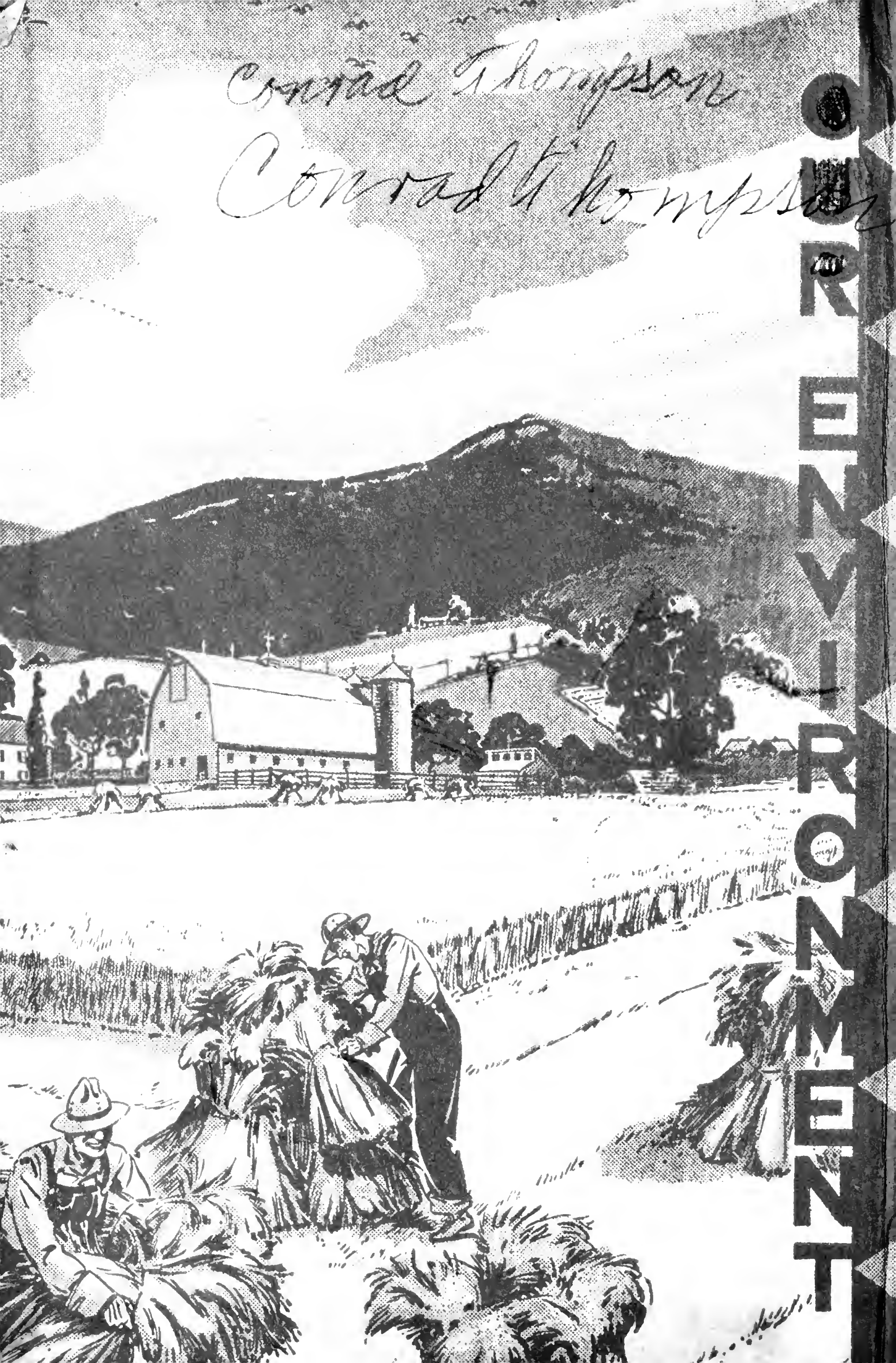
OUR ENVIRONMENT

ITS RELATION TO US

CARPENTER AND WOOD


Conrad Thompson
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OUR ENVIRONMENT

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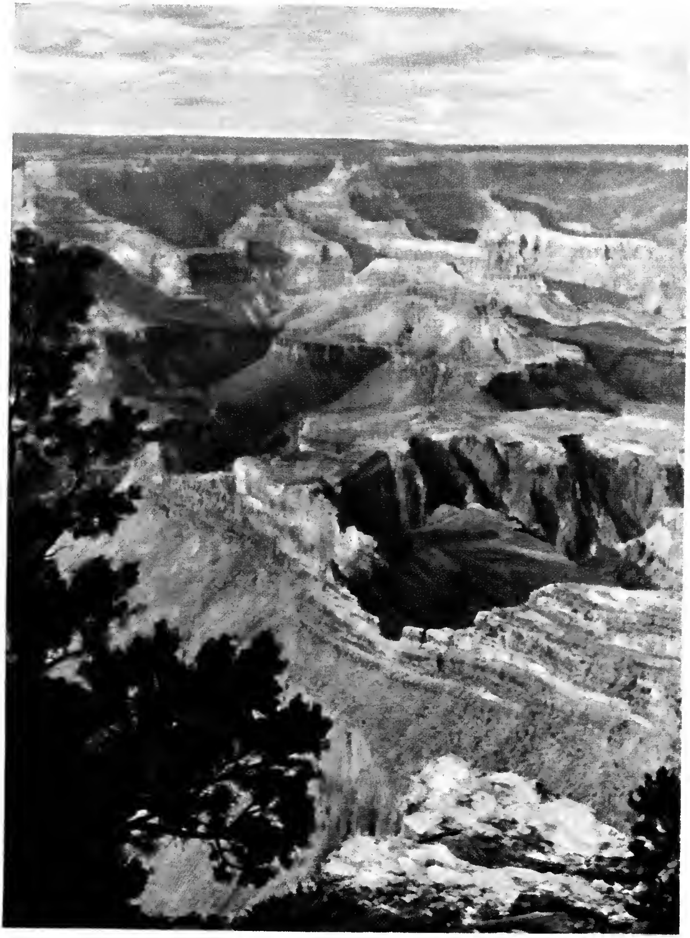

Grand Canyon of the Colorado

A tower'd citadel, a pendant rock,
A forked mountain, or blue promontory
With trees upon 't, that nod unto the world.
— Shakespeare

Modern Science Series for Junior High Schools
EDITED BY JAMES M. GLASS

BOOK I

OUR ENVIRONMENT

ITS RELATION TO US

BY

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NEW EDITION

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PREFACE

The Modern Science Series for Junior High School grades is the coördinating series between Elementary School science and the specialized sciences of the upper high school. This volume of the Modern Science Series is so organized that it may be used independently as an effective introduction to science, as well as the first-year member of the integrated series for the junior high grades.

The book is organized into a small number of related **units.** Each unit presents a unified picture and understanding of some significant phase of the pupil's environment. Each unit is developed through a series of interdependent **topics,** each topic representing a sub-unit part of the unified whole.

Problem-solving abilities are cultivated by the **general problems** into which each topic is analyzed. Each general problem may include a number of **projects.** These projects may be handled by a whole class, a group selected by the class, or by an individual. The general problem belongs to the class as a whole.

The problem method involves, first, a realization of a significant problem by the pupil; and second, a background from which he can make his attack on the problem. To these ends, the pupil's natural, everyday experiences must be reënforced by carefully directed observational training. Not only must the work of the classroom comprehend these purposes, but their attainment should be advanced also by out-of-school contacts which will crystallize the habits of careful, accurate observation and judgment.

To encourage this observational work a **Science Discovery Calendar** is included in the appendix. From day to day the pupils are assigned definite observations upon which to make a report. They thus become appreciatively aware of their surroundings and thoughtful concerning them. At the immediate moment, this observational work is not necessarily a part of the lesson. "It is an opportunity [to use one pupil's expression] for finding out things without having to study them." By the same means, the pupils are also equipped with a fund of new experiences which may later serve as a point of attack on some related problem.

Characterizing the presentation of each unit are the following special features:

1. Each unit of study is introduced by a brief *Look Ahead* into the subject matter and activities of the unit. This preview is intended to give the pupil a glimpse of his environment in a new light, inviting him to prepare for interesting adventures.

2. The material of each unit is developed as a number of related topics. The general problems of the topics lead to generalizations which provide a framework for the understanding and appreciation of the unit as a whole.

3. Each topic is introduced by a page of informal chat which serves as a motivating *survey* of the topic. This feature, together with the *Do You Know* questions, relates present experiences and knowledge to the new problems.

4. The extra-class activities of the Science Discovery Calendar are supplemented in several ways. Within each topic will be found *Field Research* problems,

Science Discovery Book *Projects,* and *Special Problems* which are graded to care for individual differences.

5. *Key Words* are found at the end of each topic. They offer a splendid background for review work. As an oral exercise, their exact meaning may be brought out in short sentences or paragraphs, thus supplying excellent drill in the formation of general concepts.

6. A group of *Key Statements* follows the Key Words in each topic. These sentences are generalizing statements and may be used for topical, oral, and written exercises, thus providing for the development of careful, exact expression.

7. A series of *Thought Questions* at the end of each topic test the ability of the pupil to apply his science to new situations.

8. The *Bibliography* has been selected with special regard for the interests of the pupils who will use this book.

9. *Experimental Problems* are numerous, and each is accompanied by the directions for performance of the related experiment. Certain experiments are labeled *Key Experimental Problems* because they are especially needed to provide for the understanding of the general problem. They focus discussion and develop scientific attitudes of mind. Reports of all Key Experiments should be entered in the pupil's Science Discovery Book. They should be used as individual pupil experiments or at least should be demonstrated to the class by pupils, when the size of the class and the equipment make this practical.

10. *Illustrations* have been selected in the belief that every picture should (1) increase interest in science, (2) amplify and interpret the text, (3) present a real

problem for study, and (4) be clear and easy to understand. Each picture carries an explanation with a series of questions which encourage close study of the picture and direct association of it with its context.

11. The carefully selected and prepared glossary will be found helpful by the pupil as an aid to clear definition and understanding.

12. A Key to Common Minerals will be found helpful to teachers and pupils desiring to identify some of the more common minerals.

Every effort has been made to keep the vocabulary and the phraseology as simple as possible. To that end scientific terms beyond the comprehension of the pupil have been omitted. The text is intensely cumulative, and transitions have been so carefully worked out that the pupil will be able to carry away from the year's work a clear concept of the interrelation of natural phenomena and their bearing upon his life.

H. A. C.
G. C. W.

ACKNOWLEDGMENTS

The authors are indebted to the general science teachers of Rochester, New York, for constructive criticisms of the text. They are especially grateful to Miss M. Elizabeth Tuttle for her work on the manuscript. Mr. William McK. Hutchinson reviewed the manuscript and accorded valuable help in the preparation of the Science Discovery Calendar. Mr. F. A. Newhall was a constant adviser in the development of the text.

The stratosphere pictures are used through the courtesy of the National Geographic Society. Mr. James F. Barker furnished the cloud pictures; Mr. Frank W. Byerly, mountain pictures; Professor H. L. Fairchild, pictures dealing with geology; Mr. William Rotmans, picture of *Amanita muscaria;* Mr. Lewis S. Edgarton, gymnasium picture; the late Mr. Clinton E. Kellogg, pictures of birds and wild flowers; Ward's Natural Science Establishment, trilobite and fossil dragonfly pictures. Mr. W. O. Kenyon and Mr. H. H. Miller provided drawings, and Mr. Edward M. Pickard helped with drawings of the structure of the earth and atmosphere.

The Bausch and Lomb Optical Company provided photo-micrographs and the picture of the microscope; "Eastman Classroom Film," charts on the tent caterpillar, codling moth, and white-marked tussock moth; the Great Northern Railway Company, the black and white photograph from which the frontispiece was made; the Rochester Department of Parks, tree pictures; and the United States Department of Agriculture, pictures on pages 130, 132, and 133.

These acknowledgments would be incomplete without a special word of appreciation for the counsel and coöperation of Dr. Herbert S. Weet, former superintendent of the Rochester Schools. His help made possible the opportunity and the equipment for the extensive experimentation by which this course in science was developed.

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OUR ENVIRONMENT

ITS RELATION TO US

A HOME LABORATORY

An aquarium discloses many interesting facts about life in water.

OUR ENVIRONMENT

ITS RELATION TO US

INTRODUCTION

1. Whys and Wherefores: —

"But, Jane, why do you keep that glass cover on the aquarium? Won't the fish suffocate? And why do you have those plants growing with the sand on the bottom? What —"

"Wait a minute, Betty. You are going too fast for me. Let me sprinkle a few crumbs of food on the water for the fish, and I'll try to answer your questions. We'll start with the cover. You see while the cover is on, the water does not evaporate so rapidly."

"What do you mean by evaporate, Jane?"

"When water changes from a liquid to a vapor or gas, it is called evaporation, and when that happens, the water leaves the aquarium and mixes with the air. The cover prevents that."

"Yes, but don't fish need air to breathe?"

"Of course they do. That's where the plants come in. During the day time, especially when the sun shines on them, they give out oxygen, which dissolves in the water. It is the oxygen of the air that animals, including fish, need for breathing. The plants supply that oxygen."

"Tell me, Jane, does the water in creeks and ponds where fish live naturally have air in it?"

"Oh, yes. You see there are many kinds of plants growing in streams and ponds, which give off oxygen just as these plants do. Then, too, when the water in the stream or pond is tossed up into little waves, it dissolves more air which has oxygen in it."

Wild Iris

Why do the plants and shrubs appear to grow better at the water's edge?

"I suppose you learned all this in science, Jane. I have to take science this year, and I have wondered what it is like. Do you like science, Jane?"

"Indeed I do, Betty. I've learned so many interesting things I never knew before."

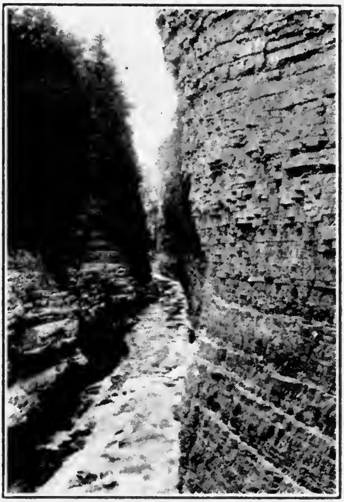
"What are some of them?"

