page, thus causing constant refocusing and consequent strain.

8. The hands may be unclean and the eyes may become infected and inflamed. The friction of the rubbing increases irritation. The solution soothes them and reduces congestion.

9. This changes the sustained focus and rests the ciliary muscles.

10. Fine print requires very fine focusing, which strains the eyes.

11. Twilight reading requires strained focusing and its results are strained ciliary muscles.

12. Continued gaze at a strong light temporarily paralyzes the nerve endings in the retina and may permanently injure them.

13. The foreign substance may injure the eye ball. The rubbing heightens the irritation and may drive the object farther under the lid.

14. Cold water causes the relaxation of the eye muscles and thus rests them.

Figure 136. The upper sprocket feeds the film at a given even speed to the sprocket below. The upper film loop prevents tension and breaking of the film. The second sprocket keeps the film flat as it passes through the film gate and feeds it at the proper rate. The intermittent movement keeps the film flat and under slight tension in the film gate and brings it down $\frac{1}{2}$ inch and stops for about $\frac{1}{16}$ of a second. The lower loop prevents tension breaking of the film. The lower sprocket feeds the film evenly to the lower reel. The condenser lenses diffuse the light rays and then send them out at the right angle through the film, objective lenses, and flicker shutter to the screen. The flicker shutter revolves at just the right speed so that the black shutter is in front of the film gate at the instant the film is moving down into place to expose the next picture. The open space lets light through the film and on to the screen at the instant the film is stationary ($\frac{1}{16}$ of a second). (In some machines 17 frames are projected each second.)

Page 268. *Figure 137.* The figures are shown in a slightly different position in each succeeding picture. The house remains the same. All that is done in the moving picture is to present a different position of the moving objects in each succeeding picture. There are about 16 of these changed positions per second. This rate of change is just a little too fast for the human eye to detect as the old image remains on the retina of the eye as the new image is coming into place.

Page 269. *Suggested Experiment:* The paraffin melts when the wick is lighted. The wick becomes blackened, showing the presence of carbon. The paraffin passes off in a vaporized form when the wick is hot, and this vapor catches fire when a lighted match is held above the wick after the flame has been extinguished. Carbon (soot) forms on the glass when held near the flame. Soot is given off from the fanned flame because the cold air interferes with the complete combustion of the carbon in the paraffin. Carbon is in the candle. This substance is a solid. Hydrogen is also found in a candle flame, evidenced by the fact that the center of the flame is blue. When a candle smokes, the carbon is not completely burned. Smoke is unburned carbon. Little smoke is seen in a steadily burning candle because the carbon is almost entirely oxidized. A candle gives most light when it burns steadily and the wick is not too long. The glowing carbon in the candle flame gives the bright light. The most carbon is found in the outer edges of the flame. Hydrogen burns in the center of the flame. Here is the hottest part of the flame. Here the combustion is most complete. No soot will be found on the wood splint where it touched the blue part of the flame. The candle gives light by means of heat, which causes the paraffin containing carbon and hydrogen to melt and vaporize into a gas which burns readily, giving off light in the process.

Page 271. *Suggested Experiment:* The fuel is in liquid form here. It burns in a gaseous form. Carbon and hydrogen burn in this fuel. Turning high the wick causes the flame to smoke because the fuel is vaporized at too low a temperature by this action to burn readily. By turning the wick down the smoking will stop. By trimming the wick the flame will be brighter. Convection currents give the draft. The draft carries oxygen against the wick to oxidize the vaporized fuel. Glowing carbon actually gives the light in the lamp. Burning hydrogen produces the bluish part of the flame. The burner controls the flame by allowing the proper amount of oxygen to reach the wick and the proper amount of fuel to vaporize from the top of the wick. The chimney keeps out strong drafts and helps carry the convection currents straight upward.

Figure 139. All essential parts shown here are explained in the accompanying *Suggested Experiment.*

Page 272. *Figure 140.* The advantage of having two places where air can enter the lamp is that the oxygen will reach both the inside and the outside of the wick, giving a larger and a brighter flame.

Suggested Experiment: The Bunsen flame is bluish, but changes take place in it due to the amount of air allowed to enter the mixing tube. There is hydrogen in the flame because it is blue. This is a sure sign of the presence of hydrogen. The most light is secured when the amount of air entering the mixing tube is decreased, causing the incomplete burning of the carbon. More oxygen hastens the burning and reduces the amount of glowing carbon. The Bunsen burner is never used for giving light, but for securing intense heat. The slit top is put in the gas burner to give a thin, flat flame, so that the yellow border is wide, thus giving more light. Its hottest part is at the center and its lightest part is at its edges. The more glowing carbon, the more brilliant the flame. The oxygen reaches the flame just as the gas leaves the gas tip. The mantle increases the intensity of the light. It does not burn but glows. Less gas is used with the mantle, for the mantle alone gives the light. It takes less gas to make a mantle glow than to cause a flame to glow enough to give a good light. The light of a gas flame may be increased by adjustment of the gas cock, thus controlling the amount of gas entering the burner. The mantle gives a better light at less cost than any other ordinary light.

Page 273. *Figure 141.* The inverted mantle is preferred because it is suspended from three points and is less liable to be broken by sudden jars than the upright mantle which touches the burner at many points. A more intense and better diffused light is given by the inverted mantle.

Page 274. *Figure 142.* The tungsten bulb gives more light because there are more wires in it and these wires are finer than in the carbon light. The tungsten wire becomes more highly incandescent than carbon which really glows, giving a yellow light. This is why few carbon bulbs are now seen. The tungsten is rapidly being displaced by the nitrogen bulbs.

Suggested Experiment: The copper wire offers resistance to the electric current. The silver wire offers more resistance because finer. The bulb wire becomes incandescent because it offers still more resistance to the electrical current than the others since it is still finer. The bulb wire must be exceedingly fine and of a material not easily broken by jars and not easily melted or consumed by the electric current. It must also become highly incandescent, giving off a white light. The bulb gives light, then, by the incandescence of a wire offering much resistance to an electric current.

Section 237. The nitrogen bulb gives a whiter and a more brilliant light than any other type of incandescent light.

Page 275. *Figure 143.* Insulators carry wires without carrying the current themselves; the conduit carries wires, preventing short circuits or injury to building by burning; the switch controls current as it enters the home; the meter measures the current entering the home; the fuse box contains the fuses which control the amperage of the current; **a,** wires carrying current in and out of house; **b,** wires carrying current underground in and out of the house in most large cities.

Page 276. *Figure 144.* The gas mantle gives the most inexpensive light. The tungsten probably gives the most light. The tungsten light is the most convenient.

NOTE: As already noted, the nitrogen bulb now gives the most efficient light.

Page 277. *Figure 145.* Kitchens and bathrooms need the maximum of light. This light shade is now little used. It is a good shade to diffuse the light by refraction, making the light easy on the eyes. The frosted bulb is now commonly used and is generally covered by a white glass shade or globe.

Section 240. The direct light gives intense illumination in a small area. This light is good for studying, needle work, etc.

Section 241. In semi-indirect lighting the shade cuts off some light though it is highly translucent. The rest of the light is sent directly to the ceiling and then reflected downward again. This is a soft light but its intensity is lost. A light-tinted wall is best for this type of light as the refracted light will be given its maximum illumination. In this method the light is but ½ direct.

Page 278. *Section 242.* The light rays are sent directly to the ceiling and there reflected. A light color scheme, especially a white ceiling, gives most light here by reflection.

Figure 146. In **A** the shade is opaque, sending the light directly down, while in *Figure 145* it is sent out through a glass shade in all directions. In **B** the room is lighted by reflected light. In **C** the reflection of the light from the ceiling and its shining directly through the translucent shade gives a soft light in all parts of the room. This is a restful, well-diffused light, but not good for close work.

Figure 147. Both **A** and **C** are better than **B** because the rays of light shine directly into the eyes in **B**. But **C** is better than **A** because the reflection of light from the page is reduced to its lowest point in **C** since the book is held in a plane parallel to the surface of the eye and the light comes from over the shoulder.

Page 279. *Section 244.* The kitchen and bathroom should be decorated in light colors to reflect light rays and give a cheerful appearance. The color schemes of north rooms should be light. South rooms may be darker. Decorations may reflect, partially absorb, or almost completely absorb light. The more reflection, the more cheerful the rooms.

Page 282. *Special Problem:* Self-explanatory.

Note: The finer hands on the lower three dials in **A** simply represent the position of the distinctly outlined hand before it began to move. The problem is to determine how much each hand has moved and figure out the number of cubic feet of gas used.

Page 283. *Thought Questions:* **1.** Everybody casts a shadow because opaque objects intercept the light rays. Behind the object there is no light.

2. Shadows are longest in morning and afternoon because as the sun rises and sets its rays shine obliquely over any object, casting a long shadow beyond it. At noon since the sun is directly overhead, no shadow will be cast.

3. Glass will not cast a shadow except at its very edge. Glass is transparent. Only opaque objects cast shadows.

4. The white walls of courts reflect light and send it into the adjoining rooms.

5. Reading on trains is a poor habit. Reading thus strains the ciliary muscles of the eyes, especially when traveling over rough roadbeds.

6. The refraction of the light rays by the glass distorts them.

7. Glass, being transparent, allows the customer to see what he is purchasing and the refraction of light rays by the glass makes the contents appear attractive.

8. Placing the seats so that light comes from the left prevents the casting of shadows by the hand when writing.

9. An unsteady, yellow light, reflected upon a glazed surface, is injurious to the eyes when studying.

10. By having reflecting surfaces in the room and by use of light ceilings and walls the ordinary room may be well lighted.

11. The tablecloth makes a room brighter by aiding the reflection of the light rays.

12. The gas flame gives light through the incandescence of burning particles of carbon; the electric bulb gives light through the incandescence of a fine wire due to its resistance to an electric current.

13. The moon shines because it reflects the light of the sun from its surface.

CHAPTER X

MAGNETISM AND THE WORK OF ELECTRICITY

Time Allotment

One period is to be used in orientation (pages 285, 286) and upon the compass (page 286). One period may be spent upon the magnet and the text matter (pages 287 to 290). One period may be spent upon each of the experiments and their subjoined text matter. Two periods may be used on the pictures, *Thought Questions*, and *Review*.

Page 284. *Key Picture.* Self-explanatory as the chapter proceeds.

Page 285. *Practical Questions:* **1.** Water is an excellent conductor of electricity.

2. Magnets are used in door bells, in motors, in telegraphs, telephones, etc.

3. The electric current cuts across and reaches its destination by a short route. This generally cuts off so much of the wire over which the current ordinarily passes that greater resistance is offered to the current by the remainder of the wire. Under such conditions the wire may fuse or overheat, causing a fire. Parts of the apparatus may be injured (flatirons, etc.).

4. Glass is a non-conductor of electric currents.

5. The electric current generated in the power house deflects the needle of the compass, making it temporarily useless.

Page 286. *Home Problem:* Self-explanatory.

Field Problem: Self-explanatory.

Figure 149. The needle always points north. By turning the box so that *N* comes under the needle you know the exact points of the compass. By turning the compass so that the needle is over *S*, the line marked 35 is pointing directly southeast. By knowing the general direction of a certain place from a given starting point, one could set the compass and then follow its reading, keeping it set the same way. If one

is lost, he could follow any given direction in a straight line until he came to a town, farmhouse, or settlement. With a compass, he would not wander in circles as most lost persons do.

Suggested Experiment: The north pole of the needle is that pole which is repelled by the north pole of a magnet or attracted by its south pole. The north pole of a magnet is that pole which repels the upper point of the needle. The north pole of a magnet is generally marked *N*. Like poles attract and opposite poles repel. The needle is deflected either towards or away from any one pole of a magnet. The jack-knife blade deflects the compass needle. A compass will not be accurate when metal is near it.

Page 287. *Figure 150.* Self-explanatory.

Suggested Experiment: The filings move. All meet at a particular line around the poles of the magnet. A line of filings is formed between the poles when the attraction is reduced. Both poles of a magnet will attract iron filings.

Page 288. *Figure 151.* In a demagnetized state (as at **a**) like poles do not all point the same way, but rather in any direction. The magnet **x** is magnetizing molecules of steel and they move to a position so that all like poles are pointing in the same general direction.

Page 289. *Figure 152.* Electrons are moving towards the metal bar because there is a lower potential in the bar — it lacks electrons. As soon as enough electrons have gone to the metal to electrify it and thus reduce the difference in potential between the comb and the bar, no more electrons will jump across the gap. At that moment there is no more attraction between them.

Page 291. *Demonstration 27. Observations:* Bubbles collect on each plate. The acid forms the bridge. This carries current across the jar. The electricity is being stored in the plates of the wet cell as chemical energy. The electric current makes the bell ring as it comes from the wet cell. It is stored on the plates of the wet cell. It comes from the transformation of chemical energy. The lead comes from the lead plates and the oxygen from the sulphuric acid (H_2SO_4).

NOTE: The electrolysis of the sulphuric acid liberates oxygen, which combines with the lead to form the brown deposit (PbO_2). These elements then form a new compound. Note also that the electricity of the dry cells is not stored in them as electricity but as chemical energy. When the bell is attached, this chemical energy is converted again into electrical energy and the current does work in ringing the bell.

Figure 153. Dry-cell batteries are commonly used to ring door bells, for testing motors, to energize small lights, etc.

Page 292. *Demonstration 28. Observations:* The carbon rod becomes coated with copper taken from the solution. But the solution changes continually by losing its copper and then taking more copper from the copper strip. When the wires are reversed, the copper is taken from the carbon rod and placed on the copper strip. In plating, therefore, the current must always go towards the metal to be plated, that is, from the anode through the electrolyte to the cathode. Thus copper plating is done by the use of an electric current, which, as it passes from one pole to another through a solution containing a plating material, deposits this on the metal to be plated.

Page 293. *Figure 154.* Self-explanatory.

Page 295. *Demonstration 29:* This is a good exercise for the pupil in following explicit directions to obtain a definite result. The bulbs will emit light, showing that the circuit is complete. When the knife switch is opened, the circuit is broken and the lights will go out. The use of the bulbs is one sure way of testing an electric circuit.

Section 259. The volume of water would at once be reduced on one side of the partition.

Page 296. *Suggested Experiment:* The knife switch when raised breaks the circuit, as has already been proved. In the home or school circuit the current may be shut off to make repairs, when leaving the building for some time, or when there is trouble on the line. The switch slot and blade are made of copper because it is a good conductor of electrical current.

When a bulb is unscrewed, the light goes out because the contact is broken. The other lamp is not affected because it is set in parallel. The lights could be controlled only by placing a wire across the gap in the knife switch. The snap switch breaks the current or circuit. The lights go out. They are often used in the base or top of an electric fixture or lamp. The flush switch also breaks the circuit. These are commonly found in the walls. These switches are more stable, better looking than other types of switches; they are never in the way and seldom get out of order. The tumbler switch is the one most used in new homes to-day.

Page 297. *Demonstration 30.* When the wooden plug is placed in the socket, nothing happens because the ends of the nails do not touch to complete the circuit. When the nails are connected with the water pipe by a connecting wire, a short circuit takes place and the fuse blows, breaking the circuit. The other nail will give no results because the current is not coming through that nail. When the bulb is put into the circuit, it lights, but the fuse is not blown because the bulb carries enough of the current to prevent too great amperage through the fuse wire. If a heavy wire were placed across the fuse gap, the fuse would not blow, but the amperage on the wire might be great enough to melt the wire and cause a fire. A 20-ampere fuse plug in a socket with a 40-ampere current through that plug would probably blow it or the cartridge fuses would blow out.

Figure 155. The mica allows one to see the fuse, yet it prevents the scattering of sparks when the fuse wire melts or "blows." The contact point completes the circuit, — joins the ends of the wires in the broken circuit. The fuse wire carries the current across the gap in the circuit.

Page 300. *Demonstration 31:* The current being grounded on the pipe will blow the fuse. When the bulb is connected in, the fuse will probably blow. A slight shock will be felt from the bare wire because a short circuit is brought about. Standing on a dry spot reduces the chances of receiving an electric shock. Wearing rubbers insures complete insulation.

Practical Application: A bird is not electrocuted when perching on a live wire because it does not come into contact with the ground and cannot ground the current. One should stand upon an insulated object or put on rubbers. One should leave fallen wires alone because they may short circuit their current through your body. Grounded circuits may take place in the home by loose wires coming into contact with conductors, by broken wires, or by wires touching in electrical fixtures because of defective insulation.

Page 301. *Figure 156.* The extinguishing of the street lamp will not affect the lights of the house because they are on separate or parallel circuits. The washing machine and electric fan are also on parallel circuits.

Page 303. *Figure 157.* Self-explanatory.

Page 305. *Thought Questions:* **1.** A knife blade may be magnetized by rubbing it against a permanent magnet for a few minutes.

2. The rods constantly carry off to the ground the accumulating charges of electricity in the air above the chimney and enough never accumulates in that locality to be discharged in a flash.

3. Stand away from any tall object. Tall objects gather in electrical charges more quickly than short objects. A bad place to stand is near a wire fence or a tree because the lightning may jump from the tree or wire fence to you.

4. Rubber makes an excellent insulation.

5. The rods are carried deep into the ground to fully ground the lightning charge.

6. The motorman can touch the trolley pole without injury because the top of the car is insulated.

7. The rubber tires insulate an automobile from the ground.

8. The wire may be overcharged with the current and the wire may fuse before the fuse will blow.

9. Try the magnet out on a compass. The pole which repels the end of the needle which points north is the north pole of the magnet.

10. Compasses work best on wooden ships, but now means of preventing their deflection have been found even for steel ships.

PREVIEW OF PART III

THE IMPORTANCE OF INDUSTRY

In Part I the pupil became acquainted with the common factors of his environment. He found out that they are governed by law, that they can do work when actuated by energy, and that the great task of man is to utilize these factors in his work.

In Part II he discovered by the laboratory method just how some of these factors of his environment are made to work, thus making lighter the effort of man in the work of the world. This part of the book is an elaboration of facts and principles. Having grasped the principles underlying our use of air, water, heat, light, and electricity, the pupil is now ready to apply every principle to the understanding of some of the great industries and public utilities.

The pupil has in the preceding chapters dealt with the materials, the methods, the observations, and the conclusions of many problems. Here in Part III he will make the *Practical Application* of all his previous work, considering that work as a whole which includes the materials, method, observations, and conclusions of *one big problem.*

A very few of these larger activities are here treated. But the basic principles are so developed that the teacher may use this material as the foundation of the specialized study of any industry in his home city. The one big thing that the teacher should accomplish in the teaching of the subject matter from page 308 to 426 is this: Make the pupil feel that the science he is now studying is the same science that is being used in carrying on the world's work; that the classroom science and the world's science are one and the same, and that he may in a very few years, as a result of his work in the classroom, be contributing to the improvement of the world's science by his own inventions and discoveries. Above all, make the pupils see that all of the energy utilized in the world has its source in the sun. For methods of teaching special industries see the Appendix.

Plate III. Self-Explanatory. This is an excellent puzzle picture. Have the pupils follow through on each path and learn the order of the principal developments in each line of industry or utility.

CHAPTER XI

THE WORK OF AIR, WATER, HEAT, AND ELECTRICITY IN INDUSTRY

Time Allotment

One period must be used in orientation (*Practical Questions, Home* and *Field Problems*, etc.). But one period need be used for *Demonstrations 32* and *33*. The equivalent of two periods should be used in the study of the pictures. Four periods should be spent upon the subject matter in connection with the study of the pictures. One period may be spent upon the *Thought Questions* and the *Summary* or the *Review Outline*. One period may be spent upon further study of *Figures 166* and *177*.

Then, if a still further study is to be made of this chapter in its community applications, two weeks may be used in class study of a particular industry or special reports may be made on this industry, such as a cotton mill, machine shop, car shop, electric power plant, etc. Just how to conduct such work is fully explained in the Appendix, page 209.

Page 308. *Key Picture 11.* The corn grew under the influence of the heat energy of the sun (1) and it was harvested (2), fed to the horse (3), and transformed into heat energy again in the muscles of the horse as he draws the wagon up the hill (4). Again, the energy of the sun caused the growth of plants and animals millions of years ago. These organisms were buried deep, disintegrated into coal and oil and now the oil is being withdrawn from the earth (5), pumped to oil refineries (6), and then loaded into the holds of ships as fuel to send them across the ocean or is carried by tank trucks to filling stations (7) for varied distribution to motor cars. The coal is mined (8) and graded (9) to be sent out on its path of varied usefulness (10). In all of the above cases the sun actually does the work.

The upper picture is so well labeled that it should be self-explanatory. Here it can be figured out that the house is lighted, the factory run, and the street car propelled by the sun.

Page 310. *Practical Questions:* **1.** Heat energy is the most common form of energy used in manufacturing to-day.

2. Our study of the *Key Picture* shows that the coal or oil contains stored energy placed there by the sun. It is preserved sunshine which is now released when burned.

3. Heat alone can not cause machines to run. The heat energy may produce steam which runs an engine, which revolves a flywheel, and this by belts runs machinery. Motion first appears in the piston of the engine and this to and fro motion is changed to rotary motion in the flywheel.

4. One hundred years ago water power was the chief power available, since the steam engine had not yet been well developed. The water wheel as it revolved turned machinery. The mill was necessarily near the stream. Now the steam engine may be operated wherever coal can be transported.

5. Answers to this question depend, of course, on local conditions.

6. Answers correspond to **5.**

7. If all men suddenly became farmers, the competition among farmers would be so great that most of them would never have any ready cash. The raw products would never be manufactured into goods as there would be no factory workers. The farmers would have to begin to make their own goods with a corresponding set-back of civilization. There would be little or no work of any value done outside of providing food and shelter. The pupils may work out other answers.

Home Problem: Self-explanatory. The acid cleans the part to be soldered of all grease, etc., and gives the solder a better chance to stick.

Field Problem: Self-explanatory.

Page 311. *Figure 158A.* The coke burns and melts the iron oxide, reducing it to iron. The lime combines with the impurities in the iron as it melts and forms the slag (impurities). Carbon monoxide, sulphur, and phosphorus oxides come out of the furnace. The iron is heavier than the slag, so goes to the bottom of the furnace and the slag floats on top of the melted iron.

Page 313. *Demonstration 32. Observations:* The terra-cotta colored lead oxide is changed to a silver color. The oxide glows. Lead begins to appear upon the surface of the oxide. This resembles quicksilver. This process removes the oxygen from the oxide. Oxygen is found in every oxide. Lead and oxygen are found in lead oxide. The oxygen of the oxide unites with the carbon in the charcoal and the hydrogen in the flame as each is a fuel element.

Conclusion: The oxygen is removed from the oxide or ore by intense heat. Coke is mostly used in smelting ores. Some ores are lead, iron, copper, zinc, etc.

Figure 158B. Self-explanatory.

Page 314. *Figure 159.* The trunnions make it possible to tip the converter so that the molten iron can be poured out of it. The uses of the other parts labeled are obvious.

Figure 160. The compressed air containing oxygen unites with the coke and produces the flame which is blown out together with impurities by the compressed air.

Page 316. *Figure 161.* Heat always causes molecules of matter to separate. This causes a substance to expand. The molecules are moving about in both **x** and **y** and mixing. In **c** the molecules of each part have mixed, cooled, become set, and locked together. The ridge in **c** is caused by the molecules not fitting as closely together as in the original pieces.

Page 317. *Figure 162.* The flame causes the molecules of steel to become active, they separate, and the metal flows. The intense light of the flame will injure the eyes permanently unless colored glass is used to protect them.

Page 318. *Figure 163.* Self-explanatory.

Page 319. *Demonstration 33. Observations:* Vapor first appears at the top of the spout. This vapor appeared white.

NOTE: Live steam, we know, is invisible. The instant the live steam comes into contact with the cool air it condenses into water vapor and this is what we commonly call steam.

What is seen here is condensing steam. Steam is a gas. The cover should be blown up by the steam. Steam possesses tremendous energy. It can do work here by raising the cover. It can do work in a locomotive by giving the engine power to pull a train.

Conclusion: Steam can be generated by heating water until it boils. Steam can expand and cause things to move (pot cover or the piston in an engine).

Page 320. *Figure 164.* Atmospheric pressure pushed the piston down due to the formation of a partial vacuum below it by the cold-water spray condensing the steam in the cylinder. The expansion of steam in the cylinder pushed the piston up. The working of the inlet valve by hand was a poor arrangement because there could be no exact regularity of movement. It was a very slow method.

Page 322. *Figure 165.* Self-explanatory.

Questions: **1.** The expansion of steam causes the piston to move.

2. The cylinder is located close to the steam chest.

3. The valves allow the live steam to enter and leave the cylinder.

4. The steam is generated in the boiler.

5. The steam reaches the cylinder through a pipe leading from the steam chest into the cylinder.

6. The steam gets into the cylinder by means of the slide valve.

7. The inlet valve opens and closes before the opening and closing of the exhaust valve.

8. The speed of the engine (stationary) is controlled by a governor not shown in *Figure 166.*

Page 323. *Figure 166.* Self-explanatory.

Page 324. *Figure 167.* The flywheel is connected with the large shaft by a belt. On this shaft are many smaller wheels and drums. These are connected with the individual machines with belts. Thus the rotary motion of the engine flywheel is distributed to every machine in the factory. (Many machines are now run by individual electric motors).

Page 326. *Demonstration 34. Observations:* The coffee pot cover should be blown upward. The wire causes the cover to fly back into place. The sudden expansion of gases due to their burning causes the cover to rise. It rises suddenly because there is an explosion underneath the cover. The gas ignites because of the flame which quickly raises it to its low kindling temperature. The pot might be compared to the cylinder of the steam engine and the cover (very roughly) to the piston. The gas engine is called an internal combustion engine because the burning of the gases takes place inside of the engine itself (cylinder).