"Well, I never knew before that rocks in layers, like those in our river gorge, were once just mud and sand on the bottom of an ocean, and at that time it was all ocean around here. But when we performed an experiment with a pickle bottle to find what happens when dirt settles in water, I saw that the dirt settled in layers, and I can imagine how they might be squeezed and hardened into layers of rock. Then, too, those rocks contain the most interesting remains or models of the queerest looking plants and animals you ever saw.

Our teacher says they are the result of ancient plants and animals, that lived along the shore of the ancient ocean, and in it. They must be millions of years old."

"Millions of years! My, that is old! If those rocks were once in the ocean, where is the ocean now, and how did that gorge happen to be right there, handy for the river?"

"As I understand it, Betty, this earth of ours is changing its shape a little all the time. Anyway, some places are sinking lower under the ocean, and some are rising out of the sea. I suppose that's what happened here. These rocks once were under water, and were pushed up out of the water sometime when the crust of the earth shifted, maybe like a big slow earthquake."



© *Ewing Galloway*

AUSABLE CHASM

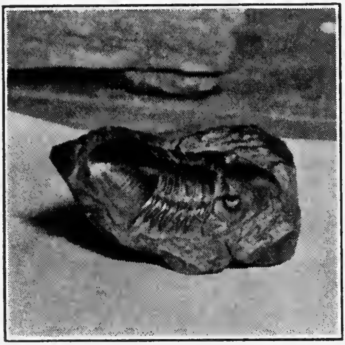
How does this picture illustrate Jane's story?

"Still, I don't understand about how that deep gorge appeared so conveniently for the water to flow through, Jane."

"Did you ever see water during a hard rain wash out small gullies in a new-made lawn? Of course you have. Well, that is just what happened to form that gorge, only the rock is hard, and thousands of years have been required for the water to wear away all that rock."

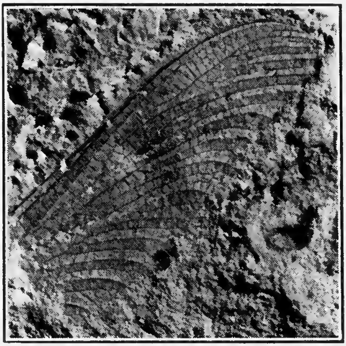
"Well, Jane, I certainly think I shall like science. I know there are a lot of things I want to find out."

2. Fun in Facts. — You are going to find out about things that are right around you — things which you see every day — old friends with whom you are familiar. You will learn something new about other old friends such as air, light, heat, land, and water, friends whom you think you know, but who will be presented to you in an entirely new light.



A Fossil Trilobite

The trilobite lived in salt water. If you found one in the rocks, what would it prove?



A Fossil Dragonfly Wing

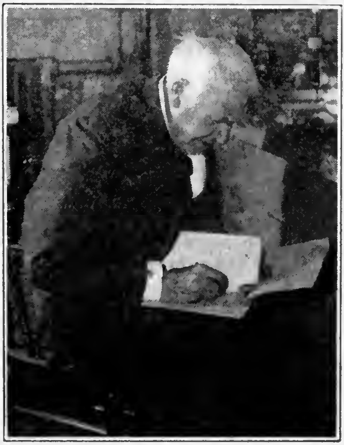
This ancient dragonfly had a wing spread of five inches. How does this compare with a modern dragonfly?

3. Successful Scientists. — Through all the ages of man the spirit of discovery has urged him on. He gets an idea from some act of Nature, — and puzzles, experiments, and works with the idea until discovery results.

Edison had an idea passed on to him from Benjamin Franklin. What a host of discoveries have resulted, — the electric-light bulb, the phonograph, the motion-picture machine, and others too numerous to mention here.

Louis Pasteur had an idea and his discovery has prevented much sickness and death. The *pasteurized* milk which you drink is freed from disease germs because of Pasteur's experiments.

Samuel Morse, Alexander Bell, Eli Whitney, Robert Fulton, the Wright brothers, and many other level-headed, clear-thinking, and hard-working people have listened to Nature's suggestions of ideas and thus made wonderful discoveries for the benefit of mankind.



THOMAS EDISON

Mr. Edison faithfully recorded the results of his experiments.

4. How to Know. — The scientist's plan for studying Nature is a good one to follow. Here it is.

1. Use present knowledge to gain more.
2. Check up on facts with the five senses plus common sense.
3. Learn the laws according to which Nature works, and test them by experiment.
4. Record the results of your observations and experiments.

With your Science Discovery Book, this text-book, your teachers and classmates, and Nature's help, you too are on the road to discoveries. Good luck to you!

YOUR SCIENCE DISCOVERY BOOK

When a scientist learns a fact, he writes it down in a notebook for future reference. So, too, you should have a notebook to record what you observe and what you think about your observations.

Admiral Peary carried with him on his trip to the North Pole a Science Discovery Book in which he recorded the important and interesting facts of his trip. When he returned, his records proved that he had actually reached the North Pole. Rear Admiral Byrd also kept records of his airplane trips to the North and South Poles. In the same way you will need to keep a record of your new discoveries. Your Science Discovery Book should be a true record of facts that you find out for yourself and your opinion about these facts.

In your science classes and at home you will experiment with apparatus and chemicals. The discoveries which you make in performing these experiments should also be recorded in your Science Discovery Book. That your record may be complete, you should tell " what you do " and exactly " what happens." What you find out is *your discovery*.

In the Appendix you will find a *Science Discovery Calendar* with directions for its use. Each week plan to make some of the observations called for in this calendar and record them carefully in your Science Discovery Book.

Your own discoveries, your reasons for " what you do " and " what happens," your opinions about the facts, and your own scientific method will make your Science Discovery Book.

UNIT I. WATER

LOOKING AHEAD INTO UNIT I

WATER is one of the strangest of all substances, and yet it is almost the commonest. It is everywhere about us; in the air, in the earth, in plants, in animals, in ourselves.

Here, it takes the form of a delicious cool drink, or a thunderous wave, or a downpour of rain; there, a seething flood or a gentle inviting stream. Sometimes it is ice to cool our tea, or snow on a mountain top. Again it takes the form of powerful steam to drive our engines of industry.

Water is at once a foe and a friend of man. Since the beginning of the earth, water has been constantly destroying here, and building there. It tears down hills, it builds fertile valleys; mountains yield to its action, and great valleys are buried.

By reason of the forces of nature, the water of the world is used over and over again. Upon this water cycle, — the never-ceasing exchange of water between earth and cloud, and cloud and earth, — life itself is dependent.

SURVEY OF TOPIC I

H. Armstrong Roberts

How many interesting things about Water and Its Ways you have experienced! Of course you know that about three fourths of the earth's surface is covered with water; you have seen water fall from the sky as rain, or snow, or hail; but do you know all the ways by which water gets into the air and what happens to send it back to earth again; or why there are so many lakes, rivers, and oceans; or how animals can live in ponds and streams?

This topic will not only help you to recall experiences you have had with Water and Its Ways, but it will help to explain those experiences and direct you to new experiences.

These new experiences will be the result of your investigation of important problems. Whatever you already know about water must be used as an aid in solving these new problems, as well as in working out experiments in the laboratory or at home, and making observations out of doors.

TOPIC I

WATER AND ITS WAYS

And he showed me a pure river of water of life, clear as crystal.
— REVELATION

Do you know:

1. How much of the earth's surface is covered with water?

2. Of some animals which make water their home and how they are fitted to live in such a home?

3. Of any living thing which can get along without water?

4. How the water gets up into the sky to form rain clouds?

5. How to freeze water?

GENERAL PROBLEM 1. WHERE AND WHAT IS WATER?

5. "Water, Water Everywhere." — Water, like air, is all about us. We find it not only on the surface of the earth, but in and above the earth as well. Have you ever watched water bubble forth from a spring? Or have you stopped to consider that the clouds sailing in the sky are really water which may fall to the earth as rain? Water is present in all living things. Many foods contain water. Without water life could not exist.

Can you think of any living thing which does not depend on water for its life? Name six or more ways in which you use water.

When we see or hear the word *water*, most of us think of a colorless *liquid*, "clear as crystal." But water is not always in the form of a liquid. Ice, hail, and similar words tell us that water is frequently a *solid.* Steam, fog, cloud, and mist suggest that at other times it is a *gas.* When water assumes the form of a gas, it is called *water vapor* and is invisible. If this gas is cooled, it changes back to the liquid form of water.

THE WAYS OF WATER IN WINTER
What two forms of water can you see?

In doing this, it may assume any of the several forms just mentioned.

There are certain words in our language which are the direct result of water, — words like *snow, skate, boat,* and *wash.* Perhaps your teacher may allow you to have a contest to see who can prepare the longest list of such words. Compound words, like *water-power,* are not to be included. Two pupils with high marks in their English classes would make good judges.

GENERAL PROBLEM 2. IS WATER NECESSARY TO LIFE?

6. A Faithful Servant. — Water is a great worker and performs many kinds of tasks. It cleanses and purifies, carries boats, turns wheels, fights fires, helps miners, and makes a comfortable home for many animals and plants. Perhaps its most important service is as a beverage, lack of which would make life impossible.

7. Water as a Home. — Mosquitoes and frogs are hatched from eggs which have been laid in water and their young spend their early days in water. Still other living things, like fish and water-lilies, cannot live except in water. They have special parts or structures which adapt (fit) them to their surroundings. A fish breathes with gills instead of lungs and has fins to help it move. Its body is shaped so that it slips easily through the water. The water-lily has little air sacs (bags) in its stem and leaves. These air sacs act like water-wings to hold the plant up in an erect position in the water. Such peculiarities of structure in an animal or plant are called *adaptations* and any special structure which fits a plant or animal to live in certain surroundings is an adaptation to the surroundings, to the *environment*, of that particular plant or animal.

Baby Loons

The loon builds its nest at the edge of the water because it cannot walk easily on land.

What special structures have you that enable you to live in the air?

There are many shore animals and plants that thrive best, if their homes are near the water. Muskrats, ducks, geese, darning-needles (dragonflies), willow and alder trees, all belong in this class.

A Baby Loon Takes His First Swim
What keeps the pond lily leaves afloat?

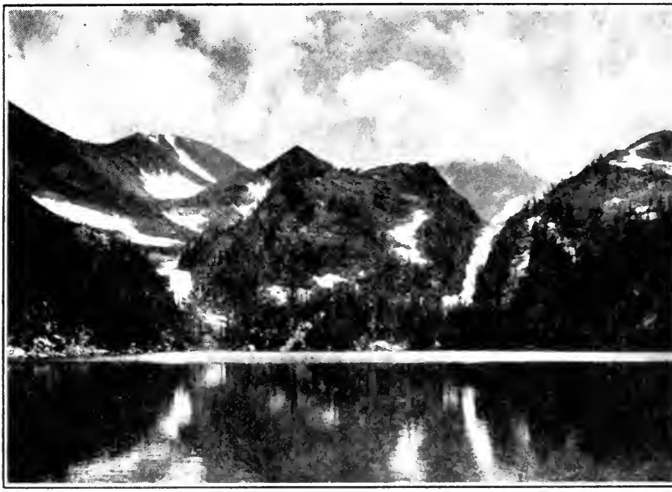
Field Research:

Locate a balanced aquarium (an aquarium in which both plants and animals are living) and make a careful study of the life going on in the jar or bowl. Note especially the fish, observing particularly the difference in form and use of its various fins. Watch also the movement of its mouth and gills. Like other animals, a fish must have air in order to live. We shall see in Experiment 10 that water contains air. The gills of the fish are the structures which make it possible for the fish to get its air from the water.

General Problem 3. What Is the Water Cycle?

8. Water Ways. — When you sprinkle water from a hose or sprinkling can on a pile of dirt, miniature hills, valleys, streams, and pools form in the dirt. In the same way rain and melting snows form streams and lakes on the earth's surface. Some of the water soaks into the soil and may appear later at some other portion of the earth's surface as a *spring*.

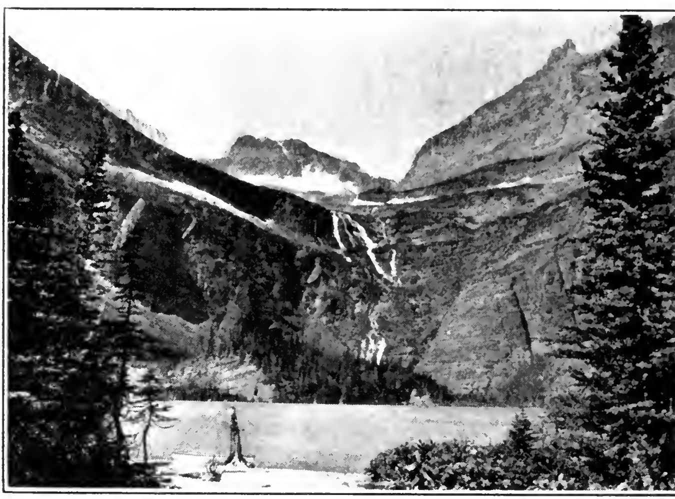
Most of the water which appears on the earth's surface comes there from the clouds. But the clouds are formed from water which *evaporates* from this same surface. Plants and animals also give off much moisture into the air. This constant give and take between



Courtesy Northern Pacific Railway

CLOUDS AND MOUNTAINS

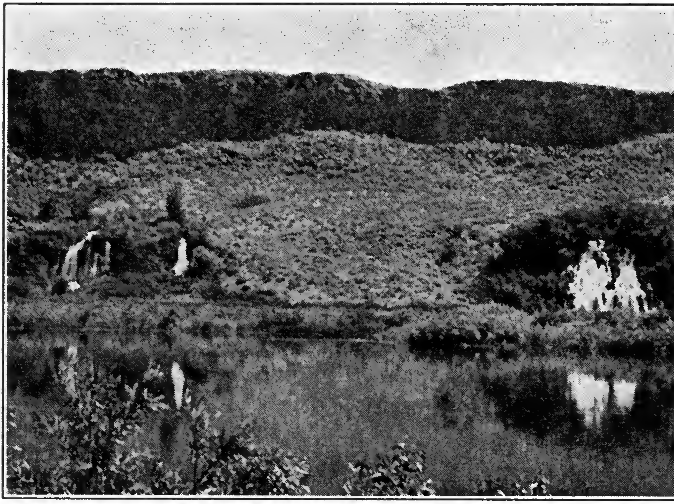
What is the relation between clouds and mountains and the water cycle ?



Hileman

GRINNELL LAKE

What part of the water cycle is illustrated by this picture ?



SPRINGS

The black layer in the background is volcanic rock. Where does the water forming these springs come from?

earth and sky can be clearly illustrated if we perform the following experiments.

Experimental Problem 1. — *How do plants give off moisture?*

What to use: A small potted plant, waterproof cloth, or cellophane, or sheet rubber, a jar that will fit down over the potted plant, a plate of glass or other flat surface.

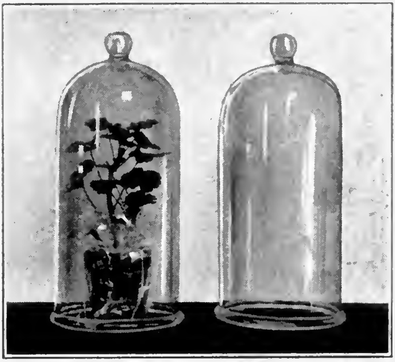
What to do: Water the plant thoroughly and then wrap the pot and all but the top of the plant in the waterproof cloth so that the only outlet for moisture from the pot will be through the stem and leaves of the plant.

Set the pot on the plate and cover with the dry jar. Set the apparatus where it will not be disturbed and observe from time to time for a few hours or a day.

What happens: 1. Does moisture form on the inside of the jar? 2. If so, where did it come from? 3. How did it escape from the pot? To prove that the moisture came from the plant and not from the air in the jar, you might set a dry jar of air beside the jar that covers the plant. 4. If no moisture appears in the dry jar, where must the moisture in the other jar come from?

Conclusion: Does water escape from a plant through its leaves and how can you prove your answer?

Application: All green leaves, such as grass, leaves of trees, shrubs, plants, give off moisture into the air. In a season the grass of an ordinary city lawn gives off approximately one thousand to fifteen hundred pounds of water. Of course the moisture given off by plants must all be taken from the soil by the roots and passed up through the stem to the leaves. (See diagram, page 17.)



EXPERIMENT 1

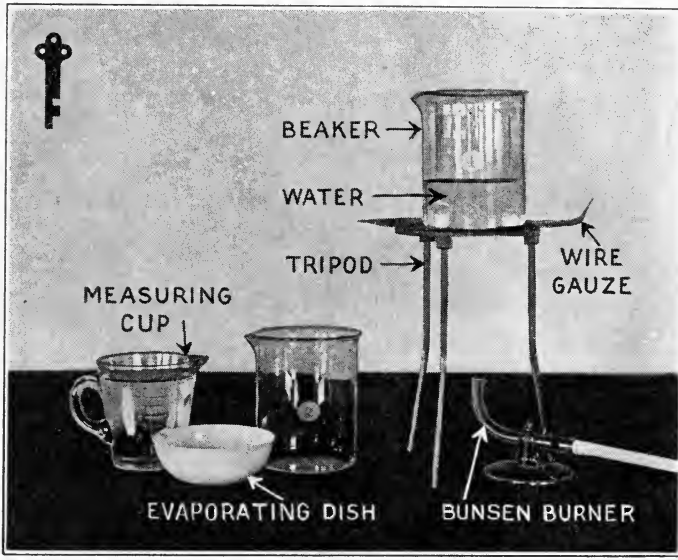
Why is the empty jar used in the experiment?

(Key) Experimental Problem 2. — ***What causes water to evaporate?***

What to use: A Bunsen burner; two basins or beakers; a porcelain or glass dish; a measuring cup; wire gauze; and an iron tripod.

What to do: Place a pint of water in a basin. Heat it slowly to the boiling point and watch closely for the first few bubbles. Keep it boiling for 15 minutes. While it is boiling hold a cold dish over it for a moment. At the end of the 15 minutes measure the water left in the dish. Set another dish of measured water in the sun. Next day observe what happened to it.

What happens: 1. When you started heating the water, where did bubbles form first? 2. Do you think that these first bubbles were air bubbles or steam bubbles? 3. Explain your idea. 4. What collected on the cold dish? 5. How do you know? 6. You measured the water remaining in each dish to find out how much water was given off as a result of the experiment. Which dish lost more water? 7. Where did the latter go?



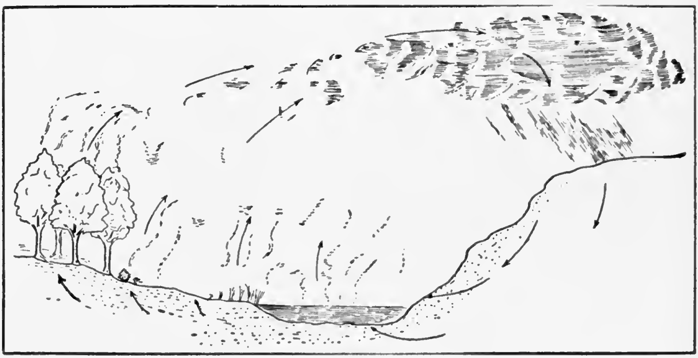
(KEY) EXPERIMENT 2

Learn the names and use of each piece of apparatus shown. Find out why the wire gauze is needed. What relation has this experiment to the water cycle?

Conclusions: 1. Does water disappear into the atmosphere? 2. What can you do to make water disappear rapidly into the atmosphere? 3. What causes water to evaporate?

When water escapes into the atmosphere by changing to an invisible gas, the process is called *evaporation.* Of course, other liquids such as gasoline and alcohol evaporate also. When gases become liquids by cooling, the process is called *condensation.* This is what happened when the drops of water collected on the cold dish which you held over the boiling water. Evaporation, caused by heat, is necessary before condensation, caused by cooling, can take place.

9. The Trail of the Raindrop. — The preceding experiment shows that liquid water may be caused to change to vapor or gaseous water, and rise in the air. Also, as in the experiment, whenever this water vapor cools, it condenses into little drops of liquid. Up in the air these tiny drops may increase in size and form rain clouds. When by further condensation the little drops become larger, they grow heavy enough to fall to the



THE WATER CYCLE

Explain each part of the water cycle. How is the water cycle important to your welfare?

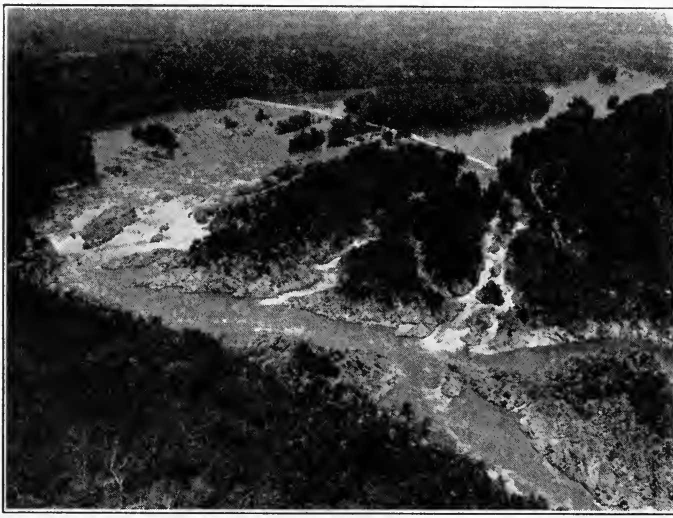
earth. If, in falling, the rain passes through a cold layer of air, the result may be sleet.

Sometimes the tiny drops of liquid water in a cloud are frozen quickly, resulting in a tiny snowflake crystal. More crystals form on the first until it gets heavy enough to fall. Sometimes a pellet of hail results from the freezing.

Field Research:

Place a little water in a tin cup and set it on a flat piece of "dry ice." Notice what happens to the "dry ice," and to the water in the cup. How can you explain what happens?

"Dry ice" is solid carbon dioxide. It is the same substance in solid (ice) form as the gas you exhale with your breath. It is very, very cold, so do not touch it with your fingers. As it gets warm, it changes rapidly into a gas, absorbing much heat. This causes moisture



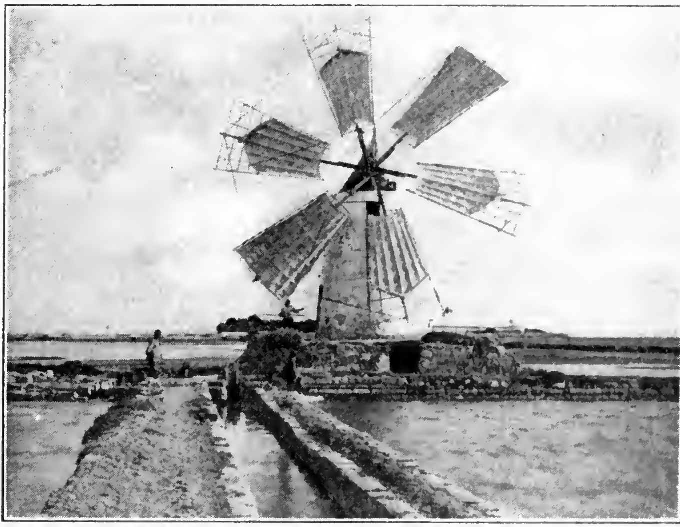
Courtesy Washington Board of Trade

WATER SEEKING LOWER LEVELS

How does water get to the upper levels?

in the air to be condensed and become visible. It also makes anything near it very cold by absorbing the heat.

Winds blow the clouds along over the earth, and in this way the moisture is distributed. Some of the rain and snow falls on the highlands and mountains, some in the lowlands. Thus water is lifted from the low places and dropped as rain or snow on the highlands from which it may flow back to the lower level. The journey of water after it evaporates from the leaves of green plants and all wet surfaces into the air, where it is condensed and returned to earth again, is called the *water cycle.*



THE PART THE WIND PLAYS

The wind pumps water from the sea into the pools. How does this picture illustrate parts of the water cycle?

Cycle comes from a Greek word meaning "circle." We can get the full meaning of water cycle if we follow once again, very quickly, the trail of the raindrop. As water vapor rises from the earth, the tiny drops of liquid water, formed in the sky by condensation, increase in size and unite to form clouds. Out of these clouds the drops of water fall back to the earth again, thus completing the cycle. You see that once the process starts, it is like a circle without beginning or end. How the process may have first started is told on page 48.

KEY WORDS

These words are of special value in helping you to remember and use what you have just been studying. Such a list will occur at the end of each chapter. Learn all you can about them. You will find opportunity to use them in your Science Discovery Book.

KEY WORDS

adaptation	cycle	liquid	water cycle
clouds	evaporation	solid	
condensation	gas	water vapor	

KEY STATEMENTS

Read these short, simple key statements thoughtfully and they will bring up pictures to your mind of what you have learned relating to them. When you have done this, describe the pictures in your Science Discovery Book or to your classmates. In this way important facts and principles which you have discovered will become fixed in your memory. They are then tools which you will use to make new discoveries.

KEY STATEMENTS

1. If enough heat is added to water, the water changes to the gas state (it evaporates). Water evaporates fastest at high temperatures.

2. Water in the gas state is lighter than air and will rise and mix with the air.

3. Water in the gas state changes back to the liquid state when cooled. If still more heat is taken away, the water changes to the solid state (ice).

4. Water in the liquid state is heavier than air and hence falls.

5. Water falling as rain or snow supplies our springs and streams.

6. Water animals and plants have special structures to enable them to live in the water while land plants and animals have special structures to enable them to live in air. Such structures are called *adaptations to environment* (surroundings).

7. Green plants give off great quantities of water through their leaves.

8. The water cycle is the very " life-blood " of our world.

Thought Questions

1. Water in the gas form occupies more space than as a liquid. Can you prove this?

2. Why do mists or clouds of steam rise?

3. Why is it that some springs or wells dry up at certain times while others in the same neighborhood do not?

4. If all animals and plants must have air to breathe, how is it that any of them can live under water?

PROJECTS FOR YOUR SCIENCE DISCOVERY BOOK

These projects are for your own scientific investigation and report. Be sure to enter your findings of each project in your Science Discovery Book. Use drawings wherever you can, for illustration.

Projects for Your Science Discovery Book

1. Make a list of things you could not have if there were no water. Make another list of things you could not do if there were no water.

2. Name several water animals and water plants with which you are familiar.

3. In September or late spring a stagnant pool of water, or a receptacle such as a rain barrel, which has caught and held water for some time, usually contains little " wigglers." These are mosquito *larvae*. *Larva* refers to the wormlike stage in the life of an insect (a caterpillar, grub, or maggot is a larva) and larvae is its plural form. Place several of these mosquito larvae in a jar with some water and cover the jar with netting. Watch the larvae for several days to see how they live and grow. Then pour a film of kerosene over the surface of the water and record what happens within a few hours.

The dragon fly will grow for you also, if you are able to procure some of the *nymphs*. The nymphs are easily procured from the bottom of a pond in early spring. They are unlike the adult in appearance, much smaller and without wings.

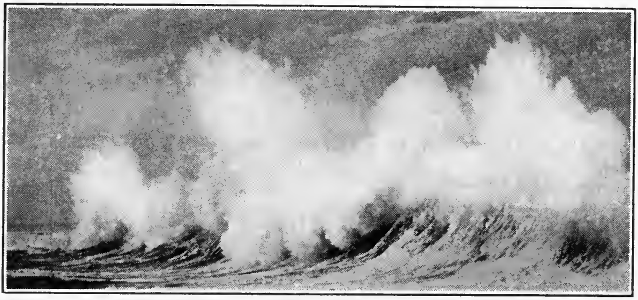
READING THE RIGHT WAY

In beginning your work in science you realize probably for the first time what a vast number of facts you can discover about nature and *our environment* (our surroundings). We cannot know every fact ourselves nor can this text give us all the interesting and valuable information we shall need. Therefore, it is very important for us to know what books will supply information relating to our particular problems. There is a list of such books in the Appendix.

Whether you are reading this text or some one of your reference books, always have a particular problem in mind. Never read or study just to learn a lesson but rather to find out things for yourself. Read to get information which you want to use right away or which may come in handy at a future time.

You have ideas about things, what they are for, how they are related to each other, to you, and to the world. Your reading and experiments will help you to test the correctness of your ideas. Read to find out what other people think or have found out about these things. Practice will give you skill in determining what facts you need to use and whether or not your conclusions about them are correct.