Conclusion: The gas engine gets its power through the sudden oxidation of compressed gases which exert a tremendous pressure upon a piston attached to a shaft by a connecting rod. This shaft as it is revolved by the connecting rods moves the wheels and propels the car (if the engine is in an automobile).

Page 327. *Figure 169.* Self-explanatory.

Page 328. *Figure 170.* The dam is above and far back of the flumes. The dynamos are situated in the powerhouse. The water in the flumes falling upon the turbines causes them to turn the dynamos attached to the same shaft.

Page 329. *Figure 171A.* The fall of the water, with a great head of water behind it, through a small pipe applies great force against the buckets of the Pelton wheel.

Figure 171B. The depth of water in the dam gives great force to the water as it runs against the turbine. The turbine is attached to a shaft which is geared into machinery or more often it is attached to a dynamo which develops electrical current which runs machinery in distant factories.

Page 330. *Figure 172.* Self-explanatory.

Page 333. *Figure 173.* The double loop, cutting the lines of force more times per second than the single loop, causes the development of more electrical energy on the wire.

Page 334. *Figure 174.* This dynamo located at the Edison plant in Brooklyn, N. Y., was the largest dynamo in the world at the time of its construction. It is run by a steam power plant. A turbine might cause it to revolve were it situated near a large stream.

Page 335. *Figure 175.* Self-explanatory.

Page 336. *Figure 176.* Self-explanatory.

Page 337. *Figure 177.* **A** and **B** are attached so that the electric current can run through them. Because one is positive (+) and the other negative (−) **D** must be changed to + so that it will be repelled by **X** and sent on up in its revolution. **C** at the same time will be changed from a + to a −. **X** will draw **D** until **D** reaches a horizontal position. The commutator changes the polarity of the moving part of the motor. In **C** the electro-magnet begins to revolve because the commutator constantly changes the polarity of the electro-magnet. Thus the poles of the electro-magnet are at all times either attracted or repelled by opposite poles of the magnet. The commutator reverses the direction of the current in the electro-magnet.

Page 341. *Thought Questions:* **1.** Electric power is more efficient, cleaner, and less expensive (after first cost of installation) than steam power.

2. Iron ore is a mixture of iron, oxygen, and other matter (impurities). Refinement places the molecules of iron together, gives the iron strength, and makes it capable of being worked.

3. Expert chemists know how to mix the contents of the furnaces to the best advantage so that the best grade of iron or steel may be secured.

4. The blast furnace burns and blows out impurities and refines the iron.

5. Pig iron is porous, brittle, and contains much carbon.

6. More carbon is burned out; it becomes more solid, less porous, is stronger, and loses its brittleness.

7. The energy that runs a watch comes from the elasticity and flexibility of steel.

8. Most waterfalls are found in mountainous regions. The manufacturing development of New England depended upon waterfalls. They are still of importance in that part of the country where the elevation is not too great. The development of electrical power plants near these falls has now scattered manufacturing somewhat because the electrical current can be carried over long distances by high tension wires.

9. Waterfalls gave New England its great start as a manufacturing region of the United States.

10. Steel is used in the construction of turbines, engines, boilers, etc. All machines are made chiefly of steel.

CHAPTER XII

THE WORK OF THE FACTORS OF OUR ENVIRONMENT IN TRANSPORTATION

Time Allotment

One period is to be allowed for the preliminary matter of the chapter. Three full periods should be spent upon the study of the pictures. Two periods may be used on the text matter and one period upon the *Thought Questions* and *Summary* or *Review Outline.* One period may be used on special reports.

A. TRAVEL ON LAND

Page 342. *Key Picture 12a.* Self-explanatory.

Page 344. *Practical Questions:* **1.** A steam engine can use energy to produce motion.

2. The gas engine loses less heat by radiation than does a steam engine. It is smaller per horse-power, simpler in construction, and its fuel is concentrated.

3. Good roads make better and more extensive transportation possible. This improves business of every sort.

4. In the electric motor neither boiler nor cylinders are required. No fuel is used. Relatively little heat is lost and it is easily controlled.

5. Because our coal will become increasingly expensive due to diminishing supply, cheap hydroelectric power will be made more easily available as power projects develop, and people will naturally turn to the use of the less expensive power.

Home Problem: Self-explanatory.

Field Problem: Self-explanatory.

Section 294. The pole drag was like a wheelbarrow in that the horse pulling on the poles might be compared to the man pushing on the handles of the barrow. In the pole drag one end of the poles rested on the ground and dragged in place of the rolling wheel in the barrow. The friction in the pole drag (sliding friction) was much greater than in the barrow (rolling friction). In the wheel and axle the friction was much reduced, occurring at two principal points, — at the axle and at the point where the wheel touches the ground. Friction in the axle is reduced by grease.

Page 345. *Figure 178.* Here rolling instead of sliding friction was used.

Page 346. *Figure 179.* The reverse lever is used to change the position of the connecting rods so that the locomotive may be sent ahead or backwards as desired. The piston does not change its direction except in the regular forward and backward movement of its impulses. The functions of the rest of the parts are obvious and the way they work may be easily developed by reviewing *Figure 166.*

Figure 180. Twenty-four drive wheels here. Its weight gives it its great traction power. This weight makes the friction of the wheels against the rails enormous.

Page 348. *Figure 181A.* The first piston at the left is drawing in gas. The second piston at the left is compressing the gas it contains. The third piston shows the power stroke at the instant the gas is exploded, while at piston four the waste gases are about to be forced out of the cylinder by the rising piston.

Page 349. *Figure 181B.* The working of this four cylinder engine has been partially explained under *Figure 181A* above. This cut shows a complete cycle of one piston only.

Page 350. *Figure 182A.* Self-explanatory.

Page 351. *Figure 182B.* Self-explanatory.

Page 352. *Figure 183.* The movement of water around the engine and through the radiator is caused by the unequal heating of the water causing the setting up of convection currents. The heavier, cool water at the bottom forces the warm water up to the top.

Page 353. *Figure 184.* The coil gives the little men more power and greater speed; the battery gives them energy;

the spark plug discharges this energy. The spark plug fires when the distributor allows the electrical current to reach it.

Page 354. *Figure 185.* Self-explanatory.

Figure 186. The work is easy for this truck because of the powerful internal combustion engine, low-geared to the rear wheels.

Page 355. *Figure 187.* Electrical energy moves the car. The movement of the car is controlled by the control handle. The electric current goes from the wheels into the rails and thence back to the power house. The arrows will show the path of the current in the complete circuit.

Page 356. *Figure 188.* Electrical energy from the overhead trolley wire applied to the wheels through motors cause the locomotive to move. The motors in the locomotive are geared to the wheels. The power comes from the power house.

Figure 189A. This kind of road makes progressive farming impossible. It requires a disproportionate amount of work and time to get the products of the farm to the market. It affects industry because it makes it difficult to bring raw materials to the factory or the finished product away from the factory. The automobile has been the chief cause of the improvement of the roads.

Page 357. *Figure 189B.* There is less friction over this road with a corresponding decrease in the time and energy required to pass over it.

Page 358. *Figure 190.* A concrete road does not need crowning to any extent. It is harder, smoother, and needs less repairs than a macadam road.

Figure 191. The raised rail counterbalances the momentum of the train as it passes around the curve at great speed. This is due to the fact that the train's center of equilibrium is moved towards the side of the lower rail.

Page 359. *Figure 192.* The plate girder bridge is extremely strong because the units are small and rigid due to the bracing of the cross pieces and the absence of much play in the parts. The triangular truss form is light and strong because light pieces of steel are used, many cross braces make it rigid, yet there is flexibility in the parts. Every part of the bridge reinforces every other part and makes it strong even though light in construction.

Page 360. *Figure 193.* This is called a suspension bridge because its main span is hung (suspended) from two great towers rather than being supported by piers.

Page 362. *Thought Questions:* **1.** Steam does work in the cylinder by moving the piston and its connected appliances.

2. The sand increases the friction, thus giving better traction to the wheels.

3. The weighting of the drive wheels opposite the crank pins helps to offset the unbalancing effect of the reciprocating parts (pistons, crossheads, etc.)

4. The electrification of steam roads saves fuel, and is more efficient since greater grades can be climbed and longer trains can be hauled with an electric locomotive than with a steam locomotive. The excessive dirt of the steam locomotive is avoided.

5. The brushes make contact with the commutator and complete the circuit through the motor or generator even though the movement of the commutator tends to break that circuit. The commutator changes the direction of the current in the generator as it is about to enter the outside circuit. The commutator in the motor reverses the current so that its movement in the motor is always in the same direction.

6. In the gas engine there is internal combustion; it is light, efficient, clean, has no large amount of wastes, and has a proportionately greater power for hauling loads. In the steam engine there is a great loss of heat, it is expensive to run, makes much more dirt, is heavy, but has value in hauling great loads.

7. Shortening the route saves time, fuel, wear and tear, and cost of maintenance. Avoiding grades saves much fuel, saves much time, makes it possible to draw longer trains without extra engines, etc. Curves use up less energy than grades.

8. The automobile must have a smooth surface to move upon, if it is to be efficient and comfortable. The enormous number of automobiles in the United States to-day makes good roads a necessity. Good roads, on the other hand, make the automobile industry expand rapidly.

9. The suspension bridge is the lightest type of bridge in proportion to its size. The Brooklyn bridge is a good example of a suspension bridge.

10. The concrete road is the best form of road made because it is smooth, gives good traction for wheels, is not affected by frost, is hard, lasting, and easily repaired.

B. TRAVEL ON WATER

Time Allotment

One and one-half periods may be used on preliminary matter of the chapter and on the development of *Demonstration 35*.

The equivalent of one and one-half periods may be used in a study of the pictures. Two full periods may be spent upon the text matter. One period may be used on the *Thought Questions*, the *Review Outline*, and *Summary*. One period may be used on special reports.

Page 364. *Key Picture 12 b.* The shape of the ships in **1**, **2**, and **3** determine how deep they will settle in the water. In **3** the huge hull displaces an enormous amount of water and allows it to hold three times the number of tons that **1** holds, yet it does not sink in the water any lower than **1** or **2**. In **4**, **5**, and **6** the number of tons on board is the same, but because **6** has a bulging hull it displaces much more water than either **4** or **5** and thus stands out of the water farther. (In discussing these six pictures the ships may be considered to weigh the number of tons indicated on each without cargo or they may be considered as weighing the amount indicated on each including the cargo. The principle is the same.)

The corner pictures roughly give an idea of the progress of water navigation. The dugout at **A** was slow, inefficient, and had to be propelled by hand. It was safe. The galley at **B** was propelled by oars and sails, and carried more passengers, but was slow and cumbersome. At **C** a sail, a rudder, a center board, and adjustable sails are used and the boat is easily controlled. Good speed is obtained, but it is not altogether safe. Tacking can be done with this boat. In **D** we have the motor boat propelled by a gas engine. This is light, swift, easily handled, convenient, safe, and efficient. What is true of this type of boat is also true of the giant ocean liners. The principle in **C** is also applied, of course, to the schooner, four-masted ship, bark, brig, etc.

Page 365. *Practical Questions:* **1.** Early water travel was slow because there was no good way of propelling ships or of keeping them in their course; methods of tacking had not yet been developed. Thus the ships had to go with the wind.

2. The invention of the compass and other navigation aids made long water journeys possible.

3. Men knew that iron would sink in water because it was heavier than an equal volume of water, but they did not know that the shape of the hull of an iron ship causes the displacement of such a large amount of water that even though the weight of the iron in the ship is many times the weight of an equal volume of water, the ship will float because of its huge bulk and water displacement.

4. Sailing ships are going out of use because they are slow, not as easily handled, and may be becalmed in certain latitudes unless aided by auxiliary engines. They give an inexpensive means of transportation, however, if time is no object. As pleasure boats, the smaller sailing vessels continue in popularity.

5. Commercial growth depends largely upon larger ships, Large ships must have deep rivers and harbors in which to navigate and adequate wharf facilities for docking.

Page 366. *Home Problem:* Self-explanatory.

Field Problem: Self-explanatory.

Page 367. *Demonstration 35.* The weight appears to weigh less than 200 grams because the water is pushing up on its bottom, buoying it up. The overflow water should weigh exactly the same as the 200-gram weight appeared to lose in the water. The weight sinks because it displaces less than its own weight of water.

Conclusion: The wood floats because it displaces water enough to equal its own weight. An iron or steel ship floats because its great bulk displaces its own weight in water.

Page 368. *Figure 194.* In the upper cut, the ballast, the weighted keel, the broad beam, all aid in making this boat stable and buoyant. The boat is somewhat unstable at **b** and more so at **c** because the weight **x** has been moved so far to the side that the gravity force down (center of equilibrium) has nearly passed in **b** and completely passed in **c** to the outside of the center of the buoyant force upward.

Page 369. *Figure 195.* This bark is a safe ship because of its broad beam. It is slow because it has to depend upon the wind for its propulsion. It is an advance step over ancient boats because it can be sailed into the wind by tacking, due to its deep keel and adjustable sails, and it can carry a vastly larger cargo.

Page 370. *Figure 196.* A body will float in water when its specific gravity is equal to 1 or less than 1.

Page 372. *Figure 197.* Self-explanatory.

Page 373. *Figure 198.* The bulk of the ship causes an enormous displacement of water and it floats. It will displace a volume of water equal to its own weight.

Page 375. *Figure 199.* The submarine floats because its weight does not exceed the weight of the volume of water which it displaces. It will sink when water is allowed to flow into its tanks and cause its weight to be greater than the weight of the volume it displaces. It will rise when enough water is forced out of its tanks to make its weight equal to or less than the weight of the volume of water it displaces.

Page 376. *Figure 200.* Self-explanatory.

Page 377. *Figure 201.* The resistance of the water against the slightly curved blades of the propeller cause it to revolve as the ship pulls it through the water. Its rate of revolving depends upon the speed of the ship, but the speedometer is so adjusted that it actually registers the true speed of the ship.

Page 378. *Figure 202A.* It is sturdily built to withstand strong wind and waves, is conveniently constructed as living quarters for the keeper, is painted white so that it is easily seen by day, and gives strong light rays by night. Its smooth surface offers a minimum of resistance to the waves.

Page 379. *Figure 202B.* Where sand bars are shifting the lighthouse would not indicate where these bars were since the lighthouse cannot be moved. The lightship, on the other hand, can follow these moving bars.

Page 382. *Thought Questions:* **1.** An object will float in water when it displaces a volume of water equal to its own weight. It will sink when it displaces a body of water whose weight is less than its own.

2. The freight must be evenly distributed in the ship to prevent a list. This makes for better speed and prevents shifting of cargo in passage.

3. The rule on the bow will indicate the weight of the cargo and will tend to prevent overloading.

4. The deep keel helps in tacking and prevents capsizing in sharp turns and in heavy winds.

5. The great pressure of the water would burst in its sides.

6. An electric motor must be used below the surface of the water because the exhaust gases of the oil engine would suffocate the crew. The oil engine is used on the surface to conserve the electrical power.

7. Because an allowance must be made for a slight declination due to the position of the magnetic pole, which is not exactly true north.

8. The log measures the speed of the boat and the sextant determines its position north or south of the equator.

9. The Panama Canal saves thousands of miles of travel, which means time and fuel. It is of great value in protecting both our coasts in time of threatened war. It cuts the time and length of the passage of globe-encircling ships by at least 8000 miles and makes trade routes possible that were not even considered before the canal was in operation.

Special Problems: All self-explanatory. Reports will differ as experiences differ. They should be original and interesting.

C. TRAVEL IN THE AIR

Time Allotment

Use one period on the *Suggested Experiment* and the preliminary parts of the chapter. Use one period on the pictures. Use two periods for the text matter, one period for the *Thought Questions,* and one period for the *Review Outline* and the *Summary.* One final period may be used for special reports.

Page 384. *Key Picture 12c.* **A.** The balloon rises because the atmospheric pressure upon the balloon from all sides is greater than the weight of the balloon, since it contains a very light gas (hydrogen). It is buoyed up very much as a piece of light wood will be buoyed up to the surface of the water when it is submerged and set free. The arrows show the direction of pressure of the surrounding air. The molecules of gas in the balloon are far apart as the gas inside is very light.

B. The kite is held up by the resistance of the air at **a** against the face of the kite. As the string is pulled the kite tends to slide up on the air. Note the slight vacuum behind the kite. In the cross section of the wing of Lindbergh's plane note that the air as it strikes the rounded front edge of the wing is forced back along each surface and at the top and rear where the plane becomes narrowed in thickness a vacuum is formed. The upward atmospheric pressure on the lower surface of the plane tends to push the plane wing up to fill this vacuum and this accounts for about $\frac{3}{5}$ of the upward lift on the plane as it flies. Note that the vacuum behind the Byrd plane America would be very great as the wings are very thick. Note the rounded shape of the wing of the *Spirit of St. Louis* and the rudder, elevators, and ailerons.

Page 385. *Practical Questions:* **1.** The stone is much heavier than the air it displaces, but the paper is only slightly heavier than the air it displaces.

2. The small piece of paper offers less resistance to the air than the large piece.

3. The warmed air in the balloon is forced up by the heavier air beneath it. Part of it fills the balloon and so lifts the bag.

4. The glider edge cuts the air and as it passes over the air the inertia of the air supports it. But as the glider loses momentum its weight overcomes the inertia of the air and it finally drops to the ground.

5. The pressure on the face of the kite is reduced as the string becomes slack and the kite will not be pulled up on the body of air in front of it.

Home Problem: Self-explanatory.

Page 386. *Field Problem:* Self-explanatory.

Figure 203. The mast acts as a mooring for the dirigible. The weight of the dirigible is less than or not more than the weight of the volume of air which it displaces. Its rudders and fins and propellers control its flight. It is propelled by gas engines. It is approximately 600 feet long.

Page 388. *Figure 204.* The Wright machine flew because its wings in moving maintained a speed great enough to prevent the overcoming of the inertia of the air over which the wings passed and because the camber of the wings formed a vacuum over them which allows the air below the wing full pressure. The rush of air immediately above the wing offsets the upper pressure.

Page 390. *Figure 205.* Self-explanatory.

Page 391. *Figure 206A.* The extra plane gives a greater lifting power to the plane. This plane carries heavy bombs for destructive work in war times. The type has not proved practical by contrast with more recent designs of biplanes and monoplanes, chiefly because of the increased parasite resistance due to the larger number of bracing wires and strats required to care for the extra planes.

Suggested Experiment: The paper will flutter up into a horizontal position. The atmospheric pressure above the sheet is less than that below it because the breath from the mouth tends to form a vacuum above the sheet of paper. The air below the paper pushes the paper up to fill the vacuum. This is the principle of the airplane in a nutshell.

Page 393. *Figure 206B.* This type can fly over both land and water (the same as the land plane), but it can also float on the water and taxi along through the water. Of course the hydroplane cannot land on land any more than the land plane can land on the water. The chief importance of this question is to open up a full discussion.

Page 395. *Figure 207.* Self-explanatory.

Page 396. *Thought Questions:* **1.** The balloon can be kept up at a given altitude for a long time by control of ballast.

2. Hydrogen is highly inflammable.

3. The atmospheric pressure is less as the balloon goes up.

4. The dirigible can be directed in any direction.

5. The body of the man cannot release enough energy to make the wings move fast enough to raise it from the ground.

6. They discovered the principle of the cambered wing.

7. The wings must be curved or cambered.

8. Equilibrium was secured in the early Wright plane by warping the wings; in the Curtis plane ailerons are used.

9. One could not fly to the moon because there would be no oxygen to breathe above a certain altitude.

10. Altitude contestants must be equipped with oxygen tanks for breathing and with superchargers to give the engine enough oxygen when it reaches the rarefied air at great altitudes.

CHAPTER XIII

THE USE OF ELECTRICITY IN COMMUNICATION

Time Allotment

One period may be used for the preliminary work of the chapter.

The equivalent of three periods should be spent upon the three fundamental demonstrations. Two or three other periods may be used in the study of the pictures. Two periods are to be used on the text matter and two periods on the *Thought Questions, Review Outline,* and *Summary.* Two periods may be well spent upon special demonstrations of telegraph sets or radio hook-ups.

Page 398. *Key Picture 13.* The parts lettered in **3** and **4** may best be identified after some study has been made of the chapter. The parts in **1** and **5** are self-explanatory.

Page 400. *Practical Questions:* **1.** People of early days knew little of one another because there was no good means of communication. The horse was the fastest means of carrying messages and the roads were very poor.

2. It took so long to carry messages from Washington to New Orleans by horse that the battle was fought before the news of peace could reach the contending forces.

3. The wires carry the electrical impulses along them.

4. The actual voice is not heard over the telephone. Variations are made in the electrical current and these modifications in the strength of the current are received by the diaphragm and interpreted as sound by the ears.

5. The ether which occupies all space between the molecules of air carries the electrical impulses or waves.

Home Problem: Self-explanatory.

Field Problem: Self-explanatory.

Page 402. *Demonstration 36. Observations:* The iron core becomes magnetized when the circuit is closed. When the circuit is broken, the iron core loses its magnetism. The rod is a magnet when an electric current runs through it. It remains a magnet as long as the circuit is kept closed. This is an electromagnet because it is magnetized temporarily by an electric current. The more dry cells used, the greater the magnetic power of the rod. The more turns in the wire about the rod the greater the magnetic power of the rod. A strong electromagnet may be made by using a large number of coils of wire.

Practical Applications: Causes of the bell failing to ring here may differ. The test will give its own explanation.

Page 404. *Figure 209.* Self-explanatory.

Page 405. *Demonstration 37. Observations:* When the circuit is closed, the small bolt rises. The bolt drops when the circuit is broken. This takes place because the large bolt is made a temporary magnet. The small bolt rises because the large bolt being electrified attracts it. There is a distinct difference in sound when the small bolt hits the box as compared to the sound made when it strikes the large bolt.

Practical Applications: Self-explanatory. The test will bring the solution.

Figure 210A. Self-explanatory.

Section 341. Results of Demonstration 37 will answer the question given here.

Page 406. *Figure 210B.* Self-explanatory.

Figure 210C. The key completes and breaks the circuit, which activates the sounder, thus sending the code signals over the telegraph wire.

Page 407. *Figure 211.* Self-explanatory. These codes can easily be practiced on the apparatus shown in *Figure 209*, page 404.

Page 408. *Demonstration 38. Observations:* The watch ticks can be heard in the receiver. The watch does not touch the pencils. The sound passes from the watch to the pencils through the wood of the cigar box and the carbon of the pencils. The vibrations alone pass through the wood and carbon. The watch causes the carbon in the pencils to vibrate. The cross pencil connects the vibrations of both pencils. The box does not vibrate at the same rate at all parts, due to the fact that the pressure varies at the points where the carbons touch each other.

Conclusion: The telephone works by an electric current, carrying a series of vibrations along a wire which are modified by the voice or any other sound and these vibrations act upon a diaphragm in the receiver, producing vibrations in the air which we interpret as sounds patterned on other sounds.

Figure 212. Every part here shown is essential and has its counterpart in a regular telephone set.

Page 410. *Figure 213A.* The diaphragm is made to vibrate by vibrations in the air caused by the voice. These vibrations in the diaphragm are carried as electrical impulses along the wires and over the line to the receiver.

Figure 213B. The diaphragm receives electrical impulses over the wires **x** and **y.** These cause the diaphragm to vibrate and the vibrations are passed along to the air immediately beyond the diaphragm. The ear interprets these as sound.

Pages 411–422. *Figures 214A* to *220C* are all self-explanatory.

Page 425. *Thought Questions:* **1.** Magnets must be used in telephones and telegraph instruments to indicate breaks in the circuit so that the modifications of the impulses may be interpreted as sound either of the voice or of the telegraph code (dots and dashes).

2. Michael Faraday laid the foundation of the telephone by experimentation.

3. The telephone needs no code; the reproduction of vocal vibrations are easily recognized; and the 'phone is more convenient in use. The telegraph, on the other hand, can send multiple messages over the same wire in both directions at once and at great speed. The telegraph also records the messages so that an exact record can be kept of messages. The telegraph is relatively more expensive than the telephone.

4. At present, the wire telephone is more reliable than the wireless telephone because it is less subject to interference.

5. The strong electric current is necessary to provide sufficient strength to the impulses transmitted from one end of the line to the other.

6. The diaphragm in the telephone is necessary to the transmission of the air vibrations. In the telegraph, the sounder takes the place of the diaphragm.

7. In the radio the important pieces of apparatus not used in the telephone or telegraph are the transmitter, loud speaker, tuning apparatus, and bulbs.

8. Tuning in wireless communication is simply the adjustment of the receiving apparatus to the use of the same wave length as that which is coming from the sending station with which it is being "tuned." No sound can be received from a receiving apparatus unless it is in tune with some sending station.

9. The human voice does not travel along the wire in telephoning. The strangeness of the voice is usually due to poor connections somewhere along the line. The modifications of the electric current made by the voice over the wire are an exact duplicate of the vibrations in the air caused by the voice and so are usually recognizable.

10. The electromagnet of the bell is the sounder of the telegraph. Making and breaking the circuit in the bell rings it; in the telegraph it gives the "dots" and "dashes" in the sounder.

PREVIEW OF PART IV

In Parts II and III you have been teaching the pupils the manifestations of energy as it accomplishes the work of the world. You should have brought out during the progress of the work in these two parts that the source of this energy is the sun.