SURVEY OF TOPIC II



Water in motion! What pictures that brings to mind of a rushing, tumbling, mist-spraying waterfall; a shallow, rippled, leaf-patterned brook; or the surging, roaring, white-capped breakers, tossing their foam over giant boulders.

The never-ending cycle of water, from the earth to the sky and back to the earth again, provides a limitless supply of water for streams, which in turn carve valleys, cut down hills, wear away shore lines, turn the wheels of industry, and perform innumerable tasks for us.

Our streams and lakes and oceans are soil makers and distributors; they serve as a source of water power and transportation; they are a source of great quantities of food, and a means of recreation; they help to make us healthy.

But moving water may be helpful or harmful. Harnessed to our use it serves us well; when it gets beyond control, it serves us ill. Floods, for example, are destructive. Therefore we need to study the causes of floods, how to control them, and how to turn them to good account, if possible. Because water is so closely connected with our daily lives and health, let us learn more of our water environment.

TOPIC II

WATER AS A WORKER

I am fain for to water the plain.
Downward the voices of duty call —
Downward, to toil and be mixed with the main.
The dry fields burn, and the mills are to turn,
And a myriad flowers mortally yearn,
And the lordly main from beyond the plain
Calls o'er the hills of Habersham,
Calls through the valleys of Hall.

— LANIER

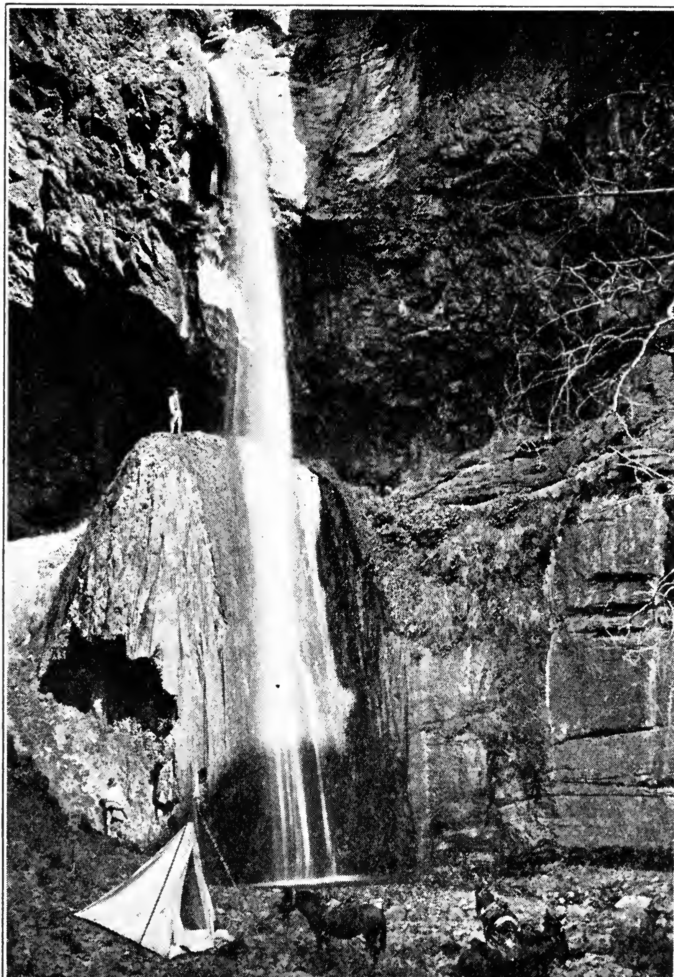
Do you know:

1. **Why water runs down hill?**
2. **Of some especially interesting work done by water?**
3. **How floods may be controlled?**
4. **Why people spend vacations near the river, lake, or ocean?**
5. **Why fish cannot live in water that carries sewage?**

GENERAL PROBLEM 1. HOW DOES WATER HELP TO MAKE AND DISTRIBUTE SOIL?

10. On the Level. — Water is seldom at rest. It is always seeking a lower level. A good deal of the rain water simply "runs off" the surface where it has fallen, forming streamlets which unite to form larger streams. These larger streams often end in a pond, lake, or ocean, showing that sooner or later the downward flow of water is stopped.

All moving water, whether in the soil or running along a stream bed, carries with it small particles of *soil matter.* This soil matter consists of very fine bits of



Atchison, Topeka and Santa Fé Railway.

WATER AS A WORKER

Study the picture and describe all the evidences you can find that water does work.

rock, gravel, and small living and decaying organisms. (An *organism* is a body that has or once had life.) The larger and faster the moving body of water, the more numerous and the larger are the soil particles it carries. As the stream flows along, it is forever pulling and tearing at the bed over which it passes. The material

A MEANDERING STREAM

Study the picture to determine where the stream cuts away the bank and where it builds up the bank.

which it carries aids this cutting process by the grinding power of the heavier pieces as they tumble and twist and spin along the bottom. The wearing-away power of such action is "slow but sure."

Consider a handful of soil. Where do you suppose it came from and how? Did water bring it?

In the little coves and pools which form along the course of the stream, the water has a brief chance to escape from the full force of the current and so to deposit some of its load. As lower levels are reached the stream slows down and here also the lighter as well as heavier particles of its load settle to the bottom and sides of the stream bed.

Have you ever stopped before to consider how powerful water is? Can you see now that it is continually at work tearing down the highlands? The material which it carries off, it uses in building up the lowlands.

Look up the following words in the dictionary or in a geography and explain their connection with this subject: *sandbar, delta, tributary, waterfalls, rapids,* and *channel.*

General Problem 2. Is Water a Source of Power?

11. How Water Works. — Moving water does both good and bad work. Floods, tidal waves, and cloudbursts are ways in which water does harm. It does

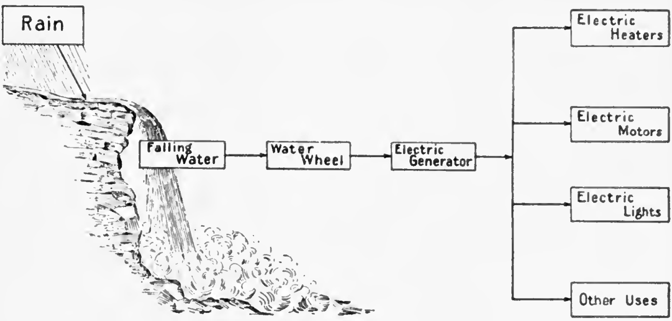
Airmap Corporation of America

Niagara Falls

How is the water power made available without a dam? What is its relation to the water cycle?

good work by turning waterwheels. Waterwheels develop the electric power to run our trolleys, to light our houses and streets, to heat our flatirons, and to perform many other household tasks. Man has harnessed this power to dynamos by means of dams and reservoirs, thus making water do useful work for him.

Energy from the sun heats the waters of the earth, causing them to evaporate. The plants evaporate



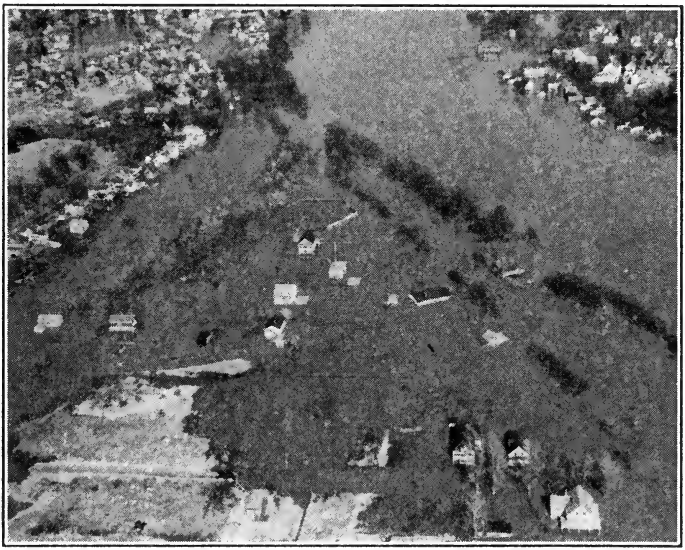
Explain each step in the diagram.

water into the air. The vapors rise and form clouds by condensation. The clouds are blown over the highlands. Here more condensation takes place and the water is returned to the earth to flow down hills into the valleys, over waterfalls, and through rapids. The forces from falling water turn the wheels of industry. Water becomes a source of power.

General Problem 3. What Are Some Results of Floods?

12. Out-of-Bounds. — You have played games in which it was unfair to get out-of-bounds. Sometimes, in the excitement of such games, players get out-of-bounds without realizing the fact. If such players are not held in check, the game becomes so confused that it must be stopped. The larger the crowd of players, the greater the danger of off-side play. So certain rules are made as checks to keep the players within-bounds.

In much the same way, Nature provides checks, such as forests which give out vast quantities of



Fairchild Aerial Surveys

A SPRING FLOOD

Is this picture evidence of the need for flood control?

moisture through the leaves, and evaporation from wet surfaces. These checks prevent out-of-bounds play on the part of streams and rivers; that is, they keep them from overflowing their banks.

High floods frequently force streams out-of-bounds, causing damage to fields and towns. Rivers at flood time have carried away bridges, undermined the river banks, and spread out over the lowlands, carrying away soil, fences, and even houses or other buildings.

Since floods are often the result of rapidly melting snow, a freezing spell will hold back the water flowing into the stream. This allows the overloaded rivers to empty themselves to some extent.

Can you mention any ways in which floods are useful?

As floods recede, much of the soil which was washed down from the hills and slopes by the swollen streams is

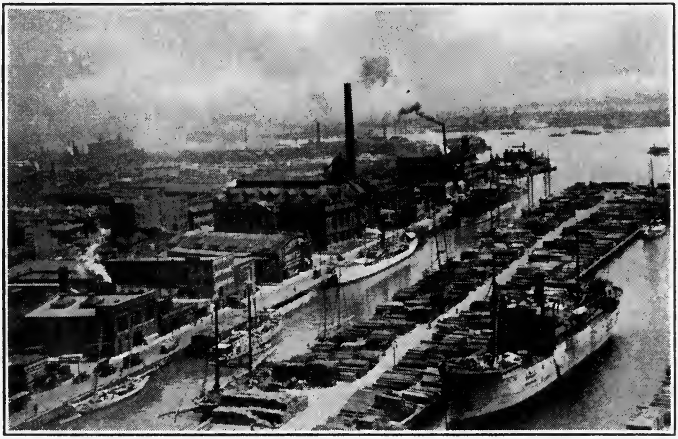
Airmap Corporation of America

A Section of the Mississippi Delta

How can a river build a delta above its normal level?

deposited along the river banks. If this *sediment* (the broken rock and soil carried along by the water while it is moving) is good soil, it will enrich the neighboring fields. The lower, more level portions of many rivers wind through fertile plains that have been built up gradually by sediment deposited by the river at flood time. Can you give an example of such a plain?

When a stream flows into a body of water such as a pond, lake, or ocean, the speed of the water is slowed down. This causes a great deal of the sediment which the stream carries to be deposited at the mouth of the stream. Oftentimes these deposits get so large that



© Keystone

A Good Harbor

Tell what you see in the picture indicating that a good harbor is one cause of city growth.

they hinder the passage of boats, and the channel has to be dredged to clear it of these soil deposits. As the heavier or coarser material is dropped nearest the shore and the lighter material carried farther out, the deposit becomes fan shaped; this is called a *delta*.

After the next hard rain, look beside the road and you will find small deltas where rivulets have washed fine soil down into mud puddles.

Thus, while the results of floods may be beneficial sometimes, for the most part they are destructive. Therefore we should try to control and prevent floods.

THE S. S. QUEEN MARY

Do you think transportation by land, water, or air is most important?

GENERAL PROBLEM 4. WHY IS WATER TRAVEL IMPORTANT?

13. A Builder of Cities. — History shows us that most large cities owe their existence to a good harbor, a navigable river, or a water-power site. Most of the early travel routes were laid out along water courses, particularly where travel had to pass through thickly wooded regions. It was natural then that the more prosperous and larger communities should develop at convenient points along these water routes.

To-day water travel is one of the most important factors in our business life. Giant ocean liners, huge oil-tankers, and tremendous river barges share their water paths with trim yachts and mighty warships. Streams annually transport thousands and thousands of feet of lumber to the mills. Great harbors with their busy craft and long wharves picture the story much better than words can tell it.

Name several cities of the United States that owe their size to favorable locations on or near an important water route.

General Problem 5. Is Water a Source of Food?

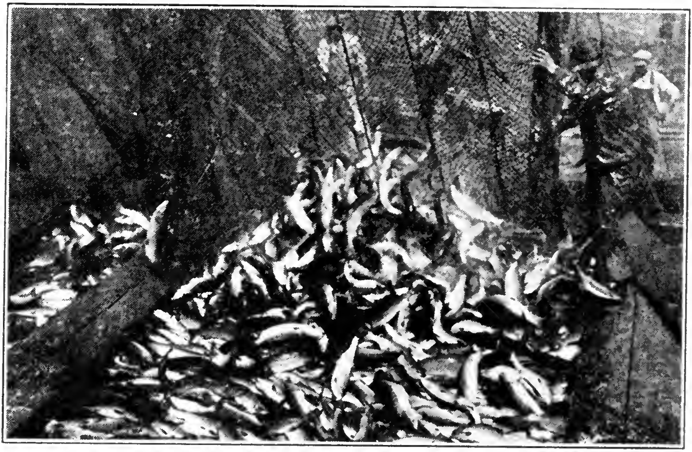
14. Fish. — Did you ever catch a fish? What kind was it? Streams that are not polluted (poisoned with filth) are feeding grounds for fish. Lakes and oceans also furnish great quantities of fish. There is no end to the supply if a few sensible rules are followed to allow the fish to reproduce, and if sewage and manufacturing wastes are kept from poisoning the water.

Name five kinds of fish that live in fresh water and five kinds that live in salt water. Do you think that oysters and whales are fish? Give your reasons.

General Problem 6. How Does Water Provide Recreation?

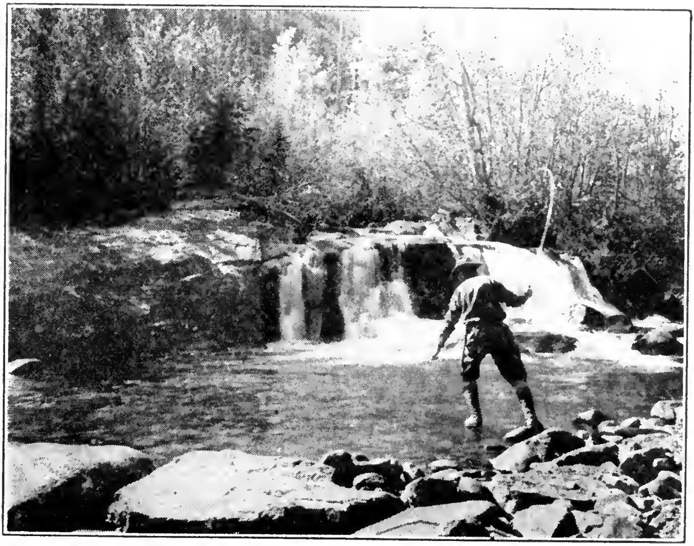
15. Water, Recreation, and Life. — Without water, our earth would be a cheerless desert. There would be no plants, no animals, no life. But with water, we have abundant vegetation, beautiful winding streams, useful waterfalls, and great oceans and lakes.

Water, in addition to all its other uses, makes life pleasanter and more interesting by offering many opportunities for recreation, — boating, sailing, swimming, diving, canoeing, water polo, and so on. Such



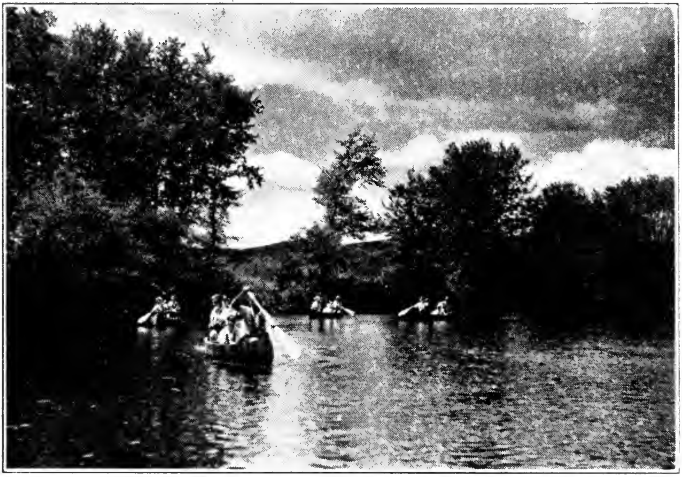
A Good Day's Haul

These are salmon from Alaska. Does fresh or salt water provide a home for these fish?



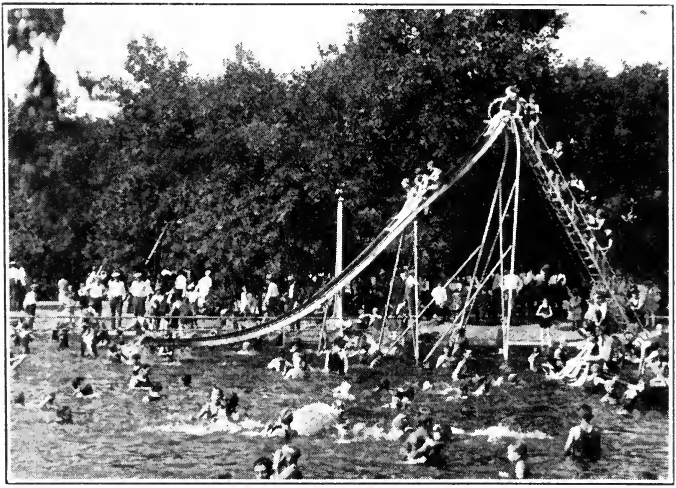
Fishing for Sport and Food

How has the work of water provided this fishing hole?



CANOEING

What factors make this recreation healthful?



WATER TOBOGGANING

Compare the healthfulness of this recreation with that of canoeing.

activities bring outdoors many people who otherwise would not profit by the health-giving fresh air and sunshine of outdoor life. The beneficial effect of these pleasures on the health of a nation is so great it cannot be measured.

General Problem 7. How Does Water Aid Health?

16. Cleanliness. — You all know how much more likable a boy or a girl is who has clean hair, clean hands and finger nails, clean teeth, a clean skin, and clean clothes, than the careless, unclean, and untidy person. Cleanliness, however, does more than improve one's appearance. It helps to ward off disease.

How can cleanliness help to ward off disease?

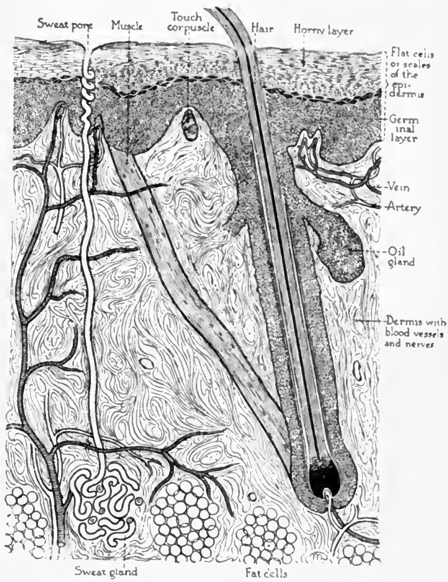


Diagram of Parts of the Skin

How is the structure of the skin related to your plans for cleanliness? What is the relation between dandruff and the epidermal cells?

What is the agent that makes cleanliness possible? Water, for it washes off accumulated dirt from the skin and keeps the pores open so that waste matter from the body may be properly removed.

Experimental Problem 3. — *Will soap aid water for cleaning purposes?*

What to use: Dirty hands, water, soap, paper towels.

What to do: Wash the hands first with plain water. Dry them with paper towel without rubbing. Are they clean? Next use water and soap, making a good suds. Thoroughly rinse off the soap and water. Dry as before. Are they cleaner than before?

What happens: 1. Were your hands clean after washing with plain water? 2. Were they cleaner after using soap and water?

Brownell

POISON IVY LEAVES

Note three-leaf arrangement and notches in leaves.

Conclusion: Based on your experiment, what is your opinion regarding the use of soap with water for cleaning the hands?

Applications: Do you think the same rule will hold for general cleansing and laundry work? Make up an experiment to find out if warm water with soap is better than cold water with soap.

It is vitally important to wash your hands thoroughly with soap and water before each meal. Though your hands may look clean, there are many places on them where dirt and germs can collect. If you accidentally touch poison ivy or other poisonous plants, an immediate washing of the skin with soap and water may prevent poisoning.

Examine different portions of the skin under a magnifying glass to see if they differ. Are some places dirty? Some clean? Is the skin rough or smooth? Do you think a rough skin will become dirtier and be more difficult to clean than a smooth skin? Why?

Water is needed not only to cleanse the outside of the body, but it is equally needed to cleanse the inside and to help carry on many of the body functions. Your body in health is constantly losing water from the lungs, through the skin, and from the kidneys at the rate of 10 or 12 glasses every day. About 6 glasses of water are taken into the body with the food ordinarily eaten each day. In addition to this, every person needs to drink at least 6 glasses of water each day to make up the total loss. On hot days, or because of exercising, the body's total loss is often greater, and more water should be taken in. Make a practice of drinking 2 glasses of water the first thing in the morning, and at least 4 more during the day.

Water is useful not only to help in personal cleanliness but in household, school, street, and community cleanliness.

Give some examples of the use of water for community cleanliness.

Key Words

delta	health	pores	soil matter
fish	lake	river	stream
floods	ocean	recreation	transportation
forests	organism	sediment	waterfall
function	polluted	sewage	water power
			waterwheel

Key Statements

1. Water is always seeking lower levels and so is usually in motion.

2. Water in motion, whether flowing along in a stream or falling from some cliff, can do many kinds of work such as wearing away rock, making soil, digging gorges, or turning wheels.

3. The more swiftly water flows, the more and heavier the material it can carry.

4. If swiftly running water slows down or ceases to flow, some of the materials which it carries will settle to the bottom.

5. Deposits of sand and gravel at the mouths of streams are called deltas.

6. Floods are a natural occurrence for which Nature provides a certain amount of control. Floods, however, are destructive to many of the works of man; hence man must make his own provision to increase control of floods.

7. Floods result in loss of water for power and in destruction of bridges, dams, buildings, and lands.

8. Discovery of new lands, progress in the development of a country, growth in population centers, and civilization itself have been dependent upon water travel.

9. Water is a natural source of food.

10. Water is necessary for body cleanliness inside and outside.

11. Drink six or more glasses of water each day.

Thought Questions

1. How can you tell whether the work a stream does is constructive or destructive?

2. Is the constructive work of a stream always useful to man? Explain.

3. Why is it that water in a stream at flood time can move rocks or obstructions that are not moved by the stream at other times?

4. Why is it that the mouth of a river must frequently be dredged, if the river is to be used by large boats?

5. How could you tell how high the flood waters of a river rise?

6. Can you suggest a practical means of controlling floods that may occur in your locality?

7. Why does a river fill in at one place and dig out at another?

Projects for Your Science Discovery Book

1. Make a list of things which you have seen streams of water accomplish. Words like garden-hose, fire-hose, water faucets, mill-wheels, and washing-machines will suggest some items for your list.

2. Make a list of cities which have favorable locations near waterways and tell what affect this location has had on the development of the city, or

Study the location of your own city, town, or home to determine why the particular location was selected. Are all the natural resources of your locality being used to best advantage?

3. Make a diagram to illustrate the course of some stream and its main tributaries with which you are familiar.

4. Tell what water sport you like best, and why you like it.

5. Make a score card, or some similar plan, for checking your personal cleanliness. (Care of mouth and teeth, hair and scalp, hands and finger nails, feet and toe nails, skin, clothes, and shoes.) Include reasons why each cleanliness activity aids in preserving your health. Incorporate rules for cleanliness. For example, how often and when should one wash the hands, clean the teeth, take a bath?

6. Report on how your home, your school, your public buildings help to promote health through cleanliness. Is there any relation between these facts and the healthfulness of your town as shown by the number of deaths per 1000 people per year? Explain.

SURVEY OF TOPIC III

Courtesy "The Milwaukee Road"

Like giant thermometers, spouting geysers indicate the high temperatures below the earth's surface. Volcanoes, active and dead, and earthquakes tell of tremendous changes taking place within the earth.

Water from the sky, wind, and the waves of the ocean; gardens with flowers, fields of grain, the sun, moon, and stars! What do they all mean; what has each to do with the other?

You have already learned that water has had a great deal to do with the breaking of rocks into soil and its distribution over the surface of the earth. Where did these rocks and soil come from?

In that far-off beginning rains fell; winding crevices and basinlike depressions in the earth's surface came to be used by rivers and lakes; streams wore away the land; as oceans deepened, mountains rose. Thus we begin to see the relation between earth and water; earth, with its solid crust, irregular and rough, and water, striving always to level this land, building up the low places and tearing down the high ones.

TOPIC III

LAND AND WATER

The hills
Rock-ribbed and ancient as the sun, — the vales
Stretching in pensive quietness between;
The venerable woods — rivers that move
In majesty, and the complaining brooks
That make the meadows green; and, poured round all,
Old Ocean's gray and melancholy waste.

— BRYANT

Do you know:

1. **How old the earth is?**
2. **Why mountains and valleys are important to us?**
3. **What a watershed is? a divide?**
4. **Why the surface of the earth is irregular?**
5. **What causes an earthquake?**

GENERAL PROBLEM 1. HOW DO SCIENTISTS EXPLAIN THE BEGINNINGS OF OUR EARTH?

17. Dry Land. — Scientists have always been curious about the age and the formation of the earth, and they have always tried to find the answer to these same questions. To-day many facts are known which, put together like the pieces of a puzzle, give an imaginary picture of the beginnings and age of the earth. But not all of the pieces are found, and some do not fit very well where they are, so we cannot say for sure how it all came about. More facts and more scientific study will bring us closer to the true story.

Many facts known to scientists indicate that the earth is perhaps two billion or more years old. At any rate, water seems to have been at work on the surface of the earth for about one and one half billion years and life may have existed nearly as long.

You may know that the ocean waters of the earth are heaped up into waves or tides by the attractions of the moon and the sun. So, too, it is thought that the great, highly heated body we call our sun once had tides; not water tides, but tidelike movements of its

AN ECLIPSE OF THE SUN

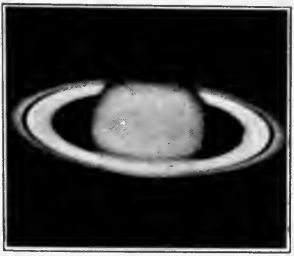
Note the burning gases escaping from the sun.

own boiling-hot material caused by the force of attraction of some other great heavenly bodies. It may be, too, that then, as now, violent boiling and spattering took place on the sun, such as one sees when oatmeal porridge boils very hard and spatters. Ordinarily the spattered parts just fall back into the boiling mass, but once in a while something may prevent this from happening and the spattered part cannot return.

Some scientists believe that the earth may have been spattered from the sun in some such way as this. They think that once upon a time, before there was any earth or other planets, another great sun or star chanced to pass in the neighborhood of our sun just when one of these tidal actions or spatterings was occurring. Then a strange thing happened. The force of attraction of the passing star was so great that the spattered material of the tide, or heap, was pulled away from its own sun and there the material was, in space, unable to fall back to its mother sun, as it had always done before, because the attraction of the passing star kept it from falling back. (This attraction of one body for another is called *gravitation.*)

The materials that were broken loose in this way from our sun are thought to have formed the beginnings of the earth and the other planets. The sun and the planets make up what is called the *solar system.*

These scientific beliefs are called theories. Where have you ever heard the word "theory" used before? A theory is an explanation of how some fact came to be a fact. The explanation may or may not be correct. To be of value the theory must fit all the known facts relating to it. Other scientists than those to whom this book has referred have suggested other theories about the formation of the earth. The theory given here, however, is thought by many scientists to explain more facts than the older theories and is therefore accepted as being nearer the truth.



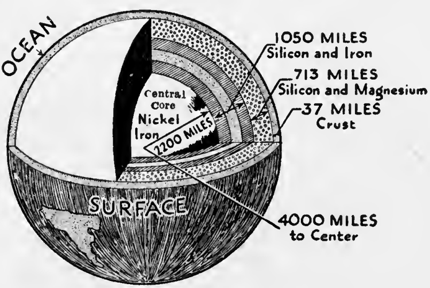
SATURN — A SISTER PLANET

The earth and these sister planets are traveling about the sun, in the same direction, each in its own path, but at different distances from it. The passing star, it is believed, not only helped at this beginning of the earth and her sister planets, but also gave them a start on their never-ending journey around the sun. Then, having started the earth on its endless journey around the sun the visiting star also helped to start the earth whirling, or rotating, on its axis. This *rotation* gives us day and night.