You are now about to make an intensive study of the sun as a part of the solar system and of the relations of the sun to our earth. The pupil should become fully cognizant of the fact that the sun is the fundamental cause of the weather and of climatic differences on the earth, modified to some extent by bodies of water, mountains, plains, etc.

The most important point of all to be made is this: The pupils should see that weather and climate have a profound influence upon the kind of life existing in different parts of the earth, upon the kind of people found over the surface of the earth, upon their occupations, and upon their industrial activities.

CHAPTER XIV

THE SUN AS THE SOURCE OF ALL ENERGY

Time Allotment

One period should be spent upon the preliminary phases of the chapter. Two periods should be spent on the *Key Demonstration.* Two periods may well be used in a study of the pictures and three periods on the subject matter. One period may be used in shaping a *Review Outline* (a new task for the pupil) and one period on the *Thought Questions* and *Summary.*

Page 428. *Key Picture 14:* At New York the day is longer than the night in June because New York is then passing through a large area of light due to the inclination of the axis of the earth. This area is then larger than at any other time of the year. In December the day is shortest. Rotation of the earth on its axis causes day and night. Much heat is absorbed by the earth in June because the earth is exposed to the sun's rays at any one spot about 16 hours out of the 24. Summer is caused by the absorption of much heat from the sun due to the inclination of the earth's axis and the revolution of the earth about the sun. Winter is caused by the reverse condition as far as the amount of heat is concerned. It also is due to the inclination of the earth's axis and the revolution of the earth about the sun. The days and nights are of equal length in September and March because the earth's axis then is so inclined that the sun's rays strike the surface of the earth at right angles to the axis. Thus every part of the earth from the north to the south pole has equal days and nights and the seasons must, therefore, be mild in the temperate zones at those times. The sun's rays strike directly upon the Tropic of Cancer in June and upon the Tropic of Capricorn in December. The sun's rays are the least direct at or near the poles. The seasons are caused by the fact that the earth is round, by the rotation of the earth upon its axis, the inclination of the earth's axis, and the revolution of the earth about the sun.

Page 429. *Practical Questions:* **1.** *Chapter I.* The sun causes plants to grow (pages 10 and 11). *Chapter II.* The sun bakes the bricks that go into the walls of many buildings (page 39). *Chapter III.* The sun's heat causes the unequal heating of the air which results in tornadoes (page 60). *Chapter IV.* The sun determines the air pressure in many localities. The warmer the air, the less the pressure, provided there is moisture in the air. This difference is shown on the barometer (page 82). *Chapter V.* Fuels are composed of organic substances originally made by the sun's heat and light (pages 122, 125). *Chapter VI.* The sun causes the evaporation of water from a pond, forming clouds (page 159). *Chapter VII.* Water power is made possible by the action of the sun in forming clouds which drop their rain in the mountains to flow down as water in the streams which turn water wheels (page 184). *Chapter VIII.* The sun's heat is the cause of a change of temperature out-of-doors. This is registered on a thermometer (page 231). *Chapter IX.* The sun is used in taking exposures on a photographic plate (page 263). *Chapter X.* The power house is run by sun-manufactured coal which, when burned, generates steam which turns the dynamo and develops the electric current (page 301). *Chapter XI. Key Picture 11* is full of examples. *Chapter XIIA.* The sun's heat thaws out the country roads and makes them nearly impassable in the spring (page 356). *Chapter XIIB.* The unequal heating of the air by the sun's heat produces winds which drive along the sailing vessel (page 369). Chapter *XIIC.* A balloon will rise more easily when the sun is shining than when it is cloudy since the sun's heat causes the gases in the balloon to expand and the balloon becomes relatively much lighter than the air which it displaces (page 384). *Chapter XIII.* Sunlight is used in the heliograph (page 398).

2. The sun's heat is a form of energy which makes it possible for the sun to do work.

3. By expansion of gases, liquids, and solids on the surface of the earth and moon, the sun causes movement, which is work.

4. The paper is made from vegetable pulp which came from plants grown largely by the sun's heat; the ink is also partly made from vegetable products grown by the sun's heat.

5. There would be no living plants, nor animals, nor human beings because plants and animals must have sunlight to live. The earth would be a frozen mass of rocks and ice. There would be no work of any kind done on the earth as there would be no one to use the sun's heat to do the work.

Page 430. *Home Problem:* Self-explanatory. The shadow clock will reflect the change in the position of the sun above the horizon at noon each day.

Field Problem: Here is a good chance for a debate upon the advantages and disadvantages of daylight saving time. Allow the pupils full initiative, asking that they be responsible for scoring the scientific accuracy of the discussion. Correlate also with the work in English.

Suggested Experiment: The dark surfaces being warmer than the silvered surfaces will cause a greater activity in the molecules touching these surfaces than among those molecules touching the silvered surfaces. These active molecules will give a greater thrust against the dark surface than those against the silvered surface and the dark surface will recede before the heat rays of the sun. The sun does work here by moving the vanes. By using a lens the heat rays could be concentrated into the radiometer. The vanes would revolve with greatly increased speed. By the use of great mirrors the sun's rays have been concentrated upon boilers so that steam was generated. With this amount of heat, cooking, baking, the melting of iron, etc., is possible.

Figure 221. Text explains this picture.

Page 431. *Section 253.* The one exposed to sunlight will have changed to a lighter color. It has faded, due to the chemical action of light on the dyes in the cloth. The outline of the leaf will appear. This is due to the action of light on the part not covered by the leaf.

Suggested Experiment: Self-explanatory. The test will answer the problem.

Page 432. *Figure 222.* Self-explanatory.

Page 433. *Figure 223.* There are about 125 stars shown in each of these pictures. About 8 constellations are named. They were named because of their fancied resemblance to animals, men, gods, etc. They are used by man to determine his location and direction at night.

Page 434. *Figure 224.* Self-explanatory.

Page 435. *Figure 225.* Self-explanatory.

Section 359. The days get longer little by little, due to the gradual change in the position of any spot on the earth in its relation to the sun's rays as the earth revolves about the sun.

Page 437. (*Key*) *Demonstration 39.* *Observations:* More rays of light (heat) strike the earth in the June than in the December position. New York is warmer in June than in December because it has the more direct rays of the sun at that time and more of them strike a given area, due to their directness. If the axis of the earth were vertical to the plane of the earth's orbit, our days and nights would be of equal length. If our North Pole did not always point in the same direction, the days and nights would vary to correspond with its movements. If the earth did not revolve around the sun, there would be no seasons. If the earth did not rotate upon its axis, there would be no day and night following one another.

Conclusion: Rotation of earth upon its axis; inclination of the earth's axis, revolution of the earth about the sun, and the fact that the earth is round cause the variations in the intensity of the heat and light rays.

Practical Applications: One could arrange to enjoy summer all the year round by moving north and south in the temperate zone (New York to the West Indies and back again). The sun never sets for six months about the North Pole because the earth's axis is inclined away from the sun for that length of time during the revolution of the earth about the sun.

Figure 227. Note that the 5 light rays are obliged to cover 30° of latitude while the 10 rays cover the same number of degrees. The curve of the earth, which is apparently greater at the poles, causes this difference. Of course, the greater heat is felt near the equator.

Page 438. *Figure 228.* The moon rises 51 minutes later each night because as the earth rotates on its axis the moon revolves around the earth. Any spot on the earth must be carried past its previous position the night before to catch up with the moon which has advanced in its orbit. The moon cannot be seen at all sometimes during the month because it is between the earth and the sun. A full moon results when the moon gets on the far side of the earth away from the sun and the sun shines full upon that side of the moon facing us.

Page 439. *Figure 229.* At 5 P.M. the tide came in, floating the boats which had rested on the beach at 10 A.M. The moon and the sun cause the tides. The extra boat sailed in at high tide because the water was then deep enough for it to navigate that part of the waters.

Section 362. The soil does not visibly move because its molecules will not slip easily over each other as occurs in a liquid.

Page 441. *Figure 230.* There are 360° of latitude and longitude on the surface of the earth. See *section 367* for the answer to the final question.

Page 442. *Section 364.* There will be 180 parallels of latitude between the equator and the north or south pole. There are 360 meridians on the earth. It is easier to locate a spot on the earth the nearer we go to the poles because the spaces between the intersections of the meridians and parallels are smaller.

Page 443. *Figure 231.* It will be morning in San Francisco. This is so because the sun's rays are just reaching San Francisco at the time it is directly over Washington. It will be 5 P.M. in London.

Page 444. *Figure 232A.* These zone lines are irregular because they are determined by the towns and cities which form convenient points for commercial, industrial, and transportational adaptation to time changes. Such centers are frequently important railway terminals and junctions. The advantage of these time zones is that train connections, business engagements, and industrial operations may be conducted according to fixed schedules with a minimum of confusion between zones.

Page 445. *Figure 232B.* If a person stays in one spot, he makes as many rotations about the earth's axis as does the earth itself. It is clear, then, that if he makes a complete circuit of the earth in the direction opposite (east to west) to the earth's rotation, he will reduce by one the number of rotations which he otherwise would have made. That is, he will lose a day. Conversely, if he makes a complete circuit in the direction of the earth's rotation, west to east, he will gain a day.

Such changes in time would be very confusing, especially in this day of travel, if uniformity were not established. Accordingly, the International Date Line has been generally approved as a means to avoid this confusion. This line is arbitrarily but conveniently fixed at the 180° meridian. The location is convenient both because of the few population centers affected and because this meridian is just 12 hours away from Greenwich. The actual line varies somewhat from the meridian in order to meet the needs of the several communities immediately affected.

Page 446.

> **Note here, in the box, that the pupils are now to make their own *Review Outlines* for the following chapters. If these outlines have been studied in the previous chapters, the pupils should have become thoroughly familiar with their purpose and value and should be able to work out subsequent outlines for themselves. By all means do not insist that the outlines be elaborate. This will kill interest and endeavor.**

Page 447. *Thought Questions:* **1.** By actual observation, the other planets are known to rotate; experiments show that weights dropped from high altitudes deviate to the east in their descent; and physicists have conclusively proved the earth's rotation by experiments with the pendulum. The proved fact of the earth's rotation about its axis and demonstrated relations of the sun to the earth's allied planets leads to the conclusion that the sun does not revolve about the earth.

2. Mr. A has the farther to go because the circumference of the earth is greater at the equator than at any place north or south of it.

3. The sun never sets in northern Lapland for six months of the year because the north pole is pointed towards the sun during that time. During the next six months Lapland is in darkness.

4. See the explanation of *Key Picture 14*, page 428.

5. See explanation of *Key Picture 14*, page 428.

6. Every point on the equator has equal days and nights the year through. Quito is on the equator.

7. It is hot in Buenos Aires in December because in the December position of the earth the South Pole and southern hemisphere receive the rays of the sun more directly than the North Pole and northern hemisphere.

8. The days increase in length as one approaches the North Pole in summer because one is approaching the area of the earth which stays longer and longer in the light as the earth rotates.

9. The sun could not get between the moon and the earth because the distance from the moon to the earth is about 235,000 miles while the diameter of the sun is about 860,000 miles.

10. A solar eclipse takes place when the moon gets between the sun and the earth.

11. An eclipse of the moon takes place when the earth gets between the sun and the moon, because the earth cuts off the light of the sun from the face of the moon.

12–15. The detailed answers to these several questions are most effectively developed by use of a globe or comparable apparatus. This laboratory method will permit of amplified discussion in which the questioned conditions will clearly reveal their resultant effects.

Figure 233A. Self-explanatory.

Page 449. *Figure 233B.* The path of darkness on the earth was so narrow because the moon was so small in proportion to the size of the sun. The eclipse was visible north of the equator only because the position of the moon in its relation to the sun and the earth was north of the equator. A lunar eclipse could occur if the earth got between the sun and the moon, thus cutting off the light of the sun from the face of the moon.

CHAPTER XV

THE RELATION OF SOLAR ENERGY TO THE WEATHER

Time Allotment

One period may be used for the preliminary work of the chapter. Three periods will be required for the demonstrations. Three periods may well be used for a careful study of the pictures. Two periods may be used for a study of the text matter and one period for the *Thought Questions*, *Summary*, and *Review Outline* (made by pupil).

Page 450. *Key Picture 15.* The storms begin in the northwestern part of the United States or the southwestern part of Canada; they follow a southeastern route until they reach the Mississippi valley; they then turn northeast, oftentimes splitting, a part going out to sea through the Gulf of St. Lawrence and the other part passing to sea off the Virginia capes and the Chesapeake Bay.

Page 451. *Practical Questions:* **1.** Warm air in expanding absorbs much moisture from the clothes. On cold days the molecules of air are closer together and so allow but little moisture to be absorbed from the clothes. On windy days new masses of air constantly strike the clothes, each mass absorbing its quota of moisture. On a calm day any given mass of air in contact with the clothes becomes saturated with moisture and does not move on. Thus the clothes can not get rid of their moisture quickly on a calm day.

2. The water in the air in coming into contact with the cold pitcher containing water condenses and forms the "sweat" or water vapor on the outside of the pitcher.

3. The moisture in the room coming into contact with the cold windowpane condenses and freezes, forming the frost.

4. A heavy dew generally indicates fair weather because it is the result of a heavy condensation of water vapor on the ground, water vapor which otherwise would probably accumulate in the air in sufficient measure to cause precipitation.

5. The great amount of moisture already in the air on such a day does not allow the perspiration from the body to be absorbed readily by the air. Ordinarily, perspiration as it evaporates from the body takes much heat with it. This heat is kept in the body when " muggy " days prevent the evaporation of the perspiration.

Page 452. *Home Problem:* These pieces of apparatus may be constructed from cardboard, tin, or light wood.

Field Problem: Usually, the wind direction changes to the west after a rainstorm. The low pressure area has passed.

Page 453. (*Key*) *Demonstration 40.* Self-explanatory.

Figure 234. Self-explanatory.

Page 454. *Suggested Experiment:* Air is in the flasks to begin with (page 73). By applying heat to the shoulder of the flask you reduce the chance of breaking the flask and also you heat a larger body of air in the flask than you would by applying the flame to the neck. The flasks should be exactly balanced in order to facilitate the observation of the effects of the heat as applied to the flask. The heated flask should rise — become lighter than the other flask. This heated flask rises because, volume for volume, warm air is lighter than cold air. Heat causes air to expand. Heated air rises because the heavier cold air about it forces it up. The heated air in the flask rises because the only outlet for the expanding particles is at the top of the flask.

Page 455. *Figure 235.* Self-explanatory.

Page 456. (*Key*) *Demonstration 41. Observations:* When the pressure on the tube is released, the mercury at once rises to its first position in the tube. When the air is withdrawn from the large test tube, the mercury drops several inches because the atmospheric pressure in the tube is much reduced — a partial vacuum is formed here. (The mercury column will rise nearly to the top of the mercury tube if the pupil now blows into the end of the rubber tubing, for he is now using compressed air.) As the air pressure varies the height of the column of mercury varies. Any change in the intensity of atmospheric pressure will cause a change in the height of the mercury column. Just before a storm the column will shorten; after the storm the column should lengthen.

Figure 236. Self-explanatory.

Page 457. *Key Demonstration 42. Observations:* The fan evaporates the water in the muslin. The amount of water already in the air and the amount of wind will determine the amount of evaporation of water from the wet-bulb thermometer. The more water in the air the less the evaporation from the thermometer. This water will evaporate fastest when the wind is blowing, while at the same time the air contains little moisture. The warmer the surrounding air, the more moisture it can absorb, with a correspondingly quicker evaporation. The more the evaporation, the more heat withdrawn from the bulb, which, of course, must show a drop in the column of mercury above it. This brings the wet-bulb reading below that of the dry-bulb reading. Such a difference means a lower relative humidity.

Practical Applications: A high relative humidity means a large amount of water in the atmosphere. A low relative humidity means a small amount of moisture in the air. A high relative humidity makes people lack energy for hard work. The relative humidity is not the actual amount of water in the air. It is the ratio of this amount to the greatest amount of water the air could hold at the same temperature. It is usually stated as a percentage.

Page 459. *Figure 237.* Ordinarily the faster the anemometer revolves the lower the column of mercury will be in the barometer. High winds usually indicate the approach of a low-pressure area because they are moving to equalize the pressure where it is low.

Page 460. *Figure 238.* The wind blows landward during the day because the air over the land is warmer during the day than the air over the water. This means that the air over the land expands more than that over the water. This means unequal pressure over both areas and a movement of the air from the high-pressure area to the low-pressure area. At night exactly the reverse condition takes place.

Section 378. This question is answered in the footnote.

Page 461. *Figure 239.* Snow consists of small particles of ice. Their formation shows that the water vapor must have condensed at a temperature below freezing. The temperature of the rock marked 50° causes condensation of water vapor which has a temperature of 70°, when that water comes into contact with the stone. The rock marked 22° has frost upon it because the temperature of the stone is at freezing (or it may be below freezing).

Suggested Experiment: Moisture appears on the sides of the can after a few minutes. This moisture could not have come from within. (This may be made conclusive by placing a cardboard over the top of the can.) Moisture will be found on all sides of the can. The moisture in the air in coming into contact with the cold can was condensed. Dew does not fall. Dew is formed on a cold surface by condensation. Pipes " sweat " in summer because the moisture in the warm air about the pipes is condensed when it comes into contact with the cold pipes. The water vapor in the warm breath is rapidly condensed as it comes into contact with the cold air. The moisture of the warm room is suddenly condensed as it comes into contact with the cold glass of the spectacles.

Page 462. *Figure 240.* The barometer falls as the moisture increases because the rising and expanding air weighs less (volume for volume) than cold air and so exerts less pressure. The moisture has nothing to do with the rise or fall of the barometer, but the warmer the air the more readily it absorbs moisture. As air rises, the pressure is lowered; as the pressure is lowered air expands; as air expands it becomes cooler. When the moisture becomes heavy enough to condense into large raindrops it falls, because of its weight, as rain. The falling water cools the air, the molecules come more closely together, increasing the atmospheric pressure and the barometer begins to rise. The humidity is lowered because the water has fallen out of the air. This means increased atmospheric pressure and fair weather.

Pages 463–465. *Figure 241A–242.* Self-explanatory.

Page 466. *Figure 243A.* Lightning rods would keep the lightning away from the church by constantly reducing the difference in potential between the clouds and the earth.

Page 467. *Figure 243B.* The tower is the highest spot in that locality and a good conductor of electricity. Franklin discovered that lightning and electricity are the same. Since the tower itself is metal, a tremendous lightning rod would be necessary to keep lightning from the tower.

Page 468. *Figure 244.* The currents of air at **a** rise and expand because of local heat. The expanding air cools and falls away from the rising column. At **b** it drops again to lower levels and rushes in with other cold air to take the place of the rising warm air.

Page 470. *Figure 245.* Cyclones are indicated here at every " low " area. The anticyclones are indicated at every " high " area. The high-pressure arrows point to low-pressure areas to indicate that there are unequal atmospheric pressures in the two areas which are becoming equalized.

Page 471. *Figure 246.* The air rises over the water because the cold air from **x** and **y** pushes it up. The warm air over the water is expanding and it is, therefore, lighter (volume for volume) than the cold air on both sides. The high-pressure area is at **x** and **y.** The low-pressure area is where the arrows are rising (pointing upward). There will be a cyclone in the Mississippi Valley and anticyclones at **E** and **W.** In summer the basin is so hot because the air settles here without great movement. There is such a wide area of evenly heated air that the mass of warm air overbalances that of the surrounding cold air, allowing little movement.

Suggested Experiment: The air must be rising from the chimney because the smoke is carried up from it. The upward rush of warmed air carries the smoke up. The air at the bottom moves towards the chimney, as evidenced by passage of the smoke in under the chimney. The cold air being heavy rushes in to push the warm air up. The air was moving into the chimney from all directions. A storm center is formed when large masses of warm air are rising in any given area and large masses of cold air are rushing in under this warm air. The chimney experiment shows this. Also see *Figure 247*.

Page 472. *Figure 247.* The storm is moving southeast. The wind is shifting in New York City because it is in the "eye" of the storm, that is, it is the center of a cyclone which draws the air into it from all directions. An east wind usually indicates the approach of a low-pressure area; a west wind, the approach of a high.

Page 473. *Figure 248.* Rain-clouds over **a** are caused by enormous evaporation from the warm waters of the Pacific Ocean. The winds carry this vapor high over **b** before it can condense enough to fall. At **c** the moisture-laden clouds come into contact with the cold peaks of the mountains and the moisture falls as rain. At **d** it is dry because very little of the rain could get over the high mountains. By the time these clouds get past **c** and **d** to **f**, they have lost all of their moisture and at **f** there is periodic drouth.

Section 393. Temperate climates alone afford pasture lands of wide extent and cereals for food. Horses, cows, etc., must be fed by food raised on farms. The above statements answer the last question in this section.

Page 474. *Figure 249.* Self-explanatory.

Page 475. *Figure 250.* The humidity is relatively low in the white zone; there is enough cold to make men work for their foods; and the change of seasons is invigorating.

Page 476. *Figure 251.* Self-explanatory.

Page 477. *Thought Questions:* **1.** Rising columns of air cause low pressure and descending columns of cold air cause high pressure in the atmosphere.

2. The sea or ocean absorbs so much heat during the summer that it keeps much of it all winter. This modifies the climate along the seashore in winter, making it warmer than that inland, hence the rain rather than snow.

3. The land loses its heat at night faster than the water does. This means that the air is cooler over the land at night than over the water. The cool air over the land being heavier than the warmer air over the water, rushes in to push this warm air up and a breeze is set up over the water. (See Figure 238, page 460.)

4. See the discussion of Figure 247.

5. The clouds act as a blanket, keeping in the heat of the earth so that it cannot escape. This keeps the air about the trees warm and prevents frosts.

6. If a storm is approaching, the pressure is dropping with a corresponding decrease in the air's buoyant force.

7. The temperature of the air drops after a storm because the heat has been absorbed or carried along by the elements of the storm.

8. Frost forms on windowpanes in winter because the moisture of the rooms is condensed on the windowpanes whose temperature is below freezing.

9. The setting of the sun means the cooling of the air surrounding the balloon with a corresponding cooling of the gas in the balloon. The contraction of this gas makes the balloon relatively heavier and it tends to sink. Throwing out ballast offsets this tendency and the balloon is kept up in the air.

10. June 21st is not usually the hottest day nor are any of the other days of June for that matter, because the earth has not as yet absorbed from the sun its maximum of heat. This condition generally comes in August.

11. Different clouds may travel in different directions at the same time, if they are carried by different layers of air moving in different directions.

12. The fireplace smokes on a rainy day because the air pressure is low.

13. The wind will blow south in Michigan; it will blow north in Mississippi; it will blow east in Kansas and it will blow west in Ohio.

14. There is always much draft near a large fire because of the huge column of warm air rising over the fire.

PREVIEW OF PART V

In the previous chapters you have told the story of the use of energy through the oxidation process. Part V is to show that green plants recombine some of the resultant products of oxidation processes (CO_2 and H_2O), to make new substances (foods) in which the solar energy is again stored as potential energy from which it can again be released as kinetic energy by oxidation. Thus the plant carries on a distinctively constructive process.

The pupil by now has comprehended more or less clearly that oxidation (energy releasing) is always accompanied by destruction of a certain amount of physical substances, — organic tissue. He knows, however, that new products result from the destruction of the old and so he is establishing a pretty thorough foundation for understanding the law of the conservation of energy when he meets it in his later study of physics.

CHAPTER XVI

THE WORK OF PLANTS IN THE PRODUCTION OF FOODS

Time Allotment

Use one period for the preliminary work of the chapter. Use the equivalent of three periods for the demonstrations. Use one period for the study of the pictures. The text proper will require about two periods. Use one period for the *Thought Questions*, *Summary*, pupils' *Review Outline*, and *Key Words*. Use two periods for extra experiments or special reports. This is such an important chapter that more than two weeks may well be used in its study. This may easily be done if other chapters in the books are reduced in treatment.

Duggar's Plant Physiology and *Osterhout's Experiments with Plants* will be found very helpful in the study of this chapter. Pupils may make special study of certain parts of these books, both published by the Macmillan Company. *Gager's Fundamentals of Botany*, P. Blakiston's Son and Company, will give a plain and simple description of the plant processes, — useful to the teacher.

Page 480. *Key Picture 16.* Absorption, starch-making, and giving off of excess water (transpiration) are the principal processes here shown. Frequent reference to this picture will give the pupils all the structural facts needed in the study of the next two chapters.

Page 481. **1.** Humus soils or sandy loam soils are probably the most valuable as they contain much organic material. But the answers to this question will differ according to locality.

2. Clay and clay loam soils become sticky after a heavy rain. Most clay gardens are not very productive unless plants needing acid juices are grown there, such as tomatoes.

3. Gardeners find the soil too soft to work. It becomes fixed in clods, if worked too soon after a rain, especially if it contains clay. Gardeners cultivate their gardens during a drouth to form a mulch of the soil to keep the moisture in.

4. In early morning or late afternoon, the sun is not high enough to produce rapid evaporation. Therefore, at these hours the water sinks deep into the soil before evaporation can take place, thus giving the roots a chance to absorb it.

5. Most of the plants in the garden are grown for their roots (radishes, carrots, turnips, beets, onions, etc.) and their leaves (lettuce, spinach, kale, chicory, cabbage, chard, etc.).

Page 482. *Home Problem:* Self-explanatory.

Field Problem: Self-explanatory.

Page 483. *Figure 252.* Factors affecting the garden are: kind of soil and its condition; moisture; temperature; drainage; sunlight; etc. Plants are grown in rows to give them room in which to grow and so that they can be reached easily for cultivation and harvesting.