How do you explain this last statement?

The journey of the earth around the sun is called the *revolution* of the earth. The revolution of the earth is one of the important causes of our seasons.

At birth the earth was not so big as it is to-day. For millions of years it grew larger and larger by attracting from space the dust and fragments of materials that it came near in its journeys around the sun. Even to-day *meteors* (shooting stars) add a little to the size of the earth, but scientists believe that for the most part the earth reached its present size millions and millions of years ago.

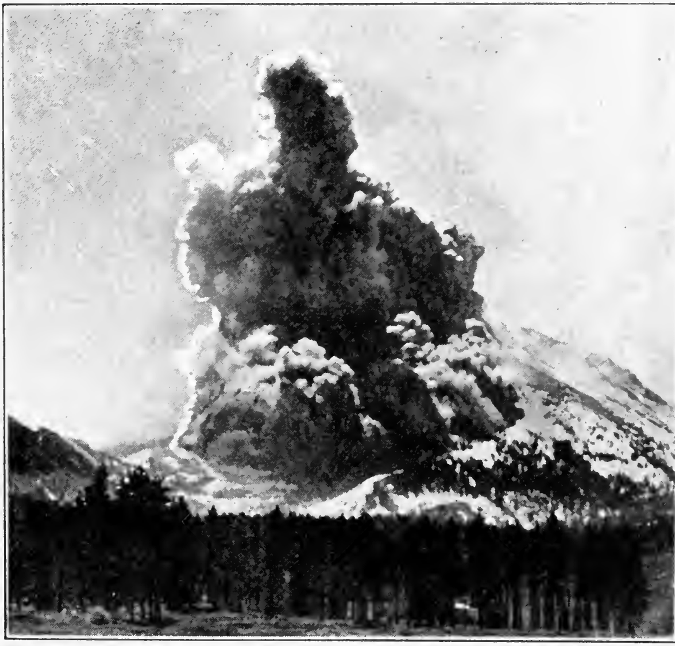


How Our Earth Is Made

Do you think this picture represents facts or theories? Why?

18. An Atmosphere Appears.—As the earth increased in size, gases escaped from it. Also the fragments that it gathered gave off gases. At first it was too small to hold these gases to its surface, and they disappeared into space. In time, however, as the force of gravitation increased along with the growth of the earth, these gases were held to the earth and formed the first atmosphere.

As the earth grew larger, gravitation probably caused the rocky materials to press harder and harder towards the center of the earth until the interior became very hot. An inner core of melted iron with some nickel mixed with it is thought to have formed. Continual growth of the size of the earth resulted in continued heating and in places it is probable that



A VOLCANIC ERUPTION

As hot gases escape from the earth into the air, rock fragments and melted rock (lava) are thrown out.

melted rock poured out over the surface and gases escaped, somewhat like volcanoes to-day.

19. Water Appears. — The young earth's surface was probably rough and uneven, built as it was by the accumulation of fragments and dust-like materials. It is likely that one of the gases of the first atmosphere was water vapor. As the new atmosphere cooled, the moisture condensed (Experiment 2, page 15) and fell back to the earth. Some of the water soaked into the earth and some ran in streams to the lower places and formed ponds, lakes, and oceans. In this way

Bert Huntoon

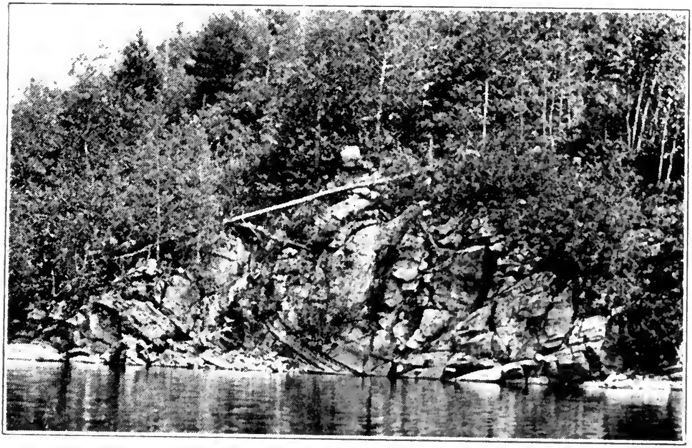
Mt. Shuksan

What evidence can you see that water has condensed from the air?

were formed the dry-land portions and the water-covered portions of the earth.

It is estimated that *erosion* (wearing away) by water, wind, and decay has been going on, on the earth's surface, for one and one half billion years. Therefore, the earth must have had a solid crust for that long, and an atmosphere something like that of to-day. This outer portion of the earth is rigid and strong, and perhaps fifty miles thick.

20. The Oceans Deepen. — It is thought that as the earth developed, water that soaked into it dissolved certain substances from the rocks and deposited



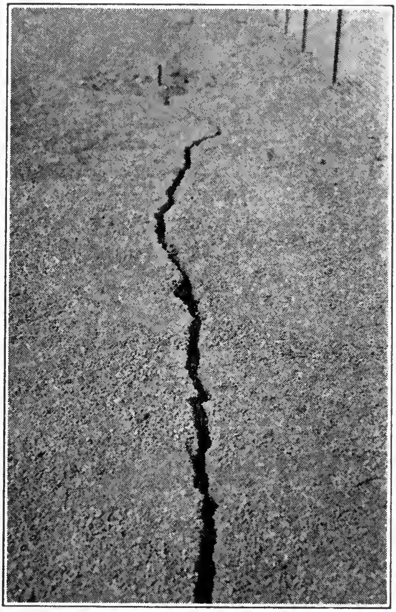
Curved Rock Layers

What does this picture tell about mountain formation?

Lava from Vesuvius

What does lava tell about the temperature inside the earth?

them on the ocean bottom so that the dry-land rocks became lighter and the ocean-bottom rocks became heavier. Gradually, the great deposits of ocean-made rocks sank by their weight and pushed still higher the lighter dry-land rocks, so that the oceans became deeper and the dry lands higher. Thus some scientists account for the formation of great ocean basins and continents.



AN EARTH CRACK

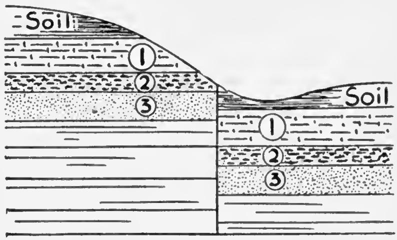
This crack occurred in filled land during a rather severe earthquake, and was due to the vibration of loose ground. Is there any filled land in your vicinity?

Study a map of the world and note the triangular shapes and sizes of the present dry-land areas and of the corresponding oceans.

When you step in some mud, it pushes up near your foot, but farther away it may not move. In the same way, only on a much larger scale, as the ocean bottoms pushed down they raised and wrinkled the rock layers at the edges of the continents.

You have guessed what we call these wrinkles and furrows. Give a few of their names. Again study your physical map of the world and note if the great mountain ranges border the continents.

As the rocks were squeezed and pushed upward, great masses slipped and slid, shaking the surface. These slippings are called *earthquakes*. Then, as now, they were more likely to happen on the continent borders. The picture of rock layers on page 49 gives us a good illustration of what happens when such earth movements occur. The curves of the layers show where and in what direction the raising and settling has taken place and with what force it was brought about.



A SIMPLE VERTICAL FAULT

Sometimes layers of rock slip out of place, causing earthquakes.

The formation of ocean basins and mountains was probably accompanied by earthquakes. Cracks, called *faults*, sometimes miles long, occur in the rocks. It is at such places that the slips occur which result in earthquakes. The slipping rock may be as far as 20 miles below the surface of the earth. However, the shake or "rock wave" travels as fast as 2 miles per second. In the early history of the earth, earthquakes may have been more violent and frequent than they are to-day because now the earth is fully grown.

The spouting of liquid rock and gases from volcanoes and the overflow of *lava* (melted rock) on parts of the earth's surface were probably more extensive in those strenuous early periods. The picture of the spring on page 14 shows a thick layer of volcanic rock that once poured out over the land.

21. A Fight to the Finish. — As soon as air and water appeared on the earth, they began to try to fill the oceans and to level the mountains by wearing away the rocks. In the beginning of their struggle with the mountains, everything was in their favor, for the air was moist and warm and contained destructive gases.

Does warm, moist air cause more rapid decay than cool, dry air? Explain. What use does man make of this knowledge?

HYDRAULIC MINING

What evidence do you see that the stream of water wears away the soil?

But as centuries passed and the earth grew larger, the heavy rock substances on the ocean bottom pushed the dry land up faster than the air and water could wear it down. That is why to-day we have our irregular land surfaces.

22. The Grand Canyon. — The age of a great canyon is estimated by the thickness of the various kinds of rocks, and by the amount of cutting done by the river after the rocks were formed. This, in turn, helps the scientist to a clearer understanding of the tremendous forces and long ages of conflict underlying our earth's present formation.

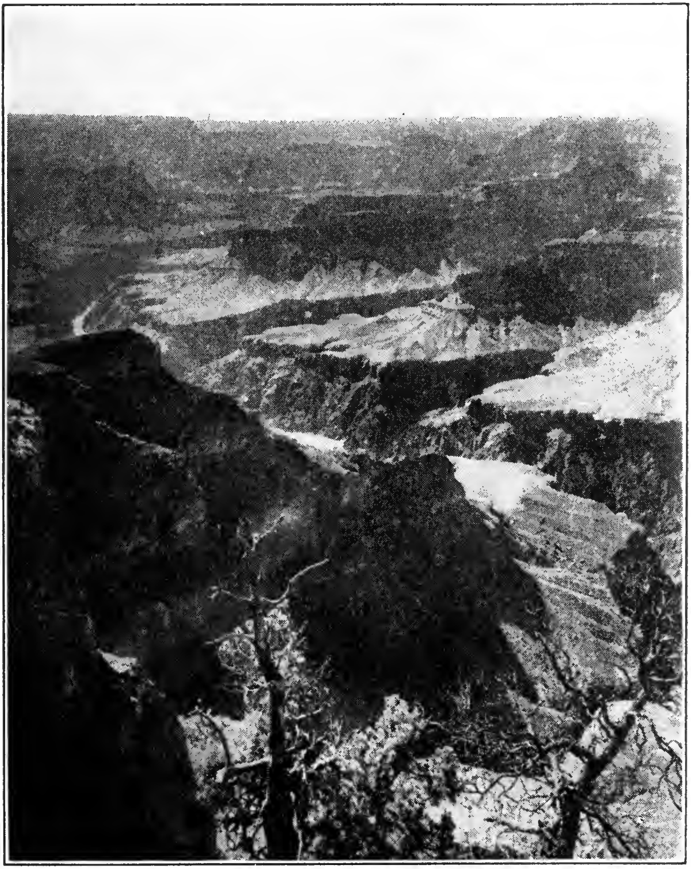
In the case of the Grand Canyon of the Colorado River it is thought that at least nine ages of growth and transformation are represented. Each age is indicated by certain formations and kinds of rock. How much time went by between the records left on these rocks no one knows.

First we may think of the rocks now found at the bottom of the canyon as the original or oldest rocks known. They are what is left of an early mountain range that was worn down to a level floor. Then movements of the earth's crust put this rock floor below the ocean level, so that an arm of the Pacific Ocean came in. It sank lower and lower until about 12,000 feet of rock material was deposited on the floor. In time, some force raised these rocks again and formed them into a second mountain range which also was worn down as the first range had been.

For a second time the sea came in while more great layers of rock material were laid down.

For millions of years after this, Nature's forces were at work. Rocks were made in water, raised up and washed away again, and the process was repeated over and over. Mountains were formed only to be washed away. Then came new rocks, new mountains, and more erosion. This is the story written in the rocks of the canyon for all to see and read.

To-day mountain formation is again taking place in that section of the country. The rock is now being



THE GRAND CANYON OF THE COLORADO

What agents of erosion helped to dig this canyon?

lifted or pushed higher and higher above sea level. And at the same time the water of the Colorado River has been sawing its way through layer after layer until now the rim of the canyon is well over a mile above the river. It is four to eighteen miles from rim to rim. The time taken to dig the canyon is estimated to be from 8 to 10 million years to 50 million years. Untold millions of years were required to prepare the present series of rock before the river began to cut the Grand Canyon of the Colorado.

Will the gorge become wider and wider until that section again is worn down to a level plain? Who can say what will happen there in the next million million years?

The struggle which began such a long time ago is still going on, as we shall see in a later chapter. Now that man is taking a part in the fight, particularly in his control of water, no one knows what the end will be. We are learning how to make Nature our ally. So the more we know about the lay of the land and the work of Nature's forces, the better we shall be able to control these forces.

General Problem 2. What Is the Relation of Stream Flow to Land Areas?

23. The Lay of the Land. — Certain mountain and hill areas are known as *watersheds*. A watershed is a great *drainage* area; that is, a region whose streams unite to empty into some river, lake, or ocean. A *divide* is an irregular ridge of high land whose sides form two great watersheds. An airplane view of such a region would show how the mountain slopes and hillsides gather the rains and the melting snows into streams and lakes.

We should see on a much larger scale just what we saw after we had poured the pail of water on to the pile of dirt. There would be many evidences of the wearing-away power of water, — here a gently sloping plain with slow-flowing streams, there a rushing torrent making a vigorous attack against some rugged cliff. And most striking of all, the great reservoirs

A WATERSHED, THE SUMMIT OF THE CASCADE MTS.

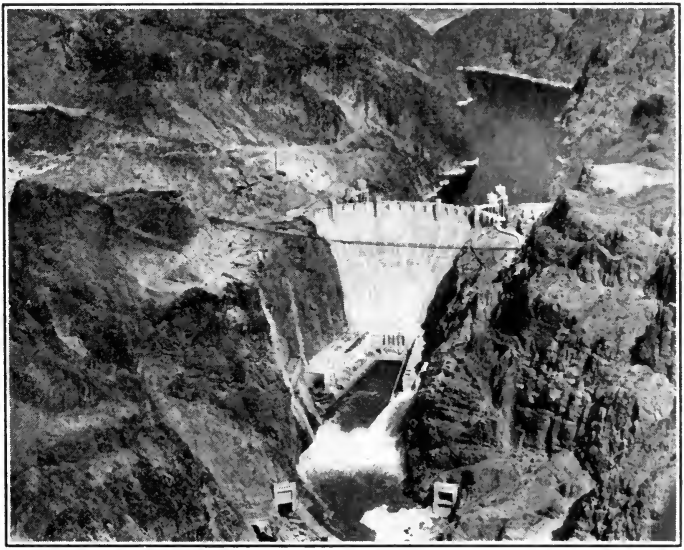
The snowfields and lake in the foreground represent natural water storage. How do you know that the mountains have been worn by water and ice?

made by the river valleys and lake basins would stand forth as the huge catch-alls of the system.

Here are the important facts which our airplane view would make plain to us: (1) the earth's surface is irregular and rough; (2) mountains and valleys are responsible for our streams, rivers, lakes, and oceans; (3) water never gives up its fight to level the land; (4) in this leveling process, water builds up the low places with what it tears down from the high places.

All this may be expressed as a single thought by saying that flowing water is constantly changing the earth's surface.

24. The Worth of Water. — Because of all these activities of water, we have the rich stretches of fertile



BOULDER DAM AND MEAD LAKE

Explain its relation to the water cycle and uses of water.

soil which flank the river beds; and the mighty power which we harness by means of reservoirs and dams, — power to light our homes, run our factories, and drive our street cars. Has it ever occurred to you that in this latter relationship, Nature, through the help of the scientist, offers us one of the greatest helps to a clean, comfortable, healthy, and happy life? Lakes and streams, summer rains, and winter snows, all can be made to work together for our good. The better we know them, the more wisely we can use them.

In Unit II we shall study other ways in which soil is made and carried from place to place. We shall also ask the rocks to give up some of their secrets.

Key Words

atmosphere	fault	reservoir
continent	gravitation	revolution
divide	lava	rotation
drainage	meteors	solar system
earthquake	mountain	tide
erosion	planet	volcano
		watershed

Key Statements

1. The earth and its sister planets were probably formed at the time of a great tidal action on the sun millions of years ago.
2. A great passing star may have helped at the birth of the earth by pulling material away from the sun.
3. The sun and its planets are called the solar system.
4. Gravitation is the attraction of one body for another.
5. The revolution of the earth about the sun gives us our seasons.
6. The rotation of the earth about its axis gives us day and night.
7. It is thought that the earth has grown to its present size by collecting dust and fragments from space.
8. The atmosphere was formed by gases held on the earth's surface by gravitation.
9. Cooling caused the water vapor of the atmosphere to condense and form the waters of the earth.
10. Ocean basins and continents were probably formed by settling of ocean bottoms and pushing up the shore areas.
11. Mountains are wrinkled or folded rock layers at the edges of continents

KEY WORD GAME OF BALL

Two pupils as captains choose sides. Each team chooses a scorekeeper and an umpire. Each team makes up definitions to fit the Key Words for at least two chapters. The definitions without the Key Words should be written on separate slips of paper, and vice versa. All of the slips are given to the pupil who is pitching.

Rules

1. There shall be three bases.
2. The captain decides the batting order for his team.
3. The team in the field has a pitcher and a catcher.
4. When the batter is up, the pitcher throws (states) a definition without the Key Word, or vice versa.
5. The batter supplies the missing Key Word or definition. If he does so correctly, he goes to first base.
6. If the batter misses, then the catcher tries for it. If the catcher gives the correct answer, the batter is out. If the catcher misses, then it counts as one strike and the pitcher throws another ball. Three strikes make an out.
7. If the first batter goes to first base, batter number two takes his place at bat. If he makes a hit, he goes to first while the man on first goes to second, and so on.
8. If a man reaches home he scores one run.
9. Three outs retire the side at bat.
10. If the pitcher gives an incorrectly worded definition, as shown by a member of the team at bat, the batter goes to first, while any man on base moves up one base.
11. The correctness of an answer is determined by the umpire. He also must keep an independent record of the score, and his decisions shall be final.

12. As the water formed, it flowed down the slopes and wore away vast amounts of rock materials.

13. Through the centuries water, wind, and decay have tended to level the mountains, while the forces of the earth have made new mountains.

14. The low lands covered with river-deposited soil are very fertile.

15. The swift-flowing streams of the mountains and hills furnish sources of enormous power.

16. Flowing water is constantly changing the earth's surface.

Thought Questions and Exercises

1. What are the principal mountains and rivers of your state? How have they helped to determine industries of the state?

2. Is there a water-power development in your locality? If not, do you know of one which is especially famous? Describe one or the other.

3. How else, besides making electricity, does man use the power of falling water?

4. What are the principal rivers of the United States? the principal mountain ranges?

5. What are the meanings of *dike, levee, dam, flume,* and *spillway* when used with reference to water?

Projects for Your Science Discovery Book

1. Investigate the Copernican and La Place theories of the formation of the earth, then tell why the planetesimal theory is favored by most scientists. (See any recent encyclopedia.)

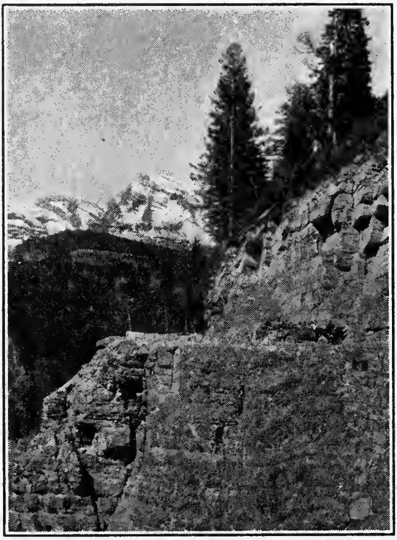
2. Investigate a rock ledge or gorge in your vicinity. Make a diagram of it and label the layers of rock. Photographs would aid your description.

3. Investigate a drainage area in your vicinity. Make a labeled diagram of it. A note about the altitudes above sea level would be useful in your description.

4. Visit a natural science museum to find out about meteorites and describe your discoveries.

5. Using a wooden or metal trough, devise an experiment to prove that swiftly flowing water washes soil away faster than slowly moving water.

SURVEY OF TOPIC IV


Hileman

"The world is so full of a number of things," and among those things are rocks, — little, flat rocks that skip so beautifully over the surface of the pond; round, shiny pebbles fit for a collection; big, gray rocks that cause the farmer no end of trouble; great stone cliffs that defy the mountain climber.

Where did these rocks come from? Do they change? Follow through this chapter and you will learn of another cycle, the rock-soil cycle, that began when the waters of the earth first started their work as soil-makers and distributors. You will discover that water helped to make several kinds of rocks; that rocks have many uses; that records of the earliest times are written in rocks; and that, in some parts of the world, water and its work on rocks has created underground caverns of sparkling beauty.

TOPIC IV

ROCKS

Tongues in trees, books in running brooks,
Sermons in stones, and good in everything.
— SHAKESPEARE

Do you know:

1. What the rock-soil cycle is?

2. What rock the Indians used for arrowheads, knives, and ax heads? Do you know why they used this particular rock?

3. The difference between water-made and fire-made rocks?

4. Which is better for the fronts of buildings, limestone or granite?

5. What a fossil is? a ripple mark?

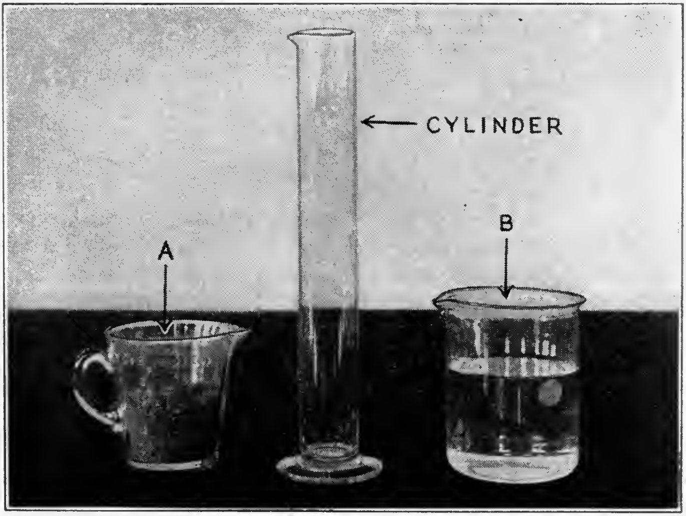
GENERAL PROBLEM 1. HOW DOES WATER MAKE ROCKS?

25. The Rock-Soil Cycle. — In the story of the beginnings of our earth, we learned how the cooling surface became hard, barren rock which the moisture and air immediately attacked. As the waters condensed from the air and joined in the attack, huge quantities of rock particles were carried along by the rivers and other streams finally to be deposited on lake and ocean floors. The manner in which these particles were deposited had much to do with the new rocks which they later formed. The following experiment will illustrate the process.

Experimental Problem 4. — *How are soil particles sorted into layers by water?*

What to use: A tall cylinder; half a cupful of soil; and water.

What to do: Have your Science Discovery Book right at hand to record your observations. Then nearly fill the cylinder with water and pour the soil into it. Cover the cylinder with the hand and shake thoroughly. Allow it to stand quietly until the water above the sediment (soil matter) has cleared.



EXPERIMENT 4

Why is a tall cylinder used? Name **A** and **B**.

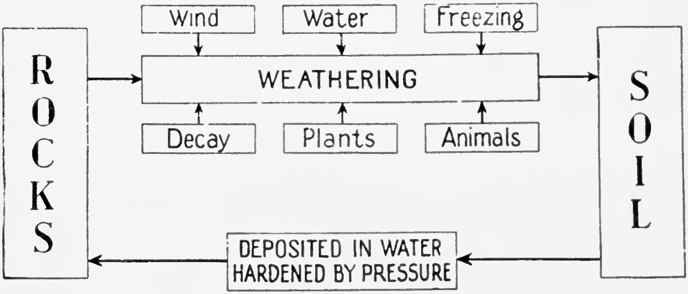
What happens: Observe carefully the way in which the sediment is deposited. Which particles settled the more rapidly, the larger or the smaller?

Conclusion: Explain how and why the sediment was deposited as it was.

Field Research:

If you can visit a sand or gravel bank, investigate it to find evidence of layering of the particles. Compare the results of your investigation with those of the above experiment.

26. Stratification. — You now know by experiment that finely broken rock matter will settle in water so as to form layers of different sizes of rock pieces. You know also that the vast quantities of matter in solution in the water will be deposited. It was in just this way that sandy and muddy material was deposited

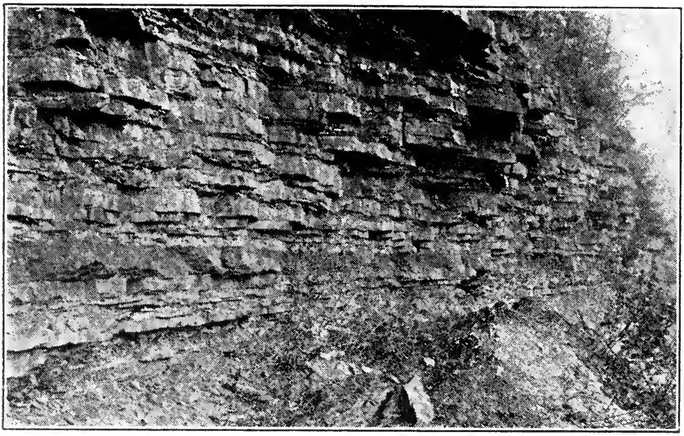


Trace the rock-soil cycle. Explain each step in the cycle.

on ocean floors during the early life of the earth, and is still being deposited.

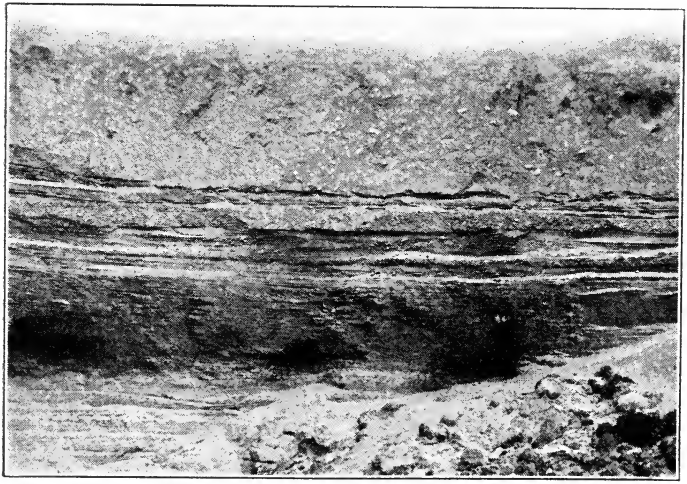
Study the pictures on page 66 and the pictures on page 98. Answer the questions under each picture.

In the long process of the earth's formation, many layers of rock materials were buried beneath hundreds and hundreds of similar layers. All together, deposits several miles thick were formed. The great weight of all this material pressing on the lower layers compressed, heated, and cemented them into solid layers of rocks. Such layers are called *stratified rocks* and their formation in *strata* (another word for "layers") is called *stratification*. Our most common rocks occur in layers and are of comparatively recent formation if their age is contrasted with that of certain other rocks



Stratified Rock

What relation has this rock formation to the way the sand and gravel in the lower picture was deposited? How do you account for the piles of rock material at the base of the cliff?



A Sand and Gravel Pit

Do you think the sand and gravel was deposited in water? Why?

which were formed before the water began its work, and similar rocks formed since.

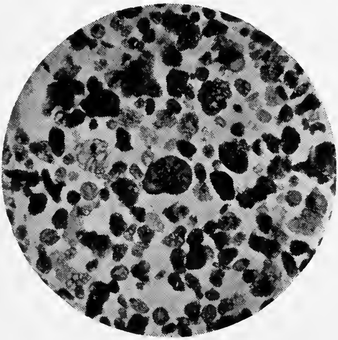
27. Sedimentary Rocks. — Since sediment is the material out of which stratified rocks are made, such rocks are also called *sedimentary rocks.* While it is true that sedimentary rocks were formed under water (sediment dropped on ocean floors), changes in the levels of

A Fossil Coral Bed

The rock above and below the coral is limestone. Coral contains lime. What does this fact suggest?

the earth's crust lifted some of them above water, where they were left high and dry, — convenient for our study and use. Three kinds of sedimentary rocks are very common to-day, — *limestones, sandstones,* and *shales.* Let us see how they are made and what they are like.