Page 484. *Figure 253.* Self-explanatory.

Page 485. *Suggested Experiment:* Self-explanatory.

Section 401. Humus may be added to the sand and sand may be added to the clay.

Page 486. *Figure 254.* Self-explanatory.

Laboratory Exercise: The study of the two seeds here required should give no trouble whatever to the pupil.

Page 489. (*Key*) *Demonstration 43. Observations:* The liquid rises in the tube. The amount of liquid in the tube has increased. It could come only from the bottle of fresh water. Careful observation will show that there is a flow of liquids both ways through the membrane. The substance flowing into the bottle is salt water, it tastes salty. The greater flow is towards the denser liquid, because the amount of liquid in the tube increases. If the tube is lifted out of the water it will not leak. Placed back in the water the leakage both ways begins. The flow will become slower as time passes because the difference in density between the two liquids becomes less and less.

Since the salt water is the denser the greater flow is always towards the denser liquid. If the position of the liquids was changed the greater flow would be downward. The wall of the root hair corresponds to the bag; the cell sap corresponds to the salt water; the soil water to the fresh water; the root to the small end of the thistle tube.

Conclusion: Water gets into a plant chiefly by osmosis. We know that it gets to the top of a plant through the plant itself and so it must enter the plant by osmosis at the roots. There must be a greater flow into the plant than out of it and this can come about by osmosis only. Water gets into the plant through the root hairs. Some cell sap probably flows out. The greater flow will be inward, else the plant would collapse.

Practical Applications: The salt will make the soil water so dense that the greater flow will be outwards and the root hairs of the weeds will collapse and be killed. The cell sap of the asparagus must be denser than the salt water.

Page 490. *Figure 256.* The root hairs are very important because only through them can water get into the plant. They do their work by osmosis. Their walls are thin so that the process of osmosis may be readily carried on. The root hairs are really epidermal cells of the root grown out into thread-like projections.

Page 492. *Demonstration 44. Observations:* Moisture gathers on the inside of the jar. This moisture could come only from the plant. The rubber tissue prevented the evaporation of moisture from the soil in the pot. The control is in every way like the second pot excepting that there is no plant present. No moisture appears here. We know, then, that the plant is the only thing that can possibly make the difference.

Practical Applications: Clouds form easily over forests because so much moisture evaporates from the trees. The trees give off moisture which cools the air over the street. The air is always moist in a greenhouse because so much moisture is being given off by the plants. Since any given amount of soil water contains very little mineral matter in solution (1 part mineral to 400 parts water) much water must be absorbed to get even a little mineral. Plants grow little during a drouth because there is so little water to carry in the minerals which they use for food. They grow rapidly after a heavy rain because there is plenty of water containing the minerals they need.

Page 494. (*Key*) *Demonstration 45: Observations:* The part of the leaf which turned bluish contains starch because iodine turns starch blue. No starch is found where the black paper covered the leaf. No starch is made in the spotted geranium where no green coloring matter is found. The lack of light prevented the making of starch in certain parts of the hydrangea leaves. Sunlight is necessary for starch-making. The cutting off of light interferes with the making of starch in the spotted geranium leaves only where the parts were colored green. No starch was made in the uncovered parts of these leaves because there was no green coloring matter there. Green coloring matter (chlorophyll) is also necessary in order that plants may make starch.

Conclusion: Green plants make starch in their leaves in the presence of sunlight. The plants were placed so in order to assure the maximum of sunlight.

Page 495. *Figure 258.* Starch is made in the palisade cells. Starch is made by the chlorophyll in the chloroplasts from carbon dioxide and water. The stomata take in the carbon dioxide and let out the excess water; the guard cells control the size of the stomata; the air spaces hold the gases used in the process; the palisade cells make the starch; the epidermal cells protect the interior of the leaf from too strong sunlight, mechanical injury, and the loss of water. The leaf vein carries water to the leaf from the roots and carries food and air down to the stem and roots. The spongy cells help make starch.

Suggested Experiment: The candle burned first because of the air in the bell jar. The candle should burn about 2 minutes. This depends upon the size of the jar. The limewater turns milky. Carbon dioxide now fills the jar. Nitrogen is there also. The carbon dioxide took the place of the oxygen. The candle should burn a little longer the second time. Oxygen in the jar allows the candle to burn. The carbon dioxide must have been absorbed by the plant. The oxygen must have come from the plant. There was more pure oxygen in the jar after the plant had been there for some time than before. Green plants are continually giving off oxygen into the air. The test just shown proves this. Green plants are a good thing in a living room because of the oxygen they give off. In public parks the trees give off much oxygen; in the mountains they do the same. CO_2 is necessary for a plant in order to make starch.

Page 496. *Figure 259.* Self-explanatory.

Page 498. *Suggested Experiment:* The air from the pea seedlings when run through limewater should turn it milky, proving that growing seedlings give off CO_2. You have already proved that CO_2 is a product of the oxidation of carbon. Therefore, oxidation must be going on in the seedlings. That is, respiration takes place in plants and what is true of the seedlings is true of all plants, no matter how old or how large they may happen to be.

Questions: **1.** Starchmaking is carried on in the daytime; respiration all the time.

2. Starchmaking is carried on in the green parts of the plant; respiration is carried on in all live cells in the plant.

3. In starchmaking CO_2 and H_2O are the raw materials; in respiration oxygen and protoplasm are the raw materials.

4. Breathing (respiration) is so closely connected with oxidation because it is the process by which oxygen is supplied for the oxidation which goes on in living things.

5. The useful product in starchmaking is starch; in oxidation, it is energy.

6. Starchmaking builds up tissue; oxidation tears it down.

Page 499. *Figure 260.* A plant, an animal, and water make up this aquarium. Arrows will pass from the plant to the fish and will be marked: food; oxygen. Arrows will pass from the fish to the plant and will be marked CO_2 and wastes containing nitrogen (N). An arrow will pass from the water to the plant and will be marked H_2O; from the water to the fish, marked O.

Page 500. *Figure 261.* Self-explanatory.

Figure 262. The potato beetle may be controlled by using a poison (Paris green) on the potato plants or by collecting the beetles every few days and destroying them.

Section 418. The water need not be changed because the plant continually supplies fresh oxygen. More water must be added now and then to make up for evaporation. The plant gets its raw materials from the water and from the waste products of the fish out of which it makes its own food; the fish feeds on the plant and gets its food from it. The jar may be sealed and both plants and animals will live because each supplies the other with the raw materials it needs in order to live.

Page 501. *Figure 263.* All of the birds shown here are useful to man, especially the bluebird, veery, towhee, woodpeckers. The English sparrow is the only one not protected because this bird destroys other useful bird's nests and feeds almost entirely upon seeds many of which are useful to man. The robin destroys cherries and other fruits, but it eats insects, too, and is a valuable friend because of its beauty and song.

Section 419. The home garden largely fed our people so that the bulk of the cereals could be shipped to the Allied Armies.

Page 502. *Figure 264A.* Those birds indicated as eating the least amount of fruits or grains are man's best friends. Protection of these birds by law makes it possible for man to exist. Kill off the birds and the insects would very soon drive man from the earth. The crow and English sparrow are not protected because they are destructive to crops. It is a question, however, whether the crow should not be included in the protected birds.

Page 503. *Figure 264B.* The bird houses can be placed on high posts with wide platforms below them so that cats cannot reach them, or upon metal posts, or attached to the side of a barn, the house, or other buildings.

Page 505. *Thought Questions:* **1.** A tree has a trunk to bring the leaves up to the light and to store food. Its branches carry the leaves out so that they will not interfere with each other in securing light. These parts do work in growing.

2. Ten important plant foods are corn, wheat, rye, barley, oats, alfalfa, sugar cane, sorghum, rice, and potatoes. Those most used to keep animals alive are corn, oats, alfalfa, sorghum, sugar cane, etc. Those mostly used by man are corn, wheat, oats, rye, and sugar cane. Many food plants are used by both man and lower animals, such as corn, sugar cane, oats, rye, etc. Those that are used by man are refined so that they will be palatable. For example: the whole oat is fed to the horse, but for man this oat is ground into oatmeal.

3. The food one eats is produced either directly or indirectly by plants. This food is built up into protoplasm and then oxidized. The heat released by oxidation is used by the body to do work in lifting a book.

4. The cat, even though it ate meat entirely, would probably still be dependent upon plants because the animals it ate would undoubtedly have been partially, if not entirely, nourished upon plants.

5. Theoretically, green plants are good for living rooms because they give off free oxygen in the daytime. At night they carry on respiration at a more rapid rate than in daytime and thus give off much carbon dioxide. Actually, the amount of this gas given off at night would not be enough to interfere with the comfort of human beings in a sleeping room.

6. The hot sun causes the plant to lose more water by evaporation through its stomata than it can take in through the roots before its stomata are closed up. It consequently wilts. But at night, when the sun is down, the plant takes in more water than it loses and thus fills up with water, becoming rigid by morning.

7. The salt as soon as it gets into a solution causes the soil water to become denser than the cell sap in the root hairs. Osmosis then works the wrong way, the cell sap is withdrawn from the root hairs and the plant is killed. This is called *plasmolysis.*

8. The trees in the parks give off much free oxygen which people may breathe. This park air is generally largely free of injurious gases, so in this way parks may be said to be healthful places.

9. The farmer lives on the money value of his crops; the carpenter works in wood, a product of trees; the tailor works with cotton, a plant product, or with wool, an animal product which the animal grew by feeding on plants; the shoemaker depends upon leather taken from animals which feed on plants; the physician uses drugs largely taken from plants; the druggist sells these drugs; every one of us lives upon foods which are plant products.

10. The denser contents of the raisins and prunes set up osmotic action with the outside less dense water, which enters the fruits, causing them to swell.

11. If soaked prunes are placed in salt water, the density of the salt water is greater than that of the contents of the prunes and the water already in the prunes comes out faster than the salt water enters.

CHAPTER XVII

THE WORK OF SOLAR ENERGY AND ENVIRONMENTAL FACTORS IN AGRICULTURE

Time Allotment

One period should be used on the preliminary work of the chapter. A second period or its equivalent should be used on the pictures. Three periods may be used on the text proper and *Summary.* One period may be used on the *Thought Questions* and *Review Outline.* Reports on *Special Problems* may occupy another period.

Plate IV (*Key Picture 17*). This picture is self-explanatory. The abundance of certain products in certain areas is due, of course, to local conditions of soil, temperature, and climate. In a picture of this size, units can be only roughly accurate, but the general design is sure to be very provocative of interesting and useful class discussion. Contrast early methods of farming with modern; bring out the urgent necessity of soil reclamation, the wide uses of farm crops, and the great importance of crop protection.

Page 507. *Practical Questions:* **1.** Answers here will vary. The kind of soil may be the factor; the lay of the land; special crops which it produces; the way the property is kept up, etc.

2. He can raise almost all the things he needs to eat and can exchange his surplus for things he needs to wear.

3. If all farmers went on strike, industries of every kind would soon be at a standstill, since all depend directly or indirectly upon the farmer. Raw materials and food must come from the farmer. He is the most important man in our society because he is the connecting link between the soil and the things the soil produces — food, fabrics, and shelter.

4. Answers will vary greatly. For example: Clothes manufacturing, transportation, milling, food-products manufacturing, etc.

5. Farm work is considered hard because it always involves a large amount of lifting and moving of matter from place to place. This is especially hard when the objects to be lifted are heavy — carrying bags of oats, pitching hay, picking up stone, guiding the plow, etc. Wonderful labor-saving machines have now relieved farming of most of its drudgery (seeders, hay loaders, reapers, binders, threshers, baggers, tedders, tractors, etc.).

Page 508. *Home Problem:* Self-explanatory.

Field Problem: Self-explanatory.

Figure 265. The breaking up of the soil is necessary to let in air and water, to keep in water already absorbed, to kill insect eggs, to turn in the surface mold, etc.

Page 509. *Figure 266.* One machine can do the work of many men and do it far better. It saves much time. It is less expensive than hand work or that of a plow drawn by horses. The source of energy here is really the sun, as gasoline is used in this tractor (see Key Picture 11). Heat energy actually turns the wheels of the tractor.

Page 510. *Figure 267.* This plow is heavier and larger than that in *Figure 265.* It turns a deeper and a broader furrow, and is more efficient in every way. The sun again is the source here (Key Picture 11). The immediate source is muscular force derived from oxidation of the muscles of the horse.

Page 511. *Figure 268.* Self-explanatory.

Page 512. *Figure 269.* Self-explanatory.

Page 513. *Figure 270.* Erosion carries away the soil from the roots of plants, exposing them to the air, and they die. It also carries away valuable plant foods, and the plants are obliged to struggle to get enough raw materials to live. Struggling plants do not give the farmer much in return for his labor in cultivating them. Erosion may be stopped by planting small trees where they may act as a barrier to the inroads of heavy winds and floods.

Page 514. *Figure 271.* This river bottom is composed of black soil which has accumulated by successive floods through ages of time. It grows fine crops of all kinds after the annual inundation of this low land takes place. In this respect it resembles the Nile valley.

Page 515. *Figure 272.* The commercial fertilizer around the roots of the plants at the left was probably composed of phosphates (compounds containing phosphorus), an especially good fertilizer for corn.

Page 517. *Figure 273A.* The ditches are dug for a considerable distance on each side of the trees so that the water will soak down into the ground near the small roots upon which the root hairs are attached. There are few small roots near the base of the trees. Under the ditches, then, most absorption will take place. The ditches are far apart here so that the water will soak through the soil both ways and meet halfway between the ditches, thus soaking all of the soil with water.

Page 518. *Figure 273B.* The ditches between the rows of crops will insure the passage of the water through the soil in both directions, thus giving the plant roots plenty of moisture. This water comes from great reservoirs of water derived from melting snows on mountain caps or from seasonal rains. Where rains are few, this method is used in order that plants may have their needed water supply.

Section 435. The soil simply lacked water to dissolve the minerals.

Page 519. *Figure 273C.* The desert shown in the picture beyond the dam is rich in minerals usable by plants. Irrigation is necessary to supply the needed water for the dissolving of the minerals so that they may be carried by osmosis into the root hairs of the plants.

Page 520. *Figure 274.* Draining swamps lets air into the soil. Roots cannot live without air. Draining also warms the soil and carries out much of its acid contents. The ground becomes friable and so may be easily worked. These ditches act not only as drainage ditches but also as irrigation ditches when the land on each side of them has been well drained.

Section 435. Too much water prevents aëration of the roots.

Figure 275. This threshing will be done by a power thresher run by a gas or steam engine.

Page 521. *Figure 276.* Soil containing just the right amount of phosphorus compounds, a light sandy loam, and a region where the days and nights are hot will produce corn like this. Iowa has such areas.

Page 523. *Figure 277A.* Perfect fruit may not be obtained unless every possible chance of its being injured by insects is eliminated. The young insects (larvæ) hide in the buds and flowers and do damage in the fruit. If they once get inside the fruit, spraying the fruits with poisons will not kill them. Three sprayings insures the killing of these insects in some one of their life history stages.

Page 524. *Figure 277B.* A great area of trees may be covered with the spray in a very short time and the plane can operate above the trees, reaching trees that could not be reached at all by the method pictured in *Figure 277A.* But much of the spray is lost by this method because of adverse air currents nor can it be so thoroughly directed to every part of each tree.

Page 526. *Thought Questions:* **1.** A plant cannot grow in a pail of water because the mineral supply of food is so quickly exhausted.

2. It is sometimes better to feed farm crops to animals than to sell the crops because the animals (cows, hogs, horses, goats, chickens, etc.) may bring more money than the crops themselves. This, of course, depends on the law of supply and demand.

3. Harrowing increases very much the volume of air in the soil.

4. They give him food, they enrich his soil through their root tubercles, and they form cover crops to enrich the soil by their rotting stems and roots.

5. Cutting young plants as they are transplanted tends to concentrate the sap in the center of the plant, causing it to send out new shoots and branches.

6. Three important ways of restoring fertility to the soil are: By planting peas and beans (legume crops); by rotating crops on the same piece of land; by allowing the land to rest for a year or more and using it as a pasture.

7. Weeds choke out the useful plants by cutting off light from them, by absorbing the water and minerals which ought to go to the good plants, and by using up the air in the soil.

8. Thorough tilling aërates the soil, keeps the water in the soil, kills weeds, mixes the top soil in with the lower layers of soil near the roots, kills insect eggs, etc.

9. The greatest corn crops are produced in the Middle West because here the land is suited to this crop and it is hot in summer, a necessary condition for good corn crops.

10. The great meat-packing industries are in Chicago because it is near the stock- and corn-raising region.

11. Forests conserve the moisture, preventing destructive floods; they furnish animal homes; they furnish a steady supply of lumber; they add to the natural beauty of the country; they enrich the soil; and they give us many valuable by-products from their lumber supply.

Page 527. *Special Problems:* All these problems are self-explanatory.

PREVIEW OF PART VI

The fundamental idea to be emphasized in Part VI is threefold: (1) The human body is an engine just as the locomotive is an engine. (2) This engine uses the fuel provided it by green plants. (3) This engine must be cared for, if it is to run well and do its work efficiently. To care for it the pupils must have a fair knowledge of its structure and processes.

Part VI brings the pupil home to himself as the very center of his environment. He should be impressed with the great importance of a knowledge of his own body so that he may be able to form right habits of conduct to keep the body in good condition. Repetition here is very essential. Also the precepts must be more than mere precepts. They must be carried over into actual conduct. To preach here is useless. To bring the pupil to act by the training of his will is the chief aim of this unit.

CHAPTER XVIII

FOOD AS FUEL FOR THE HUMAN ENGINE

Time Allotment

Use one period for the preliminary work of the chapter. Two periods will be required on the demonstrations, three on the dietaries, three on the text matter, and one period on the pictures. You will need one period for the *Thought Questions*, *Review Outline*, and *Summary*, and one period for reports on the *Special Problems*. It will be well to lay some emphasis upon the score card on page 556, but it should be kept in mind that no absolute rules may be laid down here. This is merely one way of getting at a definite standard for proper daily living.

For the teacher's use in teaching this chapter, *McCallum's Food, Nutrition and Health*, published by the author in Baltimore, Md., and *Sherman's Chemistry of Food and Nutrition*, The Macmillan Company, are invaluable.

Page 530. *Key Picture 18.* In studying this picture be sure to have the pupils make the distinction between the compounds at the left of the test tube and the simple elements in the form of gases, solids, and liquids (phosphorus, oxygen, hydrogen, iodine, potassium, etc.).

Page 531. *Practical Questions:* **1.** Your body may be called an engine because it uses food (fuel), releases heat energy, and does work.

2. Self-explanatory.

3. Self-explanatory.

4. The sun probably helped grow most of the things we eat through the starch-making process. Salt would be the marked exception. The weather may cause a decided scarcity of certain fruits (strawberries, etc.). Cold, rainy weather reduces the crop and increases the price. Hot, dry weather has the same effect. The earth movements cause the seasons and the seasons have a very marked effect upon the foods which are brought to our tables. We often speak of certain foods being " in season." This is particularly true of certain vegetables and fruits.

5. Self-explanatory.

6. A food may be short weight without causing injury to the body; coal may be short weight without endangering the life of anyone, but food that is unclean or adulterated may cause serious illness to those eating it.

Page 532. *Home Problem:* The sources of each kind of food can be discovered in a number of ways. Geography texts and reference books will help here. The home cook will also be an important medium of information.

Field Problem: This should be self-explanatory. Whether the foods are kept up off the street (vegetable stores) under glass (meat markets and food stores) or whether the stores are clean and the clerks have clean clothes and hands are all important points. Pupils should be encouraged to have their parents patronize the sanitary shops.

Page 533. *Suggested Experiment:* All the foods tested contain carbon and hydrogen since CO_2 and H_2O are given off from them when they are heated. (Not all of the water is the product of oxidation. Much of it is held in the food and driven off by the heat.) Food is a fuel because it contains the fuel element.

Page 534. *Figure 278A.* Self-explanatory.

Page 535. (*Key*) *Demonstration 46. Observations:* Iodine is the test for starch. A dark blue color is the reaction. Starch was found in the bread and potato, but none in the lemon. Most starch was found in the potato. Fehling's solution heated with the food to be tested is the test for grape sugar. An orange or rusty red color is the reaction. No grape sugar is to be found in the potato. Some is to be found in the bread (produced there from the starch by baking). Much grape sugar is to be found in the lemon. The sour juice of the lemon disguises the sugar.

Conclusion: Self-explanatory.

Figure 278B: Self-explanatory.

Page 536. (*Key*) *Demonstration 47. Observations:* The soil causes the paper to become greasy and translucent. The Brazil nut contains much oil. There is no oil in the bread (that this test will show). There is much oil in bacon. There is no oil in a potato. Nitric acid is the test for proteins, a lemon color being the reaction which may be heightened to an orange color by the use of ammonia. There is much protein in bread, little in bacon, little in a Brazil nut, and some in the potato skin.

Conclusion: Self-explanatory in the light of the observations above.

Figure 278C: All contain hydrogen and carbon. Burning each proves this.

Page 537. *Demonstration 48. Observations:* The three foods burned. Not all completely disappeared. Some of them left behind ash-minerals which are not combustible. Most ashes are white or grayish.

Conclusion: Most foods contain minerals. The most common mineral is lime.

Practical Applications: Minerals help make bone, teeth, and nails.

Figure 279. Water forms a very large part of milk. Milk is often called the perfect food because it contains all of the nutrients excepting starch and it also contains minerals for bone building.

Page 538. *Figure 280A.* Raisins, bananas, an orange, a lemon, bread, oatmeal, sugar, and shredded wheat. Starch and sugar are here found in abundance. They release heat from the body when oxidized in it.

Section 447. These inorganic foods contain no fuel elements.

Page 539. *Figure 280B.* Bacon, butter, olive oil. All these foods will make thin paper translucent if they are rubbed upon it. Fats give much heat to the body.

Figure 280C. Peas, corned beef, sardines, beef, eggs. Men doing heavy labor need these foods more than men working indoors. These foods are very appetizing and tasty. For this reason too much of them is eaten by most people.

Page 540. *Figure 281.* Most people eat more than they actually need, but this may not be so for growing boys and girls, many of whom do not eat enough food. Some people eat too much from habit and because the food is appetizing. If such people would eat more slowly, they would not eat nearly as much. Rapidly eaten foods are not properly digested and tend to clog up the digestive system with food which cannot be used (absorbed).

Page 541. *Section 449.* The bookkeeper uses less energy in his work. The amount of food used by a steel worker would cause serious digestive disorders, if used by the manager, who needs far less food since he does little muscular work.

Page 544. *Figure 282.* Potatoes, oranges, jelly, bread, milk, meat, sugar, flour, oatmeal, prunes, carrots, bacon, butter, eggs, and spinach. This is certainly a mixed diet. It is well-balanced also. Vitamins are found in a large number of these foods (spinach, potatoes, oranges, milk, prunes, carrots, butter, etc.). This selection is good because it gives a wide variety of foods.

Page 545. *Figure 283.* The rat was fed foods containing vitamins. The lesson here for the pupil is that he should eat the foods which contain vitamins to avoid malnutrition and its attendant diseases.

Page 547. *Section 458.* The potato skins contain proteins.

Page 549. *Figure 284.* Listing of the least expensive body-building foods is easily done by reference to the graphs. The least expensive foods have the least amount of water in them. But the dry foods are less attractive than the foods containing much water, so people eat more of the latter. Corn meal, beans, etc., are fed to lumbermen because they contain energy-releasing nutrients.

NOTE: The tables below will be found very valuable in making up specimen dietaries from the text (pages 542–547).

Name of Food	Weight in Grams	Proteins in Grams	Calories from Proteins	Calories from Fats	Calories from Carbohydrates	Cost
Meats						
Beef, roasted, small serving	37	8.1	32	68	—	?
Lamb, roasted, ordinary serving	34	8.5	35	65	—	?
Pork, roasted, small serving	34	7.9	18	82	—	?
Ham, ordinary serving	33	6	28	72	—	?
Oysters, six large . .	190	11.4	78	22	—	?
Eggs, one large . . .	63	7	32	68	—	?
Chicken, one half, large serving	50	9	39	57	—	?
Codfish, ordinary serving	150	21	95	5	—	?
Vegetables						
Beans, baked, small dish	75	5.2	21	18	61	?
Beets, three servings .	246	5.7	1.8	22.8	75	?
Cabbage, three servings	309	.6	20	8	72	?
Corn, sweet, one small dish	99	2.8	10	7.6	82.4	?
Onions, two large servings	240	2.4	12	40	28	?

All starred foods have a low calorie value so that it is impossible to use much of such foods and get the required heat value for the day.

Name of Food	Weight in Grams	Proteins in Grams	Calories from Proteins	Calories from Fats	Calories from Carbo-hydrates	Cost
Peas, one serving	85	5.7	25.5	14.5	60	?
Potato, one large serving	102	2.5	10	25	65	?
String beans, five servings	480*	.8	15	48	37	?
Tomatoes, four small servings	480*	4	15	16	69	?
Carrots, two servings	164*		10	34	56	?
Turnips, one serving	246*		6	58	26	?
Spinach, one serving	174*		15	66	19	?
Fruits						
Apples, two servings	206*	2	3	7	90	?
Figs, one large	33	1	5	—	95	?
Bananas, one large	100	1.3	5	5	90	?
Oranges, one large	270*	1.6	6	3	91	?
Strawberries, two servings	230*	2.2	5		95	?
Cantaloupe, one half ordinary serving	250*	.67	2.75		96.5	?
Grapes, two bunches	136	1.4	5.5		94.5	?
Peaches, three medium sized	285*	.21	4	2	94	?
Dairy Products						
Butter, one-half cube	19	.2	.5	95.5	—	?
Milk, small glass	150	5	19	52	29	?
Cheese, American	24	6.6	30.3	68	2	?
Pickles, Sweets, Oils						
Olives, seven	35.2	.7	7	81	12	?
Sugar, three teaspoonsful	8				10	?
Cereals						
Bread, white	30	2.76	11.3	3.6	6.53	?
Corn flakes, one dish	27	1.9	10	5	85	?
Bread, brown, thick slice	43	2.2	9	7		?
Macaroni, ordinary serving	110	3.3	14	15	84	?
Oatmeal, one and a half servings	155	5	18	7	71	?
Rice, ordinary serving	87	2.4	10	1	25	?
Shredded wheat, one biscuit	27	2.8	12.6	?	89	?