28. The Making of Limestones and Sandstones. — Limestones and sandstones were made from water deposits, but they differ from each other in the kind of materials and particles which compose them. Broken sea shells, coral, and skeletons of tiny sea animals containing lime and lime materials from plants were deposited in layers on the ocean floor, forming different varieties of limestone. Another kind of limestone was formed from lime materials that had been dissolved by the water soaking through rock and soil, and later deposited on the ocean floor.



Highly Magnified

LIME SHELLS FROM CHALK

How are these related to limestone?

Sandstones, as the name implies, are made by the joining together of the grains in a mass of sand. The sand particles in some varieties of sandstone are bound together by lime. However, in some very durable sandstones a substance like iron rust holds the grains together. Have you not seen red and brown sandstones?

29. How to Know Limestone. — Limestone has several characteristics which make its identification easy. It is so (1) *soft* that you can readily scratch it with a nail.

The softness or hardness of a rock is determined by reference to a scale of ten *minerals*, classified according to their relative hardnesses. Number one is the softest; number two is just hard enough to scratch the first; number three will scratch the second; and so on to number ten, which is the hardest. *Talc* is number one; the *diamond* is number ten. Limestone scales four.

A *mineral* is a lifeless substance always having the same elements in the same proportion. It usually has a crystal shape, and occurs mixed with other rock materials. See page 30 of the Appendix for Key to Common Minerals.

The next test is its peculiar (2) *odor* when it is breathed upon. Blow your breath against a piece of limestone and you can detect the odor which you will come to recognize after you have repeated the experiment with a number of specimens.

The third and surest way of identifying limestone is by the use of (3) an *acid*. Do you know what an acid is and how to recognize one? Liquids such as vinegar and fruit juices *taste sour* because they contain an acid, for acids taste sour. Acids also will *change the color of colored paper or cloth.* A specially prepared blue paper, called *litmus paper,* is used by chemists to test for acids. Blue litmus will turn to a pinkish shade if it comes in contact with a substance containing an acid.

Coquina Limestone

What does this picture suggest as to the formation of limestone?

How does acid affect a piece of limestone? If an acid is poured on limestone, a foaming, or *effervescence*, takes place due to the rapid formation of a gas, *carbon dioxide.* The following demonstration will show you what takes place.

Experimental Problem 5. — *How do acids affect limestones?*

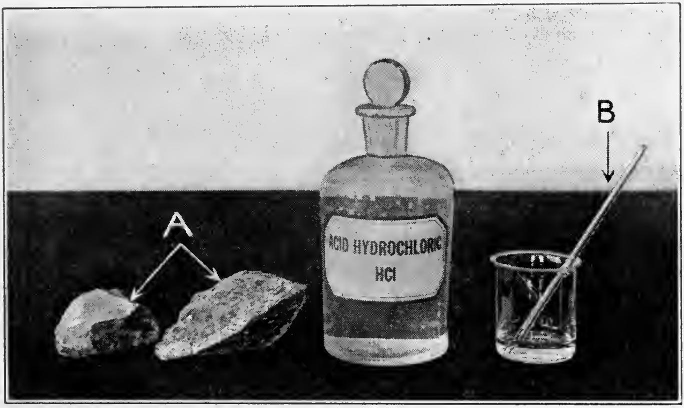
What to use: Dilute hydrochloric acid (1 part acid to 4 parts water) and a piece of limestone.

(An acid is said to be *dilute* if it contains a large amount of water. If it contains a comparatively small amount of water, it is said to be *concentrated.*)

What to do: Pour one or two drops of the acid on the limestone.

What happens: What did the action of the acid produce?

Conclusion: What general statement can you make about the effect of acids on limestones?



EXPERIMENT 5

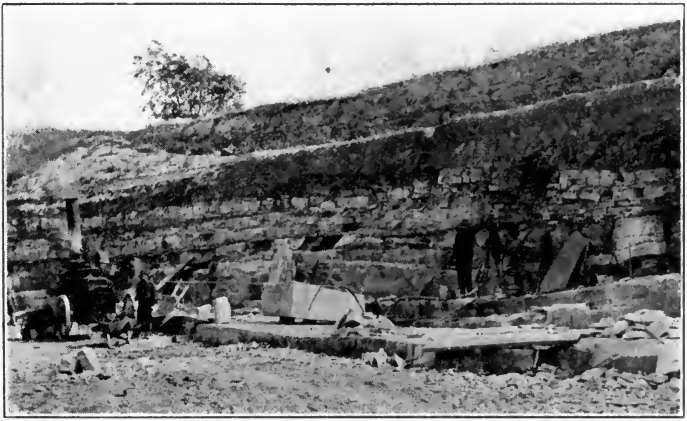
A, pieces of limestone. **B,** a dropping tube. Why use it?

Application: You now have tests by which you can identify limestone. Try the tests on several other kinds of stones to find out for yourself that they do not react with the acid in the same way.

30. An Air Acid. — There is another acid called *carbonic acid* which affects limestones. It is formed in the air by the union of water and carbon dioxide, but as it acts very slowly, it takes a long time for its effects to show on limestones exposed to it. Limestones affected by it are said to be *weather-worn.* Examine a piece of weather-worn limestone to find the little pits caused by the action of carbonic acid.

Field Research:

Examine several pieces of limestone closely, using a magnifying lens as well as the naked eye. Observe the fine grains, color, and general appearance. Test the pieces not only with acid but by odor and by scratching with a nail or file. Try to become so familiar with the characteristics of limestone that you can pick out all the specimens from a pile of mixed rocks.



A SANDSTONE QUARRY

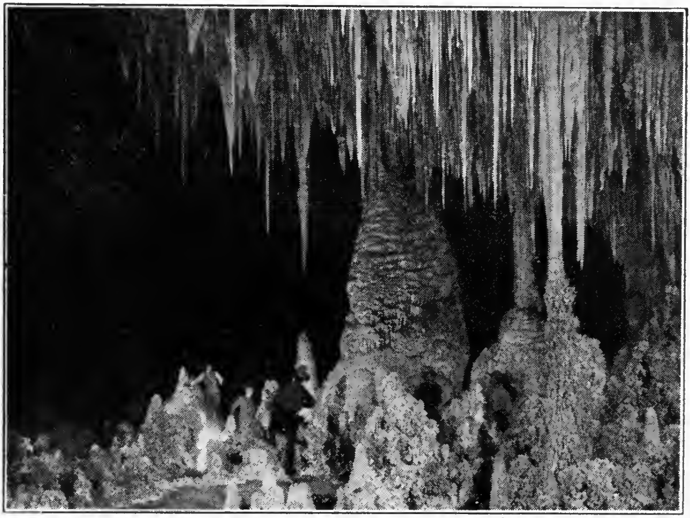
Do you think this stone was formed in water? Why?

31. Limestone Caves. — When water containing some of this carbonic acid works its way through limestone formations, it may, after millions of years, dissolve enough of the limestone to leave a cave. Some caves thus formed are very large and wonderful.

Field Research:

Get two samples of drinking water. Blow carbon dioxide through one sample of water. Then add a little powdered limestone or chalk and shake for a few minutes. Let stand till clear. Then test clear water solution with a little liquid soap, by shaking. Test an equal amount of second sample of water above, with same amount of liquid soap. Less suds (foam) indicates more lime in solution. How does this help to explain caves?

When some of the water containing lime in solution drips down through the roof or ceiling of the underground rooms, a kind of lime deposit is formed which hangs from the ceiling like icicles. The longer the water keeps dripping, the larger they get. As the lime solution drops to the floor, a spire is built up from the



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STALACTITES AND STALAGMITES

How has water helped to make these formations?

floor. Sometimes the *stalactites* (hanging from the roof) and the *stalagmites* (built up from the floor) meet and form pillars and curtains. Often they are beautifully colored by minerals. Underground streams flowing through these caverns add to their beauty.

The caverns in the Carlsbad Caverns National Park in New Mexico are the most extensive caves explored. One room alone is 4000 feet long and 300 feet high in places. The Giant Dome in this room is a great stalagmite 62 feet high and 16 feet in diameter. Scientists, judging by the rate at which stalagmites increase in size, have estimated this to be 60 million years old.

Related to the stalactites and stalagmites is travertine, also called tufa, a porous limestone-like deposit made by hot springs. Water heated by contact with hot rocks below the surface is able to dissolve lime material, and bring it to the surface. Here the water cools and deposits the lime in beautifully edged basins. Some of the colors of the rock are due to minerals, such as iron. Some of the yellow color is due to yellow organisms which can live even in hot water.

Geysers, or spouting hot springs, are similar to hot springs, except that while the hot spring flows continuously, the geyser spouts, or throws out water at more or less regular intervals.

Why geysers spout is an interesting problem. Water trickles from the surface, down through a crack of the rock, to quite a depth, where it collects in a larger basin, until the basin at the bottom and the crack or tube leading to it are filled. The water in the basin at the bottom becomes very hot, and changes rapidly to steam. All of a sudden, the steam pressure is enough to force the water in the tubelike crack out into the air, the rush being so rapid, that the mixture of steam and water is drawn out of the basin also. Of course, as soon as the basin is emptied, the geyser stops spouting. The water that has been driven out of the geyser gradually works its way back, filling the basin and the tube above. Then, after a time, it spouts again.

32. How to Know Sandstone. — There are no simple tests for sandstone such as we use to identify limestone. It will not foam when treated with acids nor does it have an odor by which you may recognize it. It does have a few qualities, however, which you will come to recognize after several observations. Sandstone (number 6 in the scale) is much harder than limestone and its particles are much larger. A comparison of the two stones will also show that the sandstone particles have a much glossier (glassy) finish than those of limestone. With practice you will easily develop ability to distinguish one stone from the other.

33. Shale and Its Formation. — In some localities the rock layers of a river bed are composed of a flat, brittle type of rock. This rock varies in color (gray, red, blue, black), is smooth to the touch, and easily broken. Such rock is called *shale.*

Shale is formed from *clay* which has been deposited in water in layers just as the sand was from which sandstone was made. The clay particles are very fine, and when wet have a gummy quality which causes them to stick to each other. You can easily imagine what happens when layers of them are subjected to heat and pressure far beneath the bottom of the ocean. The thin, smooth rock layers which result can be broken without much effort.

34. Uses of Sedimentary Rock. — Limestones and sandstones are used for building, especially where a high polish is not required. Sandstone is frequently used for steps, walks, and curbing. It is also used for grindstones. Limestone is used in the manufacture of glass and lime. It is placed in ovens, over very hot fires which drive off a gas (carbon dioxide), leaving the lime. Lime is used in preparing mortar and cement. Pulverized shale is used in making bricks and sometimes as a road-building material.

General Problem 2. How Do Fossils Help Tell the Age of Rock?

35. Rock Records. — Frequently rock layers of limestone, sandstone, or shale contain interesting records of plants and animals that lived ages ago. At the time when these rock layers were deposited as sand and mud, sometimes plant or animal life was caught, held prisoner, and became a definite part of the rock formation. The scientist calls such records *fossils*. A fossil may be only *the impression of a foot or shell*, or it may be *an exact duplicate in stone of the entire animal or plant*, or it may be even *a piece of original shell or bone*. Such remains offer the scientist a wonderful opportunity to know something of the life that was on earth when the rock was forming. The fossils found in rock layers are usually impressions of animals and plants native to salt water. What does this tell us about the origin of many rocks?

Footprint of an Ancient Reptile

What fact does this footprint in stone tell?

Fossils and petrified wood have something in common regarding their origin. In neither case has the original material changed to stone or mineral, as is sometimes thought. What really happened is, that as the plant or animal material decayed it dissolved, or was washed out gradually by water soaking through it. Then the water filled the little spaces by depositing the minerals which it carried in solution.

It is more correct therefore to say that the substance reproduced as a fossil has been *replaced* by stone or mineral. The replacement is so gradual that often the exact structure is duplicated. Of course, if the fossil is the result of an impression in soft mud, say a footprint or a raindrop, it does not represent material

Courtesy Atchison, Topeka & Santa Fé Ry.

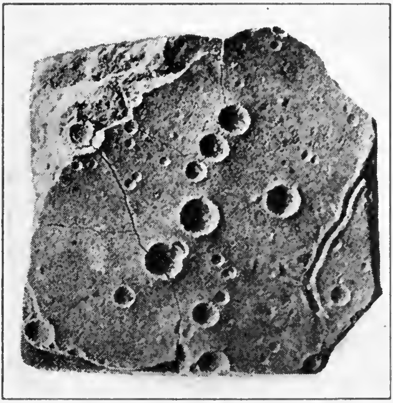
PETRIFIED WOOD

Do you think wood changes to stone?

which has dissolved away. It is simply an imprint which has remained as the rock materials in which it was made hardened.

36. An Old Story. — Fossils also show that hundreds of thousands of years ago the ocean itself stood where the rock layer in which you find the fossil now stands. The thinness or thickness of rock layers is a record of the lengths of ancient periods. A foot of one kind may have taken longer to form than a corresponding thickness of another kind.

You may have examined small fossils that look like clam shells or oyster shells (page 69). In sandstone you may have found some long reed-like-looking fossils that are the impressions of some ancient sea-weed; or you may have found portions of *trilobites* (a fossil shellfish, easily recognized because the tail portion is made in three lobes).



Raindrop Autographs

Did you know that raindrops vary in size? Here is evidence that they do. Do you think the stone was once part of a muddy shore? Why?

Fossil Crinoids

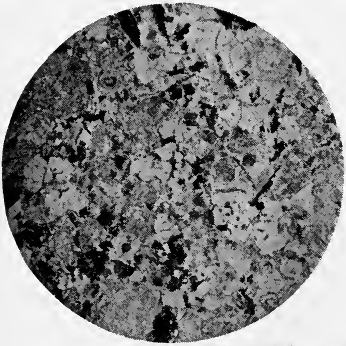
Crinoids were salt water animals. Do you think the rock was formed from fresh water or salt water deposits? Why?

Even the *ripple marks* found preserved in rocks tell a story. Waves at the shore heap the sand into line after line of little ridges which are called ripple marks. This happens only in shallow water near shore