Name of Food	Weight in Grams	Proteins in Grams	Calories from Proteins	Calories from Fats	Calories from Carbohydrates	Cost
Desserts						
Cake, chocolate, one-half ordinary serving . .	28	1.7	7	22	?	?
Doughnuts, one-half .	23	1.5	7	53	71	?
Pie, apple, one-third piece	33	1.2	5	32	46	?
Rice pudding, very small serving . . .	75	3	8	13	63	?
Soups						
Clam chowder, two plates	230	4	1		29	?
Pea soup, large plate .	105	4.8				?

In selecting foods from the above table, three things should be considered. (1) Those foods should be bought which have a low water content. Why? (2) The cost of the food should be noted. (3) Foods with little waste should, in general, be chosen. A study of the accompanying table showing the approximate percentage of the various nutrients, water, refuse, etc., will make plain these three points. The difference between the sum of the percentages and 100 % in any article of food represents the mineral content in that food.

	Proteins	Fats	Carbohydrates	Water	Refuse	Calorie Value
1. Cheeses . .	29	36	.3	32	0	2055
2. Milk . . .	3.3	4	5	87	0	325
3. Fowl . . .	14	12	0	47	26	765
4. Eggs . . .	13	9	0	66	11	635
5. Pork chops .	13	24	0	42	20	1245
6. Oysters . .	6.2	1.2	3.7	86	2	230
7. Potatoes .	2	.1	15	67	20	296
8. Peanuts . .	20	29	19	7	25	1775
9. Lettuce . .	1	.5	2	94	2	65
10. Strawberries	.9	.6	6	90	2	180
11. Corn meal .	9.2	2	75	13	0	1655
12. Beans . .	23	2	60	13	0	1520
13. Apples . .	.3	.3	11	63	25	190

Page 550. *Demonstration 49:* Self-explanatory.

Page 551. *Figure 285A.* Chemists are continually testing these foods to determine their purity. The guarantee may be proved true by an analysis of the foods. In fact, the government agents are continually analyzing samples of various foods. This constant care is a pretty sure guarantee that foods bearing the government Pure Food label are pure.

Page 554. *Thought Questions:* **1.** Dietitians know how to prepare properly balanced and mixed diets for the patients.

2. The horse will do more work on oats since they contain more energy-releasing nutrients. Of course, no man would restrict the diet of his horse to one kind of food, if he expected to get good results.

3. Man can live on bread and water alone because bread contains most of the nutrients needed to carry on the vital functions of the body.

4. The vitamins in the apples aid in the bodily processes and in the better elimination of wastes from the body.

5. Fruits and vegetables contain most of the vitamins essential to bodily activities.

6. Fats and carbohydrates should be used sparingly by the heavy person; carbohydrates and proteins by the person who is underweight.

7. Answers are dependent on the foods tested (see Demonstrations 46 and 47).

8. An individual problem.

9. An individual problem.

10. This book can be secured at a nominal price.

11. Answers will vary.

12. The teacher may secure for the class a copy of *Sherman: Foods and Food Products,* The Macmillan Company, which contains the material needed. Other sources are easily located.

13. The drug habit may be developed; the contents of some medicines may be harmful. All patent medicines must not be condemned. Some are very useful and thoroughly approved by the medical profession. Professional advice should always be secured before using such medicines.

14. We use a variety of foods for appetite's sake and because variety assures all of the nutrients necessary for growth and repair.

15. What is valuable to one person may be poison to another because of differences in organic structure and function. Acid foods are injurious to some people; sweet foods to another. Some persons are more sensitive to acids, to sugars, to proteins, than others. The reasons for this are not clear.

16. This diet contains too much protein and too little fat.

Special Problems: **1.** Self-explanatory. HINT: The list of foods might be represented in *b* by bread, oranges, oatmeal, and bacon. In *c* the four foods named are each to be tested for starch, grape sugar, oil, and proteins. In *d* the pupil is to place (for example) under bread all of the foods listed in *a* which contain much protein; all foods containing much sugar under oranges; all containing much starch under oatmeal or bread; and all containing much fat under bacon.

2. Self-explanatory.

Page 555. *Figure 285B.* Self-explanatory. Water cleans out the digestive tract, keeps the food in a liquid condition in the intestines, and helps in the elimination of wastes.

CHAPTER XIX

THE USE OF FUELS BY THE HUMAN ENGINE

TIME ALLOTMENT

One period is to be used in the preliminary work of the chapter. One period is used in *Demonstration 50.* Two periods are used in a study of the pictures and Plate V. One period may be used in Laboratory work on the blood. Four periods are to be used on the subject matter. Two periods may be used on the *Thought Questions, Review Outline, Summary,* and *Special Problems.*

Page 558. *Key Picture 19:* The circulatory system simply takes what this system prepares and carries it to every cell in the body and then eliminates the wastes produced by oxidation in the body cells. The tooth is given a prominent place in the picture because the teeth are the foundation of bodily health. Good teeth and good mastication go hand in hand. Good mastication means good digestion and good digestion means good absorption of food and general good health.

Page 559. *Practical Questions:* **1.** Too much coal in the furnace clogs it up, preventing the proper amount of air from entering the furnace to burn the coal.

2. Too many ashes in the ash pit reduce the amount of oxygen entering, thus checking the proper burning of the coal.

3. Too much food overloads the digestive organs, putting too much work upon them. The overwork may finally cause a breakdown of the organs. Too much waste clogs up the large intestines, producing auto-intoxication and also overloads the kidneys.

4. The engineer must supply his engine with water, oil, and fuel and keep it clean and in running order. The body must also have water, fuel (food), and the intestines should be kept open, with wastes fully eliminated.

5. In the mouth the food is prepared for digestion. If the work is well done here, the remainder is well done; if it is not well done in the mouth, the whole system suffers.

6. Exercise increases oxidation of the cells. The building of the new cells must be correspondingly hastened and so food is required. The internal secretions in the blood excite the glands of the stomach, causing the feeling of hunger. This is the signal from the cells that we ought to eat.

Page 560. *Figure 286.* Self-explanatory.

(*Key*) *Demonstration 50:* *A.* Filtering the saliva separates the clear liquid from the frothy stringy part and makes the saliva much easier to handle. *B.* Making the paste insures complete and rapid results in the tests. *C.* This test identifies the starch as starch. *D.* This shows that there is no sugar in the starch. *E.* This shows that there is no grape sugar in the saliva. *F.* Shaking thoroughly mixes the paste and the saliva. *G.* The Fehling's solution test now shows if anything has happened to the starch paste.

Observations: All points but the last are covered above. The testing of the saliva with iodine proves conclusively that there is no starch in saliva.

Conclusion: The only conclusion possible is that the starch was actually changed to grape sugar by the saliva, because the starch and saliva contained no sugar and the saliva contained no starch to begin with.

Page 563. *Figure 287.* Self-explanatory. This picture warrants much study.

Page 564. *Figure 288.* Self-explanatory. Fats alone go to the lacteals. Proteins (peptones) and grape sugar (digested starch) go directly to the capillaries.

Page 565. *Section 467.*

Part of Canal	Food Digested	By What Digested?	Changed to What?
a. Mouth	Starch	Saliva	Grape sugar,
b. Gullet	None	——	——
c. Stomach	Proteins	Gastric juice	Peptones
d. Small intestine	Proteins, fats, starch	Pancreatic juice, bile	Peptones, grape sugar emulsified fats
e. Large intestine	None	——	——
f. Rectum	None	——	——
g. Anus	None	——	——

2. Here a simple relocation of the parts named above is required under the heading of foods rather than that of the parts of the canal, etc.

Page 566. *Laboratory Exercise:* Self-explanatory.

Page 568. *Figure 289.* Oxygen and food leave the blood. They go into the lymph spaces and thence into the cells. These substances together with the escaped blood plasma then make up what is called lymph. Carbon dioxide, water, and other wastes containing nitrogen pass out of the cells.

Plate V. (2) Four circuits are possible in the circulation of the blood: (*a*) The pulmonary circuit from the heart to the lungs back to the heart; (*b*) the systemic circulation from the left ventricle around the body to the right auricle; (*c*) the portal circulation from the aorta across through the walls of the intestines and through the liver to the ascending vein (vena cava); (*d*) the renal circulation from the aorta across through the kidneys to the ascending vein (vena cava). Of course, these circuits are not independent of one another but all are parts of some others. (3) The function of each part is developed in connection with the development of what the blood gains or loses in each part. (4) The blood gets rid of CO_2 and H_2O in passing through the lungs; in the liver it gets rid of a part of its grape sugar and some of its old red corpuscles and of the materials out of which bile is made; it gets rid of H_2O and nitrogenous wastes in the kidneys; it gets rid of oxygen, water, and food in the capillaries; it gets rid of water, salt, nitrogenous wastes, and carbon dioxide in the skin. (5) The blood picks up oxygen in the lungs; carbohydrates and peptones in the small intestine; some grape sugar in the liver; it picks up carbon dioxide and nitrogenous wastes in the skin; it picks up nitrogenous wastes, water, and carbon dioxide from cells all over the body. (6) The blood gives food, water, salt, and oxygen to the lymph spaces and takes carbon dioxide, water, and nitrogenous wastes from the lymph spaces.

(7) The heart[1] pumps blood; the auricles receive blood from the lungs and venæ cavæ; the aorta carries oxygenated blood from the heart; the capillaries carry food, water, and oxygen to the cells and wastes from the cells; the lymph spaces hold lymph which acts as a middleman between the cells and the capillaries, carrying materials to and from the cells; the veins carry blood back to the heart from the capillaries; the pulmonary artery carries blood from the

[1] In this diagram the heart has been pictured as relatively large in order that its parts may be clearly seen.

heart to the lungs; the lungs get oxygen to the blood and carbon dioxide out of it; the pulmonary veins carry blood from the lungs to the heart; the small intestine digests foods and gives these foods to the blood and lymph; the kidneys extract water and nitrogenous wastes from the blood; the liver stores grape sugar as animal starch (glycogen), eliminates worn-out red blood corpuscles, and manufactures bile; the sweat glands eliminate nitrogenous wastes and water from the capillaries through the skin; the valves of the heart allow blood to pass from the auricles to the ventricles, but only in one direction (down).

Page 569. *Laboratory Exercise:* The corpuscles are elliptical, rounded at the edges, thick at the center, and darker at the center than at the edges. In all these ways these corpuscles differ from the human corpuscles. The blood vessels will differ in size. The blood will flow in different directions in the different vessels. In the capillaries many corpuscles will be obliged to go in single file. The blood flows away from the heart in an artery; towards the heart in the veins; towards the heart in the capillaries or, we may say, the blood flows from the arteries through the capillaries to the veins. The pulse will be seen plainly in the largest vessel (arteries). The beating of the heart causes the pulse. The pulse is least noticeable in the capillaries. There are so many capillaries that, even though they are extremely small, their combined diameters are greater than those of the arteries because of their enormous number. The blood pressure is much reduced in them, causing the loss of the pulse. A pulse in the capillaries might burst them as they are but one cell thick and the blood would go so fast through them that the process of osmosis through their walls would take place with great difficulty. The cells would suffer for lack of food and oxygen and they would be unable to get rid of their wastes fast enough.

Page 571. *Figure 290.* The knot should be twisted just tight enough to stop the greatest flow of blood, but not tight enough to cause the arm to blacken. As a tourniquet is but a temporary expedient it should be removed at the first opportunity after the arrival of the physician. He will decide this matter.

Section 473. The intermittent flow of blood from an artery is caused by the beating of the heart. Since the pulse is lost in the capillaries the flow from the veins will be steady.

Page 572. *Figure 291.* Self-explanatory.

Page 577. *Figure 292.* Self-explanatory.

Page 578. *Figure 293.* The Greek athlete developed his body by practicing the aids to bodily health and by avoiding the handicaps to bodily health outlined on pages 576–579. Nothing else would produce these results.

Page 581. *Thought Questions:* **1.** Ice water probably retards digestion of food. It is better to drink the water after the meal is completed.

2. Warm soup stimulates the digestive glands to pour out their juices.

3. Raw foods contain vitamins in excellent condition and such foods also stimulate the action of the intestines.

4. Pressing a cold object on the upper lip or at the back of the neck will usually check nose bleed. In case of a bleeding artery, place a tourniquet on the part between the cut and the heart. In case of a cut vein place a tourniquet on the side of the cut away from the heart.

5. An individual problem.

6. The cheese sandwich contains proteins, fats, and starch. The answer to this question may be readily answered by consulting the table on page 162.

7. See the answer to question **4** above.

8. An individual problem.

9. A similar booklet may be procured from the Metropolitan Life Insurance Co., 1 Madison Ave., New York City.

10. The water prevents the mixing of the saliva with the food and this interferes with digestion.

11. The boy was wrong. The apple is only in the boy's body after it has been digested and absorbed through the walls of the intestines into the blood.

12. The thinness of the capillary walls allows osmosis to be carried on effectively.

13. A man could (theoretically) live without a stomach because the small intestines can digest the same food the stomach digests (proteins).

14. The lack of good teeth by old people means poor digestion of food because it cannot be properly chewed. The result is gastric indigestion (dyspepsia). Modern dental care is making a myth of the statement.

15. Food is necessary to furnish energy for marching. The stomach is an essential part of the digestive system and here stands for the whole system. Consequently without food digested in the stomach an army could not even move.

16. See *Plate V* to answer this question.

17. When the mind is excited or the body tired the flow of the digestive juices is retarded. Eating at such times means (very often) attacks of gastric indigestion.

18. Bacteria grow best in the small intestine and in the large intestine because the conditions here are ideal: warmth, darkness, plenty of food, and moisture.

Page 582. *Special Problems:* **1,** *a, b, c.* Self-explanatory. Use the *Key Picture* on page 558 to help in solving *c*. In **2** *a* the teeth of the dog and cat will show prominent canines for tearing meat; the guinea pig and rabbit will show large incisors for gnawing, while the horse and cow will have prominent molars for grinding hay and grain. The horse will lack canine teeth. *b* is self-explanatory. *c* can be studied from the *Key Picture* on page 558. The teeth should be kept clean and hard objects should not be chewed. Cavities should be attended to, to prevent their enlargement.

CHAPTER XX

THE WORK OF CONTROLLING THE BODY

Time Allotment

Use one period on the preliminary work of the chapter; two periods on the pictures; one period on the experiments; two periods on the subject matter up to page 597, and three periods on the rules to be followed in emergencies. *Thought Questions, Summary,* and the *Review Outline* should have one period.

Page 584. *Key Picture 20.* This picture is practically self-explanatory. The teacher will find it useful to have the activities here pictured actually tried out by the pupils. Concrete applications of the principles involved are many. Have the pupils suggest some and try them out in class.

Page 585. *Practical Questions:* **1.** Repetition forms a habit. A habit once formed makes action automatic. This, in turn, makes for skill.

2. A skilled mechanic is one who does expert work of a mechanical nature as a result of long training.

3. Trained young men are more accurate in their work, do the assigned work faster, and with least waste of material.

4. Loss of lives due to drink-muddled senses may cost the railroad millions of dollars in damage suits.

5. A person often jumps on hearing a sudden, unexpected noise because his reflex action centers are affected. This is an instinctive reaction to a thing which suggests danger.

Page 586. *Home Problem:* Self-explanatory. A habit has been quickly formed in the brain. Repetition did it. The body learned the feel of the action of the muscles required to reach the coin.

Field Problem: The habit of erect posture, for example, once acquired makes for good health, self-assurance and poise, and leads directly to clear thinking and better work by the pupil. Such a habit, developed in an entire class, speeds up work, improves the social spirit of the group, and acts as a splendid tonic for the teacher. To be effective, however, practice in the development of the habit must be voluntary.

Page 587. *Figure 294.* This picture tells its own story.

Page 589. *Figure 295.* An injury to certain parts of the head may affect certain parts of the body because the brain centers are connected by nerves and muscles with all parts of the body. If any of these nerves or muscles are injured, their control of the corresponding body parts is affected.

Page 590. *Figure 296.* Numbers 1 and 2 (from left to right) are best in order of naming. Numbers 3 and 4 are bad. Good posture is a matter of habit.

Page 592. *Figure 297.* Some factors which produced the result indicated in this picture were probably: rigid discipline by efficient officers; the formation of good habits of posture and good habits of obedience to orders; good, wholesome food; plenty of sleep; and plenty of fresh air and exercise.

Demonstration 51: Observations. The movements of the protozoans will be very much retarded. The alcohol seems to make the protoplasm less active. This is probably due to the withdrawal of much water by the alcohol. The action of the alcohol upon the egg white is the same. Withdrawal of water coagulates (hardens it).

Page 593. *Figure 298A.* **I.** The alcohol had its direct effect upon the nerves, making them unsteady in their control of the muscles, hence the poor average of hits when alcohol was used. **II.** The alcohol seems partially to paralyze the nerve centers so that the muscles are not under proper control. The muscle tissues are unable to eliminate wastes fast enough and so are more or less clogged with toxins.

Section 491. The alcohol draws water from nerve cells and this paralyzes them, making them less sensitive.

Page 594. *Figure 298B.* Some workers used to get drunk on Sunday. On the next day the muscles were not under good control because of the deranged condition of the nervous system, with the result that accidents took place with great frequency.

Page 595. *Figure 298C.* The alcohol probably affects the vitality of the white blood corpuscles, either killing off great numbers of them or making them weak and unable properly to combat the germs. Other parts of the blood (secretions) may also be affected.

Demonstration 52: The fish will begin to act in a nervous manner very soon after the water becomes impregnated with the smoke. The fish will finally become inactive and float to the surface of the water. The final result will be the death of the fish. The nicotine in the smoke actually poisons the fish.

Page 596. *Figure 299.* Bar **A** represents the total number of students. The divisions in this bar do not represent the proportion of smokers, occasional smokers, and non-smokers, but simply gives the meaning of each type of bar. In bar **B** it will be seen that more than one half of the failures were furnished by the habitual smokers (although only about one fifth of the total enrolment were habitual smokers), while the non-smokers furnished less than one fourth of the failures (although they formed over one half of the total enrolment. About one tenth of the honors were won by habitual smokers, while over two thirds of the honors were won by non-smokers. Note that the length of the bar at **B** indicates the number of failures out of the total enrolment and not the total enrolment and that the bar at **C** represents the total number of those winning honors and not the total enrolment.

Page 598. *Figure 300A.* Self-explanatory.

Page 599. *Figure 300B.* A false step here or a slip may mean falling across the track and under the car wheels. Most of the deaths among boys playing about railroad yards are caused in this manner.

Page 600. *Figures 301A and 301B.* Self-explanatory.

Note : The special rules indicated under the topics of Street Accidents, Street Cars, Fire, Water, Bleeding, Poisons, Fractures and Sprains, and Fainting and Epilepsy (pp. 597–604) are all based upon common-sense principles. They need no explanation here. But some very good discussion may be developed in the class by asking the pupils the reasons for each of these rules. Attempt at all times to rationalize every rule set for pupils to follow. Simply learning rules is a waste of time unless action follows, and action will seldom follow unless the pupils see a good reason for obeying a rule. When they understand, there is some hope of observance of such rules by a fair majority of pupils.

Page 602. *Figure 302.* Poison bottles should be labeled to prevent persons using their contents for medicine by mistake. They should never be placed with the family medicines. Being tightly corked prevents the spilling of the poison, if the bottle is accidentally tipped over.

Page 603. *Figure 303.* The boards support the fractured parts and the cloth prevents undue pressure upon these parts. Slinging the arm from the shoulder supports it evenly without straining it.

Page 605. *Thought Questions:* **1.** This soldier had been trained in the army to obey orders. He had formed the habit of coming to attention on the order " Attention." This original voluntary act had become automatic and he obeyed the order without thinking of what he was doing.

2. Reflex action causes the mouth to water at sight of the oranges. The mind anticipates the taste of the fruit, whereupon the nerve centers stimulate the flow of saliva in preparation for the mastication of the fruit.

3. The eye sees the pin and the message is carried to the thought centers of the brain. Here it is decided to pick up the pin. The thought center sends a message to the cerebellum and then to the spinal cord, from whence a message is sent along the proper nerve fibers to the muscles controlling the parts of the body which will be involved in picking up the pin.

4. We do not think about our steps because walking is a pretty firmly fixed habit. This saves us much time and mental energy, but it is also dangerous because we often make false steps and fall when a " thinking step " would prevent it.

5. A habit saves time, saves mental energy, allows one to do several things at once, makes it possible to do a piece of work more efficiently, allows one to think out new actions, and reduces the number of mistakes.

6. Laziness is the result of poorly directed activities. It is a habit. Once a habit is formed it is hard to break. Consequently, a habit formed in grammar school will persist in high school.

7. The awkward squad is made up of men who have difficulty in correlating their bodily movements. They form habits slowly. Repetition of certain actions under rigid discipline reduces the number of men in the squad because right habits of action are gradually formed. When they have reached a certain standard, they are placed in the regular squad.

8. The knowledge of what is in this book is obtained by reading and rereading until the proper association processes have been set up in the brain. The primary medium of information is the eye, which transmits the thought symbols (letters, words, phrases, sentences, paragraphs, chapters) to the brain where they are translated in terms of experience. Supplementary laboratory experiences crystallize into the concrete those abstract concepts which the reading has developed. Manual processes of trial and error verify or refute the mental interpretations of the text.

9. Unskilled workmen are men who have never formed habits of expert work in the " trades." A ditch digger may be skilled in his work, but it does not require great skill to become a good ditch digger. But a maker of tools must have a great deal of skill to produce accurate and well-made tools. A workman always receives a wage corresponding to the amount of skill called for.

10. Habit formation is more important to-day than ever before because (1) the competition is greater now than ever before. This means that only the more skilled men and women will hold their positions. The complex life we live to-day calls for a much greater number of skills than early man required to live.

PREVIEW OF PART VII

The pupils should now have a well-defined idea of the human body as an engine needing control by the brain, its engineer. With this concept as a basis, your pupils are now ready to find out just how this engineer is best able to protect the engine from the dangers of its environment.

These dangers are largely invisible to the unaided eye. If you can keep before the pupils the fact that they are constantly called upon to make a fight against invisible foes, they will meet the issue and get out of this topic its essential truths.

You are referred to *Broadhurst: How We Resist Disease*, Lippincott Co., and *Bacteria and How They Grow* by the same author. *Buchanan's Household Bacteriology* and *Marshall's Microbiology*, both by P. Blakiston's Son and Company, will also be valuable aids in guiding this study.

CHAPTER XXI

MICROÖRGANISMS AND THEIR WORK

Time Allotment

Allow one period for the preliminary work of the chapter, three periods for the (*Key*) *Demonstrations*, two periods for the text proper, and two periods for the *Thought Questions*, *Review Outline*, and *Summary*.

Page 608. *Key Picture 21.* **1.** Each mold is produced by a tiny spore, which in turn produces other spores in large numbers, which in turn produce other molds.

4. The jar was not properly sealed and the air entered, carrying with it the yeast cells, which grow in the sugar and cause it to ferment or "work," spoiling the contents of the jar.

5. One bacterium divides into two. These two divide into four and the four into eight, etc. This is called cell fission and because of this bacteria are called *fission fungi*.

8. The bacteria act upon the refuse, breaking it down into gases and simpler compounds which finally disappear.

12. Yeast causes sweet cider to ferment or "work."

13. The one boy who has already taken a bite from the apple may easily transmit bacteria from his mouth to the remaining fruit which the other boy is about to put to his mouth. This is one of many ways of transmitting disease. Pencils, cups, etc., may serve as germ carriers in like manner.

Page 609. *Practical Questions:* **1.** Refrigerators keep down the growth of bacteria in foods and so prevent the spread of disease.

2. The dryness of the bread box prevents the growth of molds and mildews, since these plants can grow only in the presence of moisture.

3. Sealed and canned goods prevent dust from getting to the contained food. Dust frequently carries bacteria in large numbers. Such protection also prevents the spoiling of foods through the growth of molds, mildews, etc.

4. Cleaning the floors of lunch rooms and classrooms removes large masses of bacteria and the oiling of the floor catches the germs and holds them on the floor where they cannot be carried about by moving currents of air.

5. Clean dishes and cooking utensils are usually germ-free.

Page 610. *Home Problem:* Self-explanatory.

Field Problem: Food collects in the cracks of the dishes and decays. Washing may not remove all of it. This food works out into the food of the person using the dish. Disease may be transmitted in this manner.

Page 611. (*Key*) *Demonstration 53. Observations:* The Petri dish exposed to the air of the room will probably have the greatest number of colonies, although this will not always follow. Conditions may vary. In cold weather the colonies may be few. The air contains much dust and, therefore, many bacteria. Each bacterium which alights on the agar may start a colony. The colonies generally differ in size, color, and shape. These differences are marks of the identification of the species of bacteria to the bacteriologist. They indicate differences in the structure and activities of different kinds of bacteria. Many of the bacterial forms will be found to be moving, while some seem to be stationary. The shapes will follow in general those indicated in *Section 509.*

Figure 304. The Petri dishes contain the agar, a natural food for bacteria. The control dish is not opened and, therefore, remains sterile. If it continues to remain sterile, this will conclusively prove that the bacteria in the other dishes could come only from the materials introduced into them. Otherwise, one might justly conclude that the agar was not sterile in the first place or that it contains bacteria anyway. Thus the great advantage and even necessity of the control.

Page 612. *Figure 305.* Self-explanatory.

Page 613. (*Key*) *Demonstration 54. Observations:* Dishes 1, 4, and 6 will show the least growth of colonies of bacteria, while dishes 2, 3, and 5 will show the greatest number of colonies. Dampness, darkness, and warmth are very conducive to bacterial growth.

Practical Applications: Foods should be kept dry, cool, and so far as possible in the light. Compliance with the latter requirement is not so essential, however, provided the first two conditions are completely satisfied.

Suggested Experiment: The cork will probably have been forcibly expelled during the night. An alcoholic odor will be noticed in the bottle. The limewater will turn milky, indicating the presence of carbon dioxide. We may conclude that yeast ferments food containing sugar and moisture, giving off alcohol and carbon dioxide as a result of the process. Yeast spoils the syrup and spoils foods containing sugar.

Molds will be found, in all probability, growing upon the bread. The bread will have a disagreeable odor. The mold spoils the bread, making it unfit for use. Several kinds of molds (indicated by differences in color) will generally be found upon the bread.

Page 615. *Figure 306.* Self-explanatory.

Page 616. *Demonstration 55. Observations:* The meat will begin to appear slimy, in all probability. The odor from it will be a very disagreeable one. The meat has spoiled. Bacteria acted upon it, causing it to spoil. They accomplished this by digesting it and then after absorbing it, gave off wastes into the meat, making it unfit for human use. Bacteria cause meat to become slimy and malodorous, spoiling it.

Page 617. *Figure 307A.* The fly's feet and the boy's hand carried many bacteria, which were left on the agar, where they at once began to grow.

Figure 307B. The human hair also harbors bacteria. The agar exposed to air shows the presence of bacteria upon almost every particle of dust that alighted upon it.

Page 619. *Figure 308.* Self-explanatory. (See page 613.)

Page 620. *Figure 309.* The bacteria disintegrate the soft parts of the flax stem and soften the rest of it, making possible the linen threads pulled from the stem fibers.

Page 621. *Figure 310A.* Self-explanatory.

Note: These tubercles may be easily seen by having pupils dig up some common clover plants for examination of the roots.

Page 622. *Figure 310B.* Self-explanatory.

Page 625. *Figure 311.* Canning keeps the salmon from spoiling by shutting out bacteria. The steaming kills the bacteria which may have been on the salmon when the can was sealed.

Page 626. *Figure 312.* The ice keeps the milk so cold that the bacteria which may be in the milk cannot multiply. *Demonstration 54* shows a principle applied here.

Page 627. (*Key*) *Demonstration 56. Observations:* The milk becomes thickened to some extent as a result of the boiling. There should be no apparent change in the milk brought to a temperature of 145° F. The milk in 1 after 48 hours should be spoiled (soured). Bacteria in the milk rapidly multiplying in it caused the souring. The milk in 2 will show little souring, if any. That in 3 will show no spoiling. Neither 2 nor 3 should give off an odor indicating that souring is taking place. The milk in 3 will taste differently than that in 2 because boiling destroys some of its food value and changes its chemical composition.

The Petri dish containing a culture from beaker 1 will show the greatest number of colonies. The Petri dish containing bacteria from beaker 2 should have relatively few, if any, while that from beaker 3 should show none. Boiling destroys much of the food value of milk.

Conclusion: Milk is pasteurized by keeping it at a temperature not to exceed 145° F. for about 20 minutes.

Page 628. *Figure 314.* Cleanliness is a sure guarantee against the presence of germs.

Page 629. *Figure 315A.* Four things wrong here are: 1. The bed should not be in the kitchen. 2. There is little light. 3. The dishes are exposed to the dust of the room. 4. The oil lamp is a fire hazard in its present location.

Why each condition named is wrong may be easily developed from the study of the picture.

Page 630. *Figure 315B.* The essential things here are: Light, plenty of air, a stove, sink, cupboards, hot and cold water, garbage can, table, stool, refrigerator. It is a model kitchen, first, because it contains most of the essentials of a good kitchen, and secondly, it is clean and conveniently arranged.

Page 632. *Thought Questions:* **1.** Cooking foods makes them more palatable, more digestible, and frees them from bacteria.

2. The use of the vacuum cleaner and a " dustless duster " (a chemically treated cloth which picks up dust and does not scatter it), and good ventilation will help in keeping the air of the home clean. Food may be kept clean by using a good refrigerator, clean utensils and dishes, and by having clean hands when handling foods. The water may be kept clean by using it in clean containers and handling it in a cleanly way.

3. The conditions necessary for the growth of molds are: warmth, moisture, and food. Their growth may be prevented by keeping foods cool, dry, and away from air currents.

4. Explained on page 492.

5. Bacteria thrive better in the presence of a good amount of moisture than in an environment containing little moisture. Hence they always thrive in fresh, moist meat.

6. Dried beef will keep indefinitely (if kept dry) because bacteria cannot thrive except in the presence of moisture.

7. These foods are dry and contain little or no moisture. Therefore, bacteria cannot thrive on them. However, they should be protected from the ravages of the meal worm. Cleanliness and fresh air are safeguards here.

8. Disease germs may be carried by dust in the air, by water, food, by contact of one person with another, and by coughing or sneezing.

9. Forcibly sending out the breath carries with it droplets of sputum upon which thousands of bacteria are lodged. This spray may be breathed in by some one. If it carries disease germs, they are transmitted to the person who breathes in the spray. Then, again, the spray may lodge on a drinking cup or similar article which will transmit the germs to its users. Influenza, colds, diphtheria, whooping cough, tuberculosis, and mumps are diseases which may thus be transmitted.

10. Spitting on the sidewalks may spread disease (especially respiratory diseases). The sputum of a person so diseased dries, leaving the spores of the bacteria to be scattered through the air by every dust-disturbing breeze.

CHAPTER XXII

THE PROTECTION OF THE HUMAN BODY IN THE HOME

Time Allotment

Use one period for the preliminary work of the chapter, one for the pictures, three for the text proper, and two for the *Thought Questions, Summary,* and *Review Outline.*

The books already named in connection with the previous chapter, together with *Folsom's Entomology,* P. Blakiston's Son and Company, and *Chandler's Animal Parasites and Human Disease,* J. Wiley and Son, are recommended for your use in connection with the presentation of this chapter.

Page 634. *Key Picture 22.* Self-explanatory.

Page 635. *Practical Questions:* **1.** It is important to know the whole life history of insects which live about the home because we are thus better able to control them. For example: The clothes moth is most susceptible of control during its larval stage. By carefully brushing our clothes every so often we get rid of these larva which cannot live anywhere else but in the clothes. By placing cedar or moth balls among the clothes the adult female is kept away from them and so has no opportunity to deposit eggs thereon.

2. Insects such as flies, ants, roaches, weevils, etc., may carry disease germs into the food, if allowed to reach it.

3. Borax spread on shelves where they run will generally drive them away. There are insect powders of several kinds which are quite efficacious in controlling such pests.

4. One can help the body ward off disease by avoiding great crowds, by getting plenty of sleep, eating plenty of good wholesome food, getting plenty of exercise, drinking plenty of water, and avoiding stimulants and narcotics.

5. The housefly is the most dangerous of household pests because it spreads disease, principally typhoid fever, by flying into the house after having left manure piles, sputum, and filth of every kind. It is a dirty insect, leaving refuse wherever it may be. Its hairy body makes it a most favorable place upon which millions of bacteria can ride. This means that when the fly leaves any bacteria in food he leaves many thousands at once. (See Key Picture 22.)

Page 636. *Home Problem:* Self-explanatory. Consult a good text-book in zoölogy or a book on insects. (See Book References, page 655.)

Field Problem: Self-explanatory.

NOTE: The presence of mosquitoes in large numbers generally means a swamp near at hand or empty lots covered with many tin cans in which rain water may accumulate. Getting rid of the cans in a general clean-up campaign and the spraying of swamps with oil are the best means of ridding the community of these pests.

Page 637. *Suggested Experiment:* The second Petri dish is the control. The dish showing the colonies will be the dish in which the fly walked. The bacteria should be visible under the high power of the microscope.

Figure 316. The fly's legs must have been covered with innumerable bacteria.

Page 639. *Figure 317.* The striped legs and the fact that the hind pair of legs are held in the air are characteristics of this species of mosquito, the anopheles. (See Key Picture.)

NOTE: Be sure that the children understand that the mosquito here pictured is a large model.

Suggested Experiment: The oil cuts off the supply of oxygen to the larvæ and they suffocate. You will note that these larvæ come to the surface often to get air. They cannot pierce the film of oil with the little tube through which they secure their air, so they die very soon for lack of air.

Page 640. *Figure 318.* The weevil destroys peas, beans, and corn in storage. The ant eats food about the home and may carry disease. The bedbug sucks human blood and is known to carry disease. The croton " bug " eats human food and is filthy. It may also carry disease. The larval form of the clothes moth destroys clothing containing wool.

The "cootie" sucks human blood and is known to carry diseases, typhus fever being one of these diseases. Insecticides will control all of them except the clothes moth. The control of this has already been explained. The thorough fumigation of all clothing is necessary to rid the body of the "cootie" and the use of body preparations is also deemed necessary.

Page 642. *Figure 319.* Self-explanatory.

Page 644. *Figure 320.* Good food builds a body which requires cleanliness, exercise, and plenty of fresh air to keep it in a healthy condition. Sleep follows proper exercise. Successful living depends upon a good coördination of these several essentials.

Page 645. *Figure 321.* The wool fibers are more irregular and less uniformly joined than those of cotton, linen, or silk. Therefore they seem rougher.

Page 646. *Figure 322.* Self-explanatory.

Page 647. *Figure 323.* Self-explanatory.

Page 648. *Figure 324.* The list of rubber articles should be long. Make a composite list from the several submitted.

Page 649. *Figure 325.* Self-explanatory. Consult a good physiology text for an elaboration of this treatment.

Section 546. The moisture laden air does not allow the perspiration to evaporate from the body taking its heat with it. On clear cold days evaporation of perspiration is rapid due to little moisture in the air.

Page 651. *Figure 326A.* Self-explanatory.

Page 652. *Figure 326B.* Most of the weight of the body is thrown forward upon the toes, while at the same time the toes are being pushed back and the arch is being strained.

Page 654. *Thought Questions:* **1.** Consult the office of the local Board of Health.

2. The breeding of mosquitoes may be prevented by eliminating their natural breeding places, such as tin cans, old barrels, and similar containers that may hold water, or swamps and slow-flowing streams. Frequent oiling of stagnant water and propagation of natural enemies, like the dragon fly, will do much to rid a community of mosquitoes.

3. People who expectorate may be suffering from some infectious disease. The spores drying up may float away, enter the mouth or nostrils of other persons, and give them disease.

4. Prevention of the use of public drinking cups by law prevents the spread of disease. One person placing such cup to the lips may be diseased and thus spread a disease through the cup to the mouth of the next person using that cup.

5. A disease carrier is an organism that carries disease from one organism to another. For instance, the mosquito carries malaria from a person suffering from this disease to another person who is not infected.

6. Keeping foods under glass prevents handling by customers and also keeps them free from the dust and from the sprayed mucus of coughing and sneezing persons.

7. The statement is probably true. The organisms which we cannot see are everywhere, but the larger animals are relatively few in number, and while each weighs a good many pounds more than many millions of bacteria and other microorganisms, yet the enormous number of the latter everywhere in the world makes this statement seem plausible.

8. Man is learning better and better how to control disease and how to take care of his body so that it can withstand the attacks of disease germs. This, naturally, makes his average life longer. The average length of life has been raised eight years in the last seventeen years.

9. The bacteria are so small and so widespread in habitat that it is impossible to establish, at present anyway, an effective means of eliminating the bad while preserving the good.

10. Keeping food in sealed containers keeps it dry, fresh, and free from bacteria and molds.

CHAPTER XXIII

THE WORK OF PROTECTING THE COMMUNITY FROM THE DANGERS OF ITS ENVIRONMENT

Time Allotment

One period may be used in the preliminary work of the chapter, a second period in the study of the pictures, three periods on the text matter, and a final period on the *Thought Questions, Summary* and *Review Outline.*

Kelly's Walter Reed and Yellow Fever is an excellent work published by Norman, Remington and Co., of Baltimore, Md. A series entitled "*Health Heroes*" by the Metropolitan Life Insurance Co., 1 Madison Ave., New York City, is also highly recommended for work in connection with this chapter.

Page 656. *Key Picture 23.* In the case of smallpox, the vaccine on being placed in the body gives off toxins which cause a mild form of the disease. The blood and cells at once begin to form a natural antitoxin to combat the disease. They make enough antitoxin not only to overcome the mild form of smallpox but to act as a preventive against later infection with the actual smallpox germs.

In the case of the use of the diphtheria antitoxin, the production of the antitoxin occurs in the body of the horse. The injection of this antitoxin into the human body after the disease of diphtheria has been contracted immediately neutralizes the diphtheritic toxins and the person does not develop the disease. In the body of the horse, the cells are active against the disease, developing an *active* immunity; in the human body the cells are passive. This illustrates what is known as *passive* immunity.

As regards the experiments of Sir William Ross, it may be added that malaria is not a common disease in England. Ross thought that if some of the mosquitoes which carry malaria were caught in Italy and shipped to England and there allowed to bite a well person it could be proved whether or not the mosquito really carried the disease. This was tried and the well persons in England bitten by these mosquitoes came down with the disease. This proved beyond any reasonable doubt that the *Anopheles* mosquito carries malaria.

On milk routes the cans often become contaminated when handled by unclean farm hands in filthy conditions as here shown. This milk is placed in cans and distributed to homes. The dots in the various blocks show how typhoid fever (for example) may be and often has been transmitted in this manner, causing epidemics and many needless deaths.

Page 657. *Practical Questions:* **1.** We fear epidemics less now because we know their causes and can usually prevent their development or can check them when started because we know how to control most of the germs which produce them.

2. Obeying the orders of the health officers not only may save your own life but it may save the lives of others. In large communities where people live closely together, the carelessness of one person may cause an epidemic. This is especially likely to take place when people will not observe a quarantine.

3. Epidemics are rare in country districts because people live so far apart that they do not come into close enough contact with each other to spread diseases widely and because as each person drinks from a different well, the infection of a family from impure water will affect only the members of the family using that water.

4. Machine-made ice is made from spring or distilled water which is free from bacteria, hence it is generally pure.

5. Self-explanatory.

Page 658. *Home Problem:* Self-explanatory.

Field Problem: Self-explanatory. The previous discussions should make this an easy problem to attack.

Figure 327. This stable is a good one because it receives plenty of light and air; the floor, being of concrete, is easily kept clean, and the stalls are open and sanitary.

Page 659. *Figure 328A.* The sign is far from indicating the true conditions here. The food is not properly covered; the cat crawls over the food; some food is on the floor; the store is poorly lighted and ventilated; and the clerk is not dressed in clothing that protects the food from contamination.

Page 660. *Figure 328B.* Here the food is under glass; it is up from the floor; the clerks are dressed in a manner to protect the food; and the store has more light and more ventilation.

Section 555. The regulations help prevent contamination by bacteria or kill most of bacteria in the foods.

Page 661. *Figure 329.* The meat is inspected here to determine if it complies with the cold storage laws of cleanliness, freshness, and freedom from disease germs.

Page 662. *Figure 330.* The bad conditions here are: poor light, untidy disposition of clothing, etc., and little ventilation.

Figure 331. Self-explanatory.

Page 664. *Figure 332A.* On August 1 the milk was distributed which contained some typhoid germs. Wherever the milk was used cases of typhoid fever developed. As time went on, the same kind of milk developed other cases until on September 1 the epidemic was at its height. This epidemic all came from one source.

Figure 332B. This card is placed upon a house where diphtheria exists. It warns people to keep away. It is evidence that all members of the family who have been exposed to the disease are required to stay in the home until the case is complete and the home made germ free. This protects the public.

Page 666. *Figure 333.* Self-explanatory.

Section 563. To wait for report before inoculation may be fatal to patient. If the report is negative no harm is done by the inoculation.

Page 669. *Figure 334.* This cup is easy to construct and it works. Have the pupils make them in numbers. The advantage of this cup is that it is an individual cup and can be thrown away after use. It is a preventive of disease transmission.

Section 570. Each factor helps to build up a strong body resistance to the germ toxins if they enter the body.

Page 670. *Figure 335.* Self-explanatory.

Page 672. *Figure 336.* Self-explanatory.

Page 674. *Figure 337.* The diphtheria death rate has dropped radically in the United States since 1901 because we have learned largely to control it through the improved use of antitoxins, through use of toxin-antitoxins, and by better quarantine observance.

Figure 338. Control of diseases, better sanitation, better knowledge of treatment of disease, better knowledge of diets, more outdoor life and exercise are a very few of the reasons why the average person is living longer now than in 1800.

Page 676. *Thought Questions:* **1.** The frequent sprinkling of streets cleans them, removing filth and multitudes of bacteria. The water forms lenses which concentrate light rays and kill bacteria lodged on relatively clean streets.

2. The oil on the roadbeds keeps down the dust and this keeps the cars cleaner and helps to prevent the spread of disease.

3. Artificial ice is inexpensive, clean, and generally free from disease germs.

4. The answer to this question may be obtained from the body of the text or from any good text on physiology.

5. Between 1896 and 1910 the cause and control of yellow fever were discovered.

6. This assignment requires reference study and report by the pupil. He should prepare a short biography together with a personal comment on what the control of smallpox means to the race in the light of earlier experiences with the disease.

7. Borax and kerosene kills the eggs of flies and other insects which develop in manure piles, thus reducing the possibility of disease epidemics.

8. Oil prevents the production of mosquitoes by cutting off air from the larvæ.

PREVIEW OF PART VIII

The one fundamental idea you need to bring out in connection with this part is: if the work of the world is to go on, life must be conserved and improved.

The pupils should be taught the essential facts about the origin of life in the lower forms of plants and animals and in the flower and frog. In the study of these, he develops a vocabulary which permits him to talk about life easily and intelligently.

If the pupil can be made to see the importance of conserving and increasing useful plant and animal life, if he can be made to comprehend the great importance of the principles underlying this study, he will be the better citizen, even though he does not say much about it. Certainly, every pupil should be trained in the importance of the improvement of his environment. This unit offers the teacher an opportunity rich in its promise of training for good citizenship.

CHAPTER XXIV

THE ORIGIN, CONSERVATION, AND IMPROVEMENT OF LIFE

Time Allotment

Spend one period on the preliminary work of the chapter. The equivalent of two periods should be used on the pictures. Three periods should be used on the text matter and one period on the *Thought Questions*, *Summary*, and *Review Outline*.

Guyer's Being Well Born, published by Bobbs-Merrill Company, *Walter's Genetics*, published by the Macmillan Company, and *Goddard's The Kallikak Family* should be in the hands of every teacher of general science.

Page 678. *Key Picture 24.* The new animals formed by the dividing of one amœba will be exactly like the parent because there is but one parent involved here. There is no chance for variation. The cell **cz** contains chromosomes from both parents having different qualities and, therefore, the cell in some respects is different from both parents and in others like both parents. It has the same number of chromosomes as the parent cells. The rest of the Key Picture is self-explanatory.

Page 679. *Practical Questions:* **1.** Bacteria and yeasts reproduce asexually while the bird reproduces sexually. The lower organisms can reproduce tremendous numbers by cell division in a very short time; the bird but few in a relatively long period of time. Most of the lower organisms may be destroyed and yet have comparatively many left. The bird can produce few young. These must be taken care of so that the race of birds will not die out, since the loss of a few birds means a far greater loss than the loss of myriads of lower organisms. Hence the care of the mother for her young.

2. By eggs: snakes, birds, turtles, duck bill, etc. By birth: dogs, cats, horses, sheep, cattle, human beings, etc. The geranium and begonia easily reproduce by "slips"; the same plants reproduce by buds, and others, as the onion, tulip, etc., may be added. All flowering plants reproduce by seeds.

3. The boy may look and act very much like his father. Thus he is a part of his father or a "chip off the old block."

4. Through heredity a peculiar combination of the factors of the chromosomes often results in a person of peculiar traits, disposition, and capabilities. If this person "goes wrong," as he often does, he is called a "black sheep."

5. The environment in the slums is such that bad habits are easily formed. These lead easily into deeds that the well-disciplined person would not think of committing.

Will training and good habit formation are the important factors in correcting such tendencies.

6. The above answer will give the clue to the answer here.

Page 680. *Home Problem:* Self-explanatory.

Field Problem: Self-explanatory.

Page 682. *Figure 339.* The body of the bee is covered with hair which catches and holds the pollen. The bee has a tongue well adapted to secure nectar from flowers. Besides, it has pollen baskets on its hind legs for carrying pollen in quantities.

Figure 340A. The functions of the parts may be learned in the laboratory exercise begun on this page.

Laboratory Exercise: The tulip is used here because it is a large flower, the parts are distinct, and it is easily procured in season. On the other hand, it is not typical, as the flower is really asepalous (without sepals). But for purposes of study in this connection (the understanding of the parts and functions of the parts) the outer row of parts may be called the calyx and its parts the sepals. This is done in several texts in biology. This asepalous condition is *true* of all *true* lilies.

Page 683. *Figure 340B.* Self-explanatory.

Page 684. *Figure 341.* This flower (corn) is cross-pollinated because the pistils and stamens are separate flowers, even though those flowers are on the same plant.

Page 685. *Figure 342.* Note the cell multiplication here. Each new division is at right angles to the previous division and the number of cells is always doubled by the process. Note the hollow structure at **5** and the invagination of this same egg at **6** and the formation of layers of cells. **7** does not look much like what has gone before or like what is to come. But at **8** the real resemblance to a frog appears and by metamorphic changes in **9** and **10** the adult frog appears at **11**.

Page 688. *Figure 343.* All these offspring are alike in fundamental characteristics. This is because the parents were fundamentally alike. All are different because their parents were different in certain respects.

Figure 344. These variations are not easily explained. We know that they exist and they may influence the next generation if they happen to affect the germ cells, but most variations do not do this.

Page 689. *Figure 345.* Self-explanatory.

Page 690. *Figure 346.* Self-explanatory.

Figure 347A. A better selling cucumber was gained because the offspring was a better appearing cucumber.

Plate VI. The whiteness of the white does not appear in the first generation because red is dominant to white and masks the white. Three out of every four of the offspring of **XY** will be red because by this is the only possible combination of the chromosomes which will produce this result. (See Figure 348.) **XX** will produce nothing but reds because there is no white factor here and **YY** will produce nothing but whites because there is no red factor here. When the **XY** flowers are self-pollinated in the third generation the results will be exactly the same as in the second generation — three reds to one white.

Page 691. *Figure 347B.* The offspring is larger than either of its parents. It resembles its parents in general characteristics and in shape. It does this because it has the characteristics of each in its cells.

Page 692. *Figure 348.* Self-explanatory.

Note: In crossing, a chromosome bearing the red factor may combine with another chromosome bearing a red factor or it may combine with a chromosome bearing a white factor. This is merely a matter of chance. But given a large number of flowers to be crossed and out of a hundred flowers crossed, the chances are that one quarter of the pure red factors will get together; one half of the red and white factors will get together, and one fourth of the white and white factors will get together. This can be proved by taking eight marbles, four of which are white and four of which are red. Shake them up in a bag and draw out two at a time. Five times out of six they will come out as follows: **RR–RW–RW–WW.** Try it and prove it for yourself.

Page 694. *Figure 349A.* Self-explanatory.

Page 695. *Figure 349B.* There are larger kernels and more of them in the right ear than in the left one. The kernels are also more perfect. Finally, they cover the whole cob in the right ear. This was all done by careful selection and crossing according to the Mendelian law.

Page 696. *Figure 350.* It is hard to say which side of the triangle has the greatest influence upon one's life. Heredity would be claimed by many as the chief influence. It is certain that without a good inheritance the other factors do not go far in rounding out a life. Great-grandparents according to Galton each contribute one eighth of the hereditary qualities to the great-grandchild.

Page 697. *Figure 351.* The baby does not resemble the oldest man more closely because the baby is five generations removed from him and a parent from another family has contributed his or her characteristic to this child. It resembles him to some extent because of the hereditary factors which were carried down by the persons here represented in the pictures. It should be noted that each person resembles his immediate parent or offspring very closely.

Page 698. *Figure 352A.* Self-explanatory.

Page 699. *Figure 352B.* The strong line of descendants at the left no doubt received their characteristics from Elizabeth Tuttle, who was exceptional.

Page 700. *Figure 353.* The dangers here are bodily injury and disease.

Page 701. *Figure 354.* Many boys and girls do not enjoy such an environment because of a lack of appreciation of its importance by the parents, or because of a lack of money.

Page 703. *Thought Questions:* **1.** The number of yeast plants will be approximately 18,613,888. Conditions are not favorable enough.

2. Reproduction can take place in plants without the use of seeds by buds, cell division, slips, spores, runners, etc. The farmer can be sure that he is getting a plant true to type in the next generation if he uses slips, for example, to produce new plants. The seedsman produces new trees which he can guarantee by slips, grafting, buds, etc.

3. Most people cannot make a fortune by raising chickens because the cost of food, labor, and marketing is high. And, of course, as in all businesses, expert knowledge is essential to success.

4. The struggle was between the beetles and the quail. In nature, this is going on all the time. Were it not for the birds, man would probably starve. This is the way the balance of nature is kept.

5. Since the codfish takes no care of her young, overproduction of eggs is needed to insure the maturity of some. Thus the race is insured.

6. Birds care for their young and so usually not more than four can be cared for at once.

7. A man may use a mutant to start a new line of plants or animals of great value. A mutant always breeds true.

8. The farmer has had rust-resisting wheat produced for him by the Mendelian laws. The gardener may produce a new rose or vegetable by this method.

9. They show crosses of several strains.

10. Heredity through millions of parents insures variations in all offspring.

11. Plants being stationary can be handled with greater ease than animals and they can be grown faster and in greater numbers.

12. Consumptives have weak lungs. The children of such parents may inherit weak lungs. People with weak lungs are more subject to tuberculosis than persons with strong lungs. This is why it is often said contrary to the fact that tuberculosis is hereditary.

13. If the parents are clean, upright, physically sound, and strong-willed, the offspring will have an even chance, at least, of inheriting some of these qualities. Thus the training of the child really begins in the parents.

APPENDIX A

SPECIAL PROBLEMS

In all of the following problems place as much of the responsibility of collecting materials and performing the work as you possibly can upon the pupils. This will make the pupil self-reliant and independent; it will relieve the teacher of the annoyance of keeping in mind the details of work which should be done by the pupil. The sure way to make special problem work non-effective is to help the pupil do the work. The teacher should inspire, guide, and suggest but should never do much of the actual work. Any problems involving much work on the part of the teacher should not, in general, be attempted.

Chapter I

1. This is a problem in observation. The report should be based upon several general ideas, as follows: Adaptations for (*a*) eating, (*b*) locomotion, (*c*) protection from enemies, and (*d*) weather. This will cover enough ground to give a good account of the principal external features.

2. The objects should be so placed that all may be seen at once but in marked disarray.

3. Self-explanatory.

4. Here the problem is more difficult because the number of objects will ordinarily be many. The test will be a real one and an interesting one if you do not allow the imaginations of the pupils to interfere.

Chapter II

1. A study of *Darrow's The Boy's Own Book of Great Inventions* and *Masters of Science and Invention* by the same author (Harcourt, Brace and Company, New York) will give all the information needed here. *Harwood's New Creations in Plant Life* (Macmillan Company, New York) gives in a readable form the work of Luther Burbank.

2. *Bachmann's Great Inventors and Their Inventions* (American Book Co.) and *Cressy's Discoveries and Inventions of the 20th Century* (E. P. Dutton Co., New York) are rich in material for this problem.

3. This problem may be best attacked by securing from automobile companies the loan or gift of some of their catalogs running back fifteen or twenty years. The principal things to be noted in the stories are: (1) the change in the appearance of the body, (2) the differences in the chassis (frame) and wheels, and (3) the controls. The interior parts are too difficult to study unless some pupil is interested enough and has the ability to make a comparative study of the evolution of the engine block, number of cylinders, and valve arrangement and control. Only the salient features which are easily understood by the average pupil should be included in any of the reports.

The year 1900 could not have produced this year's car because the science of automobile manufacture, including the improved accessories, had not sufficiently developed. As with every other complicated mechanical device, improvements in the automobile come only with the testing of experience. The aviation periodicals and other library aids will tell the story of airplanes. Airplanes perhaps show fewer differences in construction than automobiles, but they, too, are developing a wide range of models and uses "suited to every need and purse."

4. Various home problems may be begun at home, such as determining the efficiency of a vacuum cleaner, the values of different kinds of fuel for heating the home, the amount of water lost by dripping faucets, the best method of ventilating a living room, keeping a weather record for two weeks, making a house thermometer, etc. Many problems will be suggested by the pupils themselves through observation of their home environment.

Chapter III

1. All simple machines excepting the wedge and the pulley will be found in the ordinary meat chopper.

2. Every simple machine will be found in the bicycle and all but the wedge and pulley will be found in the washer and separator. Even these exceptions may be found in some types of the two latter machines.

3. Every type of machine will be found in the derrick or shovel. It is best here to take a group of pupils to a spot where these machines are being used and there study them as they work, noting the simple machines employed and their dependence upon one another.

4. The greatest friction will occur at the axles, gears, and in the cylinders. This friction is considerably reduced by careful lubrication.

5. Every machine but the pulley will be found in the ordinary egg beater.

6. This problem is self-explanatory. See page 60 for the law of machines.

7. $R \times RD$ equals $E \times ED$ or 100×3 equals $75 \times ?$ $300 \div 75 = 4$.

8. $E \times ED$ equals $R \times RD$ or $150 \times ?$ equals 300×3. $900 \div 150 = 6$.

Chapter IV

1. Self-explanatory.

2. The ink in the well is kept in simply by atmospheric pressure. Testing this should give the answer.

3. The lever forces air out of the bulb and, as it is released, a partial vacuum is formed. The atmospheric pressure on the surface of the ink in the bottle forces the ink up into the pen.

4. This information may be best secured from a good encyclopedia. This warning should be given, however. In all reports requiring the use of reference books, the pupils should be impressed with the idea that they are not to include anything in their reports which they do not fully understand and that their reports should be in their own words and not copied word for word from the reference book. Reports in which these warnings are not heeded are often a jumbled mass of unintelligible facts which confuse the class and kill the interest in the topic assigned for special study.

5. Self-explanatory.

6. Secure an inexpensive sprayer from a hardware store and, filling it with water, test it out. Set some pupils to work to find out how it works and report upon it to the class.

7. This can easily be constructed from a bottle with the bottom removed and a one-holed stopper in the top through which air is forced by an air pump. The open end of the bottle may then be immersed in a jar of water and the experiment begun.

Chapter V

1. The various conditions make this problem vary in details although the principles will not vary. The best method to follow here is to have the pupils make a sketch of their sleeping rooms, indicating the location of windows and doors and the position of the bed. Then have the pupils put in air currents in this room based upon openings in the room, according to the conclusions of *Key Demonstration 16*. This work may then be placed on the board, the report made, and the sketch criticized by the class as a whole.

2. A study of these devices in any hardware store will give the pupils the clue here. With these as models, the pupil may produce his own device for the home.

3. This study may be made in your own school unless some other building in town offers more modern and more accessible equipment. The teacher ought to go over the system very carefully before considering it with the class. If possible, consult the manufacturer's specifications. More interest attaches to the study if it is made in some other building than the home plant.

4. This report may be best worked out by having certain pupils visit any good sized manufacturing plant in your town and asking the superintendent just how the problem of dust is solved. This may start something in the particular plant visited, if dust removal is not efficiently done.

5. Secure a copy of the Health Code of any large city near you. For example, copies of the *New York City Health Code* may be secured by writing to the *Health Commissioner*, *New York City Department of Health*, telling the reason for the request.

6. Select a few pupils to carry on this problem. Have the pupils on one day, during a certain set number of minutes, multiply together several sets of numbers each having four or more figures. Note the time required for each multiplication and the number having the results correct. The conditions should be ideal: plenty of ventilation and the temperature of the room at approximately 68° F. On the next day try the same experiment again, with the windows all closed and with no proper ventilation, using the same figures as before but changed about as regards their position in the number (to avoid the advantage gained the day before through familiarity with the numbers) and allowing the same amount of time for the test. Note again the time taken for each problem by each pupil and the number of errors made. Average the results of both days and determine your conclusions. To make this problem of the greatest value, the experiment should be tried two or three times.

Chapter VI

1. Self-explanatory. Be careful not to use too much lye.

2. Self-explanatory. In this problem as well as the one above the pupils should describe the apparatus they discover and the steps they followed in the cleaning process.

3. Write the *Bureau of Water Supply, New York City,* for booklet or *Los Angeles Water Board* for a booklet on their water system.

Not more than one copy should be requested. Also see General Science Quarterly, Vol. 6, nos. 3 and 4, and Vol. 7, nos. 1, 2, and 4.

4. Self-explanatory. Have pupils follow the Department of Agriculture pamphlet very closely, using only the material they understand, however. Also send for *Gates: Farm Water Supplies;* Circular 18, Massachusetts State Board of Agriculture.

5. This problem may be answered by some pupils far better than by others. In general, select pupils who represent homes of the middle class of people where intelligent mothers do most of their own cooking. In these homes the mother may be called upon by the child to help solve the problem. The advantage of this plan is that the parents see the practical side of the science their children are studying and in most cases will be active in their aid in solving similar home problems.

Chapter VII

1. This problem is easily solved by using two feet of rubber tubing with several small holes punched in line along one side. Through these holes may be inserted pieces of glass tubing to represent hydrants, faucets, fountains, etc. By attaching one free end to an outlet in a gallon varnish can and tying up the other end, water may be sent out of the glass tubes with some force, depending upon the height the reservoir is held above the glass outlets. The ingenuity of the pupils should be given free rein here.

2. This problem may be solved either by having pupils visit the town water supply office; or by securing maps showing the location, sources, and distribution of the town or city water supply system; or by making a first-hand study of that part of the system within easy distance of the school.

3. Information may be secured from the town or city Health Officer or from the town Water Supply Board.

4. Multiply $62\frac{1}{2}$ lbs. by 16 to get the number of ounces. Divide this product by 144, the number of inches in a square foot, and the result will be the pressure in ounces upon one square inch. For 10 cu. ft. multiply $10 \times 62\frac{1}{2} \times 16$ and divide the product by 144.

5. Secure from the *U. S. Department of the Interior* material upon the irrigation and land reclamation projects in the west. This should give ample material for discussion on this point.

6. Secure information from same source as in **5.**

7. Pictures will be included in the material sent you from the *U. S. Department of the Interior.* Also send for Reclamation Service Publications, U. S. Department of Agriculture, Washington, D. C.

Chapter VIII

1. This can be done by having two pupils paired, one of whom has a hot-air heating plant in his home and the other a steam heating plant. They can examine each plant together, compare notes, get information from their parents, and then bring in their reports.

2. This is best done by securing a catalog of a hot-water heating company product and then studying such a plant in actual operation.

3. Secure a catalog of an electric range firm or go to your electric power or light company and ask questions about the stoves they have on display.

4. Information on this report may be obtained by sending to the *U. S. Department of the Interior at Washington, D. C.*, for literature on the coal industry. Also much valuable material may be obtained from *Gibson's Romance of Coal*, published by Lippincott, Philadelphia.

5. If you do not have gas works in your town you may be able to substitute for this visit another to some manufacturing plant where much coal is used to release heat and report upon how this coal is used. Reference to the *Book of Knowledge* will help on this report.

6. Material for this report may be obtained from a good encyclopedia, the *Book of Knowledge*, or from *The Popular Science Library.*

7. Material on this may be found in the *Popular Science Library.*

8. Material on this may also be found in the *Popular Science Library.*

9. The *Department of the Interior, Washington, D. C.*, will send matter on this topic. The *Book of Knowledge* will also give much good material.

Chapter IX

1. Self-explanatory.

2. This can best be done by securing permission from the owner of a new home to go through it before it is to be occupied. Comparison with other new houses will give much information for discussion. Plans of houses in House and Home magazines showing position of lights will also be helpful. Reports on actual tests in the new homes of class members will be interesting and useful in developing this problem.

3. Fuses may be secured at any electrical supply store.. Take them apart if necessary and study them. Try them out on your apparatus for Chapter X.

4. Secure material for this from the *United States Glass Company, Pittsburgh*, or get the information from the *Book of Knowledge.*

Chapter X

1. Self-explanatory. See problem 4, with a view to combining, perhaps. The study of a simple push-button bell contact will help in the solution of this problem.

2. The way to present this problem is to secure a bell and push button with connections. Put different parts of it out of order and then have pupils find the trouble and fix the part out of repair. This practice will be found invaluable. "Trouble-shooting" on bells, motors, etc., always stimulates much interest and provides splendid instruction.

3. Secure a wet cell glass jar, some sal ammoniac, and lead terminals. Dissolve a quarter pound of the salt in water, connect the wires to the cell terminals, and cause a bell to ring. Now put in an old lead and note results. Note how the parts of this cell may be renewed. Note what parts never need renewing because of wear and tear of parts. In renewing, the carbon shell should always be thoroughly washed and dried.

4. Self-explanatory.

5. Directions for assembling the St. Louis motor come with it. The running of the motor can be observed and explained by reference to page 337 in the text.

6. This problem may be done with the bell, the motor, the telegraph, the electric fan, etc.

7. This can be done with the assembled St. Louis motor.

8. Self-explanatory.

Chapter XI

1. Self-explanatory. (*d*), (*e*), and (*k*) will best be determined by talking with the superintendent or owner of the plants.

Chapter XII A

1. Self-explanatory.

2. Self-explanatory. It may be added that the engine can rarely become set on dead center because the starter will practically always throw the connecting rod of the piston to be first fired past the dead center. The momentum then prevents the engine from becoming stalled on a dead center. The timing device is at the front of the engine and is attached to the crank shaft by a gear. Each cylinder is fired in its proper order and in the proper time by this device.

3. The types studied will be dependent upon the location. The plate girder type will be found the most common across small streams and the truss bridge will span the wider streams. Each will have its own advantages.

Chapter XII B

1. Self-explanatory. This work will be helped by having pupils read *Miller: Canoeing, Sailing and Motor Boating,* Doran Co.

2. Self-explanatory.

3. Again use Miller's book noted in **1** above.

4. This report will depend for best results upon whether any member of your class has had experience with a motor boat. If you have such a member in your class let his experiences, through a report, become the common knowledge of the class as a whole. Otherwise, make use of reference books.

Chapter XII C

1. This balloon may be made from tissue paper and wire. A small bit of cotton dipped in kerosene will give off enough heat to raise it. This experiment should be tried in open country, however, to avoid any possibility of igniting any buildings, if the balloon should come down too soon.

2. Self-explanatory. The box kite has rectangular sides and square ends. It is about two times as long as it is wide. Rarely does a class fail to include or develop an expert in box kite construction.

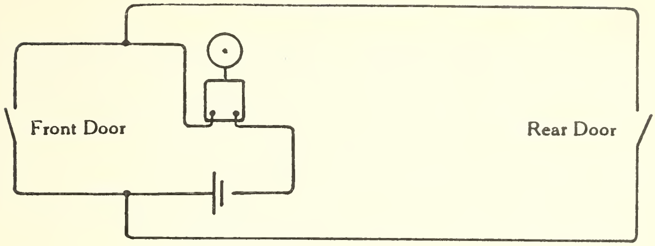
3. Self-explanatory.

Chapter XIII

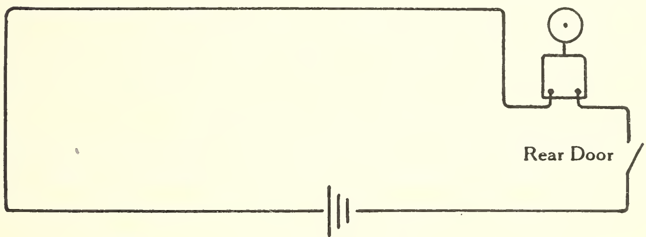
1. The wiring of the bells under the problems *a*, *b*, *c*, and *d* is shown on the opposite page.

2. Radio may be substituted here for wireless plant. Some pupils in the class may be owners of a radio set and may be able to demonstrate it, telling the class the points indicated in the problem. The best way to have pupils practice the codes is upon a sender or key of the buzzer type.

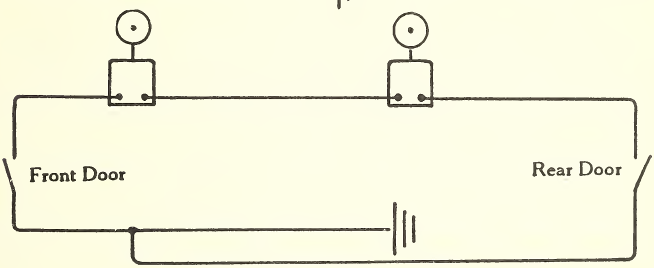
3. The crystal sets are somewhat out-of-date, yet they are very inexpensive to make and the principles of the radio are easily understood through their construction and use. *Wheeler: The Boy with the U. S. Radio,* Lothrop; *Collins' Radio Amateur's Book,* Crowell, and *Collins' Book of Wireless Telegraph and Telephone,* Appleton, will give full particulars about this and the preceding problem. *Dunlap's Radio Manual,* Houghton Mifflin Company, and *Snodgrass' Radio Receiving Set* are excellent manuals for this work. The U. S. Bureau of Standards, *Principles Underlying Radio,* published by the World Radio Company, is also a useful reference for these problems.


Front Door
Rear Door

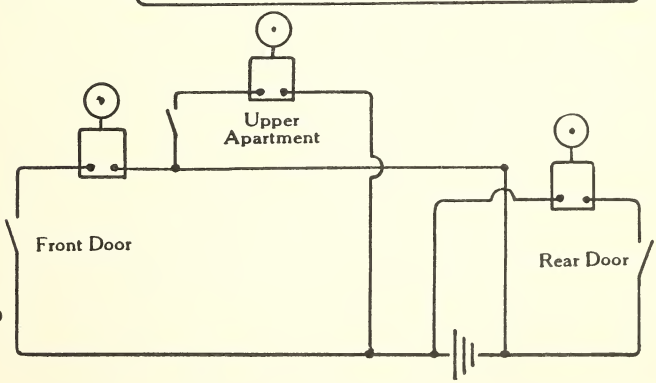
A


Rear Door

B


Front Door
Rear Door

C


Upper
Apartment
Front Door
Rear Door

D

Chapter XIV

1. This is a simple problem of tracing the motion of the locomotive back through the steam, the heat, the coal, the plant out of which the coal was made, and to the sun which made the plant grow.

2. This eclipse may be studied by referring to the files of the *Scientific American Magazine* for February, 1925.

3. *Astronomy with the Naked Eye, Serviss*, published by Harper's, or *Astronomy for Young Folks, Lewis*, published by Duffield, will give all the information needed to solve this problem.

4. This model may be easily made with putty, pieces of stiff wire, and a board. Use a geography to secure relative sizes of the planets and their relative positions. This may be made a really valuable exercise for the whole class and the models may be a permanent contribution to the future work of the class.

5. Self-explanatory. The work may be aided by reference to the books quoted in **3** above and by constant reference to page 438 in the text.

Chapter XV

1. The records of the local weather bureau man may be studied and the weather man himself questioned. A study of the daily newspaper weather conditions is most instructive if carried through several successive issues of the paper.

2. On the approach of foul weather the frog will climb up out of the water of the aquarium on a ladder, if one is provided. The leech becomes restless on approaching bad weather. The spider shortens his web. The halo about the moon and falling smoke are common signs. Test them out by class observation and record. Gulls flocking in from the sea is a sign of an approaching storm. The pupils may gather others from various local sources.

3. Use graph paper and record dates across the top, with inches entered at the left side of the graph. The height of the barometer should be indicated under each day by means of a cross or dot. At the end of the observation all the cross marks may be connected by a line. This line will show the variations day by day, and the average pressure may be determined by adding up all the daily pressures and dividing the total by the number of days during which the pressure was observed.

4. In general, the lower barometric pressures will be accompanied by cloudy or stormy days. Reasons for this relationship are explained by reference to Chapter XV in the text.

5. This may be made by using two dry-bulb thermometers and fitting one of them with muslin and a water reservoir. The relative humidity on each day may be determined by use of the table in the text on page 458.

6. This record may be made on the same plan as the air pressure graph in **3** above, except that in place of the inches in the left-hand column the percentage of humidity (relative humidity) is placed in a note-book each day until the record is complete. Then the graph is made by placing the lowest humidity percentage at the bottom of the left-hand column and the highest at the top and the intervening percentages in their proper order between. Then a dot should be placed under each day opposite the percentage of humidity for that day and the graph completed by connecting all of the dots by one line. This will give the variations at a glance. The average may be obtained as before.

7. In general, the high humidity days will be found to be the low barometric pressure days (the cloudy or stormy weather days). This is variable, however. The relationships here may be checked by studying Chapter XV in the text.

8. A simple and effective rain gauge may be made by using an ordinary vegetable can and fastening upright on its inside wall a six-inch ruler. The height of the water in the can after a rain will show the average rainfall, if the can is placed in an exposed position.

Note: For the above problems you are referred particularly to the following books as being very helpful. *Brooks: Why the Weather?* published by Harcourt, Brace and Co., New York; *Humphries: Weather Proverbs and Paradoxes*, published by Williams and Williams; and *Weather and Weather Instruments* by the Taylor Instrument Company, Rochester, N. Y.

Chapter XVI

1. This is self-explanatory, especially if *Farmer's Bulletin No. 255* be secured. *Rockwell's Gardening under Glass*, published by Doubleday, Page and Company, Garden City, L. I., may be used with profit here.

2. Self-explanatory. *Rockwell's Around the Year in the Garden*, by the Macmillan Company, will be very helpful.

3. Much of this should be based upon observations. *Howard's Insect Book*, published by Doubleday, *Craigin's Our Insect Friends and Foes*, published by G. P. Putnam's Sons, New York, and *Herrick's Insects of Economic Importance*, by the Macmillan Company, will all be of value in this problem.

4. The books named above will also serve for this problem. Pupils should also get first-hand information from neighboring gardeners.

Chapter XVII

1. The best procedure here is to have several of your pupils consider farms with which they are acquainted. Have them consult with the owner or manager of the farm concerning the problem.

2. This can be done in the classroom. Each factor may be emphasized in connection with several different plants, the other factors being constant. Combinations of these factors may be tried.

3. This is best done by first-hand observation. Have the pupils grow corn, wheat, and potatoes in the school garden or in a box containing plenty of soil. Have them keep a careful record of the growth of each plant and then write up the story in full. Then have them read *Chamberlain's How We Are Fed*, Macmillan Co., and *Carpenter's How the World Is Fed*, American Book Company.

4. This problem is best solved by careful observations of the plants named or of any others which may be selected. Have the pupils study *Shaw's Weeds and How to Eradicate Them* or *Pammel's Weeds of the Farm and Garden*, both published by the A. T. DeLaMare Co., New York City.

5. This problem may be studied best by actually observing the insects in their natural surroundings. But this study will be much aided by a study of *Craigin's Our Insect Friends and Foes*, G. P. Putnam's Sons.

6. This is best solved by following the advice of a good book on plant propagation. *Hottes' Practical Plant Propagation,* published by the A. T. DeLaMare Company, is recommended.

7. Follow the suggestions of the book named in **6** above to solve this problem.

8. For suggestions on corn clubs write the *Cornell University Extension Courses in Agriculture* at Ithaca, N. Y., for literature on the subject or to the *U. S. Department of Agriculture, Washington, D. C.*, or your local state department.

9. Self-explanatory.

10. Secure material for this problem from *Harwood's New Creations in Plant Life,* The Macmillan Company.

Chapter XVIII

1. This problem may be easily solved after the basic tests are made in the class. Nitric acid, iodine solution, some Fehling's solution, a test tube or two, and a gas stove are all that is needed to test the foods.

2. Self-explanatory. In most cases the food will cost at least one third more than it should cost because of too much waste or overeating or because foods with too much waste are purchased. With the help of the tables on pages 542 and 543 of the text, and pages 156–158 of this manual, the exact amount of food needed to give the total number of calories for each member of the family can be figured and the cost computed.

Chapter XIX

1. Self-explanatory. If no model or dissected frog is available, study parts in a good text on zoölogy.

2. Self-explanatory.

3. Actual observation of the teeth of the animals named is the best way of solving this problem. Note that the canines are most prominent in the dog and cat for tearing flesh; the incisors in the rabbit and guinea pig for gnawing; and the molars in the cow, horse, and sheep, for grinding foods. Look in a good text in zoölogy for a comparative study of the teeth which cannot be observed in the live animal.

4. Self-explanatory. Use a good biology text to aid in this. Man has become an omnivorous animal and no one kind of teeth in his jaws is prominent.

Chapter XX

1. This is a matter of close observation. For example, the sudden shutting of the eyes when a door is slammed is a protective measure. Others will suggest themselves.

2. Self-explanatory. For example, lacing the shoes each morning without thinking about it is a daily habit. Others will suggest themselves.

3. Self-explanatory. For example, the habit of standing erect when reciting is a good one. Follow the directions indicated relative to this or any other habit being formed.

4. Self-explanatory.

5. This is a matter for close observation. For example, a certain dog learned within a few days to know that when the word "walk" is spoken that it means going for a romp. He now is very animated and jumps and barks when he hears the word spoken. This is a habit formed by the dog of connecting the idea of a walk with the word "walk" and the reaction of barking follows.

Chapter XXI

1. Self-explanatory. Discuss the reports in class.

2. Self-explanatory. Be sure that the pupil sees the right things here and that he does not become supercritical.

3. This is best done by placing the same number of drops of raw and pasteurized milk on Petri dishes prepared with agar. Count the colonies after several days and this will give an index of the relative number of bacteria, assuming that each colony contains about the same number of bacteria. This may be assumed at any number.

4. *Paul DeKruif's Microbe Hunters* (Harcourt, Brace & Co., New York) will give an excellent story of the experiments of Pasteur. *Radot's Life of Pasteur*, published by Doubleday, is excellent.

5. This problem may be solved by following directions on page 613. The pupils should enlist the help of their mothers on this problem.

6. Clover plants may be dug out of the ground, the tubercles observed, and a few of them may be crushed on a glass slide, a drop of water added, and the bacteria studied under the microscope at leisure.

7. This problem may be worked out on the plan suggested in conducting *Key Demonstration 56.* The odor of each kind of milk will tell the story. Microscopic study of the milk will also indicate the density of the bacterial life in the milk.

8. Odors may be killed by certain disinfectants. Wash bowls and toilet bowls and drains are kept sweet by such disinfectants, which means that the germs are killed by them. Have the pupils confer with their mothers on this problem and check on it in the classroom by actually killing bacterial growths in Petri dishes by use of different disinfectants.

9. Self-explanatory. Any food factory where food is sealed will be a good source of study.

Chapter XXII

1. Study *DeKruif's Microbe Hunters* for information on this point. See also *Broadhurst: How We Resist Disease*, J. B. Lippincott Co.

2. Information on this may be secured from a physician or the Board of Health.

3. Secure information on this from the *Red Cross Handbook.*

4. For this problem study *Doane's Insects and Disease*, Henry Holt and Co.

5. For this problem study *Herrick's Insects Injurious to the Household*, The Macmillan Company.

6. For this problem write to the *U. S. Department of Agriculture, Washington, D. C.*, asking for the booklet on this subject.

7. Study *Turner's The Nature of Fabrics*, D. Appleton and Co., to secure information on this problem.

8. *Herrick's Insects Injurious to the Household* will serve for this problem.

9. Confer with your Board of Health or your health officer in solving this problem.

10. Secure information on this problem from the same source as in **9** above.

Chapter XXIII

1. In this problem the source of mosquitoes is first determined. If it is a swamp, the town authorities should be consulted about the matter. If the source is rain barrels, a campaign to cover rain barrels may be begun; if it is the old cans in open lots, a clean-up campaign may be begun by your pupils. Engage the town authorities to help in this work. Your classes may be the means of stirring up public sentiment and of doing something of real value along this line in the community.

2. This problem may be solved by securing your town or city health code.

3. Visit the filtration plant and ask questions about its working. In lieu of this, have pupils consult with or write to the Water Board of your town or city concerning the points involved in this problem.

4. Test borax on the larvæ of flies or other insects. Note results and have pupils draw their own conclusions.

5. This is rather difficult unless done under the careful guidance of the teacher. If you will consult with your health officer or Board of Health, you will secure information as to how this work has been done and you may plan your little survey accordingly.

Chapter XXIV

1. Self-explanatory.

2. Observe the method in each animal, supplemented by a good text in zoölogy.

3. Geraniums, hydrangea, coleus, begonias, etc., are good plants for this work. Pots may be used in the school for this work if it is not convenient to do this work at home.

4. Self-explanatory. This problem may be made a very interesting one and one where careful observation counts. Large numbers of seeds of any one plant do not necessarily indicate that a large number of plants of this kind will grow in that locality the next year. Many factors enter in to cause difficulties in the growth of the plants from the many seeds. One of the pupils' problems will be to determine what some of these inhibiting factors are.

5. Self-explanatory. The average number of petals might be increased by subjecting the plant to very marked changes in its immediate environment or by crossing plants showing tendencies to change the number of petals. Breeders follow these very methods in producing new plants.

6. Self-explanatory. The comparison of extremes both ways, the poorest with your pupils' environment and the best with their environment will give the best results.

APPENDIX B

A STUDY OF MANUFACTURING AND PUBLIC SERVICE

A. A MANUFACTURING INDUSTRY

If you have great talents, industry will improve them; if moderate abilities, industry will supply their deficiencies. Nothing is denied to well-directed labor; nothing is ever to be obtained without it.

— *Sir Joshua Reynolds.*

1. Man's Natural and Artificial Environments

1. Our Two Environments. — In Parts I and II of their study of Environmental Science your pupils learned something of the factors of their environment which are essential to their life and existence. Air, water, heat, and other factors make up their *natural environment.* But in almost every chapter they saw how the ingenuity of man had been able to use these factors to lighten his labor or add to his comfort, as in his use of compressed air, the pump, the steam-heating plant, the electric light, the turbine, the steam engine, and the electric motor.

All these things which help to make up man's *artificial environment* are man-made, and primitive men knew absolutely nothing about them. A little thought will show that most of these artificial factors are to be seen within the walls of buildings. The question naturally arises: Where did all these factors come from? Where were they made? Out of what were they made? By whom were they made?

2. Some Typical Manufacturing Industries

2. Some Manufacturing Industries. — It is impossible to place before your pupils a complete list of all the present-day industries which work up raw materials into finished products. There are over fifty industries in this country using wood alone as their basic material. Some of the industries named below will be found in your town or city or very near you. It is suggested that your class make a study of them. The more important examples of manufacturing industries are:

1. Iron and Steel Industry (blast furnaces, steel plants, foundries, pipe factories, plate mills).

2. Steel Products Industries (boiler factories, steam and gas engine factories, car shops, drop forgings, tool and instrument factories, farm machinery shops).

3. Wood Products Industries (saw mills, box factories, pulp mills, furniture factories, wooden utensil factories, sash and blind mills, cabinet and book-case factories, paper mills).

4. Fabric Products Industries (cotton and woolen mills).

5. Animal Products Industries (meat packing, leather products, shoe factories, fur clothing factories).

6. Stone Products Industries (quarrying, monument works, artificial stone, cement, bricks, terra cotta, tiling).

7. Food Products Industries (canned meats, vegetables, and fruits, bread and cake factories, breakfast food factories, cheese and milk factories, relish and pickle factories).

3. The Study of a Manufacturing Industry

3. How to Make a Special Study of a Particular Industry. — Having selected one or more industries which are found in your town or city, try to arrange a visit to them. Have the pupils, by observations and questions, find out the things indicated below and make a full report to the class of what they learn. Mimeographed sheets of such parts as you desire to use of the material below may be placed in the hands of the pupils for special study.

A. Principal Products. Find out what these are and determine (1) whether they are raw or finished, (2) what their exact composition is, and (3) what their principal use is. You will need to ask questions to determine these answers.

B. Materials Used. Find the receiving room or the place where the materials of manufacture come in. Note (1) whether these materials are raw or manufactured, (2) what their sources are, (3) how they are prepared for use in this factory, and (4) how they are brought here.

C. In this factory determine (1) the power used, and (2) by reference to the chapter on Industry give details of the apparatus for using water, steam, or electrical power. (3) Be able to explain the principle of each in a clear and connected manner and (4) show just how the energy released or the power developed is applied to the special machinery in this factory. (5) Keep in mind at all times the transformation of energy and show how it is applied in every step from the source of power to its final use. Finally, (6) be able to describe the special machines for doing special work in this factory and be able to tell how they do their work.

D. Find out from the foreman or proprietor (1) how much of his product is sold, (2) where most of it is sold, and (3) for what purpose.

E. (1) Discover what the waste products of this factory are; (2) determine if they are of value, and (3) whether they are utilized in any way or simply wasted. If of no value, (4) determine how they are disposed of, and if of value, (5) how the product is used. (6) If wasted, try to discover and suggest a use for this waste.

F. Determine from your own observations and by conference with others the reasons for the location of this industry (1) in your town and (2) in the particular spot in the town where you find it.

G. Determine (1) how much this factory is dependent upon natural resources or products of your community or vicinity and (2) how its removal or closing down would affect your community.

H. Next, determine (1) if any chemicals are used in this industry, and if so, what are used, (2) how and why they are used, and (3) what is the result of using them. Next, determine (4) what laws of matter are specially used in this industry, such as gravity, friction, inertia, and heat in expanding or cold in contracting matter, (5) how motion is obtained and controlled by levers, pulleys, and other machines, and (6) whether water is used to buoy or float matter and whether air is used to move it.

I. Finally, determine (1) what relation living things, other than man himself, have with the manufacturing process (such as bacteria, yeasts, molds, and plant and animal parts) and (2) just how they are related. Determine (3) if these living things or their parts are essential to the industry and (4) why they are essential.

If it happens that you make a study of a manufacture which contributes to the building industry, it will be well for you to make (1) a special study of the methods which are peculiar to this particular industry (glass making, brick making, cement making, and the like). (2) Emphasis may also be placed on the kinds of machines used in handling the raw and finished products. A study of Chapter XII Special Problems will aid the pupils here.

If your study of an industry should include a food-producing factory, it will be well to pay (1) particular attention to the manner in which the raw foods are secured and cared for before being treated; (2) what changes take place in the food during its preparation; (3) the processes used in its preparation, and (4) the methods of protecting the finished product from dirt and spoiling during its storage and distribution to the consumer.

4. Special Study of a Primary Industry. — Your geographical location may make it advisable for you to take up the study of a primary [1] industry, especially if you live on or near a coast where fishing is the chief occupation; in a western state where large ranches make herding an important industry; in a state where mining is important because of the abundance of minerals, or in the center of a rich agricultural region. The following outline is phrased for the use of the pupils. Here again mimeographed copies may be prepared and placed in the hands of the pupils. Or make the outline a dictation exercise.

Fishing, herding, mining, and similar industries

1. Principal Products.
   (*a*) This means a listing of the chief products of the industry and includes any by-products. (*b*) Observe whether they are raw or finished, (*c*) note their composition, and (*d*) carefully determine all the uses to which they are put.
2. The Materials Needed.
   (*a*) Carefully note and list all raw and manufactured materials used in this industry, (*b*) find out the manner of their preparation for use in this industry, (*c*) where they are obtained, and (*d*) how they are brought to the place where they are used.

[1] A primary industry is one which depends upon our natural environment; a secondary, depends on our artificial environment.

3. The Power Used.
   (*a*) Note the kinds of power used (for generally more than one kind is needed). When this is determined, (*b*) carefully study the construction of the machines for generating this power. This information may be gained by observing the machines in action and then making a study of the type presented in Chapter XII. (*c*) Determine just how the power is applied at the place where it is needed and (*d*) how energy is transformed in the process.
4. (*a*) Next in importance is the study of how and where the product of this industry is marketed. (*b*) A study of the way the wastes are utilized or disposed of is important because of the importance of economizing our natural resources. (*c*) The dependence of the industry upon natural resources is plain, but there are ways in which chemicals and living things are used in the industry which make it of particular interest. These should be carefully observed.
5. Finally, make a careful study of the ways in which air, water, heat, and light are used in the industry, particularly in connection with the action of the laws which control matter (inertia, gravity, friction).

5. How to Make a Study of Agriculture. — Since the tilling of the soil is perhaps the fundamental industry of the country, special study ought to convince every pupil of his complete dependence upon it. For this reason any study of this industry should be made by observations at first hand, aided by the study of Chapter XIX on Agriculture. Next, it will be best to follow in detail the ten points outlined in section 3 under *H* and *I*. (*a*) The physical laws of matter most important in farming are friction, inertia, gravity. (*b*) Simple and compound machines are used as tools and farm machinery. (*c*) Chemical laws are evident in the composition of fertilizers and manures and (*d*) in the changes taking place in them. (*e*) Biological laws govern the souring of milk and cream, the making of butter, cheese, and other things of food value.

(*a*) The importance of the green plant and its functions, Chapter XVI; (*b*) the structure and functions of the flower, Chapter XXIV; and (*c*) the improvement of plants and animals, Chapter XXIV, should all be called upon to contribute their share to this study. The study of food production (Chapters XVI and XVII) is the most important in the whole study of Environmental Science. Have your pupils

Remember that:

1. Our artificial environment has produced a demand for thousands of things which make up our everyday lives and this has resulted in the development of many small and special industries.
2. Some industries are fundamental or primary and will always be important because they satisfy needs common to all of us.
3. The most important fundamental industry is agriculture.
4. All fundamental industries contribute directly to our need of food, clothing, and shelter.
5. All special industries produce non-essentials and luxuries.

B. A PUBLIC SERVICE UTILITY

I'm the worker! Night and day
Without food or drink or pay
Thro' the sunshine and the storm,
Winter cold and summer warm,
At the midnight's stillest time,
And the morning's earliest chime,
My hands are ever busy found—
Days and years—a ceaseless round—
I am Service. —*Macaulay.*

1. The Meaning of Public Service

6. The Importance of Public Service. — The growth of large towns and cities was made possible by the development of the steam engine as applied to the steamship and the locomotive. Enormous quantities of raw materials could thus be brought to these cities. The more raw material brought in, the more factories were built. The more factories built, the more people came to live in these cities. If these cities were near waterfalls, companies built dams and erected power houses to generate power to furnish motion to the factory machines. As the population grew, water companies were formed to tap lakes at a distance or to build reservoirs from which to pipe pure water to the inhabitants. Lighting companies were formed to generate electricity and run wires to every home. Telephone companies were organized to build central telephone plants, wire the houses, and connect all who wished with a direct and convenient method of conversing.

2. The Study of a Public Utility

7. How to Make a Special Study of a Particular Public Utility. — Select one or more public utilities in your town or vicinity and arrange to have your pupils visit them. Let them ask for information along the following lines. Mimeograph or dictate the directions.

A. Determine why this utility was situated where you find it. What were the special needs of the community which caused the company to be formed to render the service given?

B. Learn all you can concerning the beginning of the utility. Find out the successive steps in its development over a period of years down to the present time. Pictures may be secured to aid you in showing this.

C. Determine the kind of power used in running the utility.

Discover how and where this power is developed and what fuel, if any, is used.

Make a study of the power plant and give some interesting and valuable facts about it to your class in your report.

D. Find out what problems, if any, the company had to face in constructing the plant, railroad, or whatever the utility may be. Find out just how these problems were solved and when they were solved. Determine if any improvements in the solutions of the problems have been made recently.

E. Determine the nature of the products transported, especially if the utility is a trolley, truck line, or railroad.

F. Discover how the utility you study is dependent upon the natural environment of your town (as a mountainous stream used to generate electric power).

G. Do the natural resources of your vicinity make the commodity furnished the community cheaper than in other regions? Investigate this point fully.

H. Give special attention to the science of the industry. If you study a gas company, for example, find out exactly what chemical action happens in the coal as it is changed to gas. If it is a telephone company, be able to tell just how the physical laws work which control the carrying of electrical power from one place to another. If it is a study of an air transportation company, discover just what natural laws must be considered by the aviators while flying.

8. Other Important Factors in the Study of a Public Utility. — (1) In the investigation of a transportation utility you should have the pupils fully work out, as a background study, the early history of transportation on land, water, or in the air, as the case may be. This will lead to the importance and value of the present-day utility chosen for study. Help the pupils find out the names of the men who have contributed most to the development of the utility up to the present time and determine what each contributed.

Next have the pupils report to the class the working principle of the automobile or of the steam engine, with special emphasis upon energy transformation, if you are studying the locomotive or truck. Finally, if you are studying a trolley line, be able to explain just how the car is built to be driven by electricity.

In addition, report on the construction of the roadbed, the trolley lines and poles, bridges, and the like. Make clear the methods by which friction is reduced and safety in travel is secured.

(2) In a study of communication you have an excellent chance to make plain the early history of the utility, with special reference to Morse and Bell. Explain fully with the aid of drawings the principle of the electromagnet. A demonstration of its principle before the class would be an excellent plan. If you select the telephone for study, explain the principle of it to the class so that they will understand it, but remember that you must understand it yourself before you can make them do so. In explaining both the telephone and the telegraph it will be well for you to have some simple apparatus to aid you in your work.

(3) In the observation of a light and power utility require a special observation of the source of the power and how it was obtained. The way in which the power of the water

is utilized to cause mechanical motion in the turbine must be made clear. This is best done by drawings on the board.

Next show clearly just how electrical energy is generated in the power house. This means that you must understand just how a simple electric generator works. This should be demonstrated before the class. Follow this by showing just how the electrical energy is transmitted to your town or city from the power plant and how it is used as light, heat, and power in the home or factory or trolley car.

If you can secure two small motors, hitch them up, using one as a generator. Thus you can show before the class how electricity is generated. Determine also, if possible, the fall of water, its velocity, the amount falling on the turbines, the velocity of the turbines, the horse power generated by each turbine, the volts sent from the power house and how far they are " stepped " up and down for use in your town or city and how this is done. Have your pupils

Remember that:

1. Many industries manufacture no material product (to be eaten or worn), but give service by providing light, heat, water, power, transportation, etc., in wholesale quantities.
2. Most public utilities use the chief factors of our environment (air, water, heat, light, electricity) in their work.
3. All service industries depend upon the fundamental or primary industries for the materials which they use.
4. All primary industries depend upon natural resources for their materials.
5. Most public utilities furnish service at a cost far below that for which the individual could produce the same service.

APPENDIX C

Below are listed all of the pieces of apparatus and materials actually needed to perform all of the (*Key*) *Demonstrations* in the text together with those needed to cover all of the suggested experiments. Without the more expensive pieces of apparatus which are starred and which may be omitted from the list as being not absolutely essential to the completion of the experiments with which they are connected, the total cost of the materials in both lists should not exceed the sum of $25.00.

Most of the materials here listed, outside of the chemicals, may be picked up here and there by the pupils themselves. On this basis $10 to $15 should cover cost of the essential apparatus for all experiments. Once the materials are assembled they will last indefinitely.

Agar-agar, 6 oz.
Alarm clock
Alcohol, wood, 1 qt.
ammonia, 6 oz.
bandaging, 1 roll 1″
barometer tube, 30″
battery jars, 6 each 6″ × 8″
beam balance, 8″
bell jar, 10″ × 14″ open at top
borax, 1 package
bottles, wide-mouthed, 4 6 oz., 4 8 oz.
box, wooden starch
camera, small bellows
candles, 1 pound of
cans, several empty vegetable
cardboard, heavy sheets
clamps, 2 or 3 iron
cloth, cotton, 1 yd.
cover glasses, ½ oz.
* ear model
ether, small can
exhaust pump, 1
Fehling's solution, 8 oz.
filter paper, 12 sheets, 6″ in diameter
flask, Florence, 1 of 1000 c.c.; 2 of 500 c.c. capacity.
flatiron, 1 old-fashioned
funnels, 3 with 6″ stem
glass tubing,
  $\frac{3}{16}$″ bore, 2 lbs.
  $\frac{3}{8}$″ bore, 3 lbs.
  1″ bore, 3 feet
gauze, wire, 2 sheets
glass plates, 3, 4″ × 5″ in diameter
hydrangea plant, potted, 1
hydrochloric acid, 1 lb.
ink, red, 1 bottle
iron filings, 6 oz.
iodine solution, 3 oz.
lens, 1 hand
limewater, 1 pint
* Magdeburg hemispheres, 1 set
manganese dioxide, 1 lb.
medicine droppers, 2 or 3
mercury, 2 lbs.

model glass pump, 1.
* microscope, compound, 1
muslin cloth, 1 yd.
needles, dissecting, 2
nitric acid, 6 oz.
palm glass, 1
paper, black, 1 sheet
paramecium culture, 1
Petri dishes, 6
platform balance, 1
phosphorus, 3 oz.
pinch cocks, 4
porcelain dish, evaporating, 3″ diameter
potassium chlorate, 1 lb.
pump, glass model force, 1
ring stand, iron with rings, 1
rubber sheeting, 6 oz.
rubber stoppers, various sizes, 1 dozen in all, some with 1 hole, some with 2 holes, and some with 3 holes
rubber tubing, $\frac{1}{4}$″ bore, 10 feet
seeds, bean and pea, 1 packet each
sawdust, 2 oz.
slides, glass, 12
soap, 1 bar
sugar, grape (glucose), 6 oz.
sulphur, 6 oz.
test tubes, 12,
8 each 6″ × $\frac{5}{8}$″
4 each 8″ × 1″
thermometer, dry and wet, 1
thermometer, Fahrenheit
thistle tubes, 2
tuning fork, 1
varnish can, 2-quart
yardstick, 1

The materials listed below include all those used in the suggested experiments which are not duplicated by those found in the foregoing list.

ammonium chloride, 6 oz.
asbestos sheets, 2 each 12″ × 16″
ball, wooden, 1
rubber, 1
balance, spring
balloons, toy, 4
beakers, 6 each 500 c.c.
bell, electric, 1
binding posts, brass, 2
bladder, foot-ball, 1
blow pipe, 1
bolts, machine, with nuts, two, 6″ and one 4″ long
boxes, cigar, 3
brackets, porcelain wire, 12
brass rod, $\frac{1}{4}$″, 1
burner, Welsbach and mantle, 1
bulb, incandescent electric, 30 watts, 1; 15 watts, 1
bucket, overflow (latch), 1
can, overflow, 1
clay soil, 1 lb.
collodion, 6 oz.
charcoal, willow, 2 oz.
copper rod, $\frac{1}{4}$″, 1 foot long
copper sulphate, 1 lb.
copper strips, 2, 2″ × 6″
corks, flat, 6
dish, shallow, glass or tin, 2
dish, deep, glass, 1 (to be secured when needed)
dry cells, 4 (to be secured when needed)
dry cell, 1 old
flasks, Erlenmeyer, 3, 500 c.c.
flowers, tulip (one for each two pupils), gladiolus (one for each two pupils)

fuses, 15 ampere cartridge, 2
 15 ampere plug, 2
fuse block, cartridge, 1
 plug, 1
graduate, glass, 2, 1000 c.c.
glass, window, several pieces
humus soil, 1 lb.
iron rod, $\frac{1}{4}''$, one foot long
joss sticks, several
lamp chimney, common, 1
lamp sockets, 2
lead ore, 1 lb.
lead oxide, 3 oz.
lead, sheet, 1 piece, $6'' \times 6''$ square
lenses, convex, 1
 concave, 1 bi-concave, 1
magnet, horseshoe, 1
magnifying glass, small, 1
membrane, animal, 1 small piece
mosquito eggs and larvæ
needle, knitting, 1
oil, crude, 6 oz.
paraffin, $\frac{1}{2}$ lb.
pipette, glass, 50 c.c., 1
pliers, 1 pair
pot, coffee, 1
pump, bicycle, 1
putty, 3 oz.
radiometer, 1
sandpaper, No. 1, 1 sheet
salt, 1 small bag
sand, 1 lb.
screw eyes, $\frac{3}{4}''$ eyes, 6
sodium nitrite, 6 oz.
solder, soft, 6 oz.
spoon, iron, 1
sulphuric acid, 6 oz.
switches, flush, 1
 knife, 1
 snap, 1
* telephone receiver, 1
tin, sheet, 8″ square, 1 sheet
tinfoil, several small pieces
tumblers, glass, 6
vaseline, 1 small tube
windmill, toy, 1
water wheel, toy, 1
wire, copper insulated, No. 18, 10 feet
 copper insulated, No. 24, 10 feet
 fuse wire, 4-ampere, 1 foot
 German silver (No. 30) or nichrome resistance (No. 30), 10 feet
wooden block, weighted to fit overflow can, 1

APPENDIX D

TEACHERS' BOOK LISTS

Babcock and Clausen: Genetics in Relation to Agriculture, McGraw-Hill.

Berry: Teaching Agriculture, World Book Co.

Brigham: Geographic Influence in American History, Ginn.

Buller: Essays on Wheat, Macmillan.

Carrier: The Beginnings of Agriculture in America, McGraw-Hill.

Chamberlain: Origin of the Earth, University of Chicago Press.

East: Mankind at the Crossroads, Scribner's.

East and Jones: Inbreeding and Outbreeding; Their Genetic and Sociological Significance, Lippincott.

Farrington: Gems and Gem Minerals, A. W. Mumford.

Frank: How to Teach General Science. P. Blakiston's Sons & Co.

Freeman: Visual Instruction, University of Chicago Press.

Harris and Butt: Scientific Research and Human Welfare, Macmillan.

Harrow: Glands in Health and Disease, Dutton.

Hayes: Breeding Crop Plants, McGraw-Hill.

Hodge: Nature Study and Life, Ginn.

Hopkins: Soil Fertility and Permanent Agriculture, Ginn.

Holmes: The Trend of the Race, Harcourt, Brace.

Howe: Chemistry in Industry, Chemical Foundation, N. Y.

Huntington: Civilization and Climate, Yale University Press.

Jones: Genetics, Wiley.

Jordan and Everman: American Food and Game Fish, Doubleday.

Lutz: Field Book of Insects, Putnam.

Mees: Fundamentals of Photography, Eastman Kodak Co.

Mills: Within the Atom, Van Nostrand.

Moulton: Introduction to Astronomy, Macmillan.

Newman: The Nature of the World and of Man, University of Chicago Press.

Noyes: Organic Chemistry, Holt.

Nystrom: Textiles, Appleton.

Oliver and Hottes: Plant Culture, A. T. DeLaMare Co.

Pucher: Perfumes and Cosmetics, Van Nostrand and Barrows.

Pearl: The Biology of Death, Lippincott.

Richards and Elliott: Chemistry of Cooking and Cleaning, Whitcomb.
Rogers: Manual of Industrial Chemistry, Van Nostrand and Barrows.
Russell: A, B, C of Atoms, Dutton.
Sherman: Chemistry of Food and Nutrition, Macmillan.
Sherman: Food Products, Macmillan.
Slosson: Easy Lessons in Einstein, Harcourt, Brace.
Smith: The World's Food Resources, Holt.
Stoddard: The Rising Tide of Color, Scribner's.
Tancock: Astronomy, Elementary Descriptive, Oxford University Press.
Thompson: Population: A Study of Malthusianism, Columbia Press.
Twiss: Teaching of Science, Houghton.
Weatherwax: The Story of the Maize Plant, University of Chicago Press.
White: Principles of Floriculture, Macmillan.
Wiggam: The New Decalogue of Science, Bobbs-Merrill.
Wiggam: The Fruit of the Family Tree, Bobbs-Merrill.
Woodhull: Teaching of Science, Macmillan.
Vallery-Radot: The Life of Pasteur, Doubleday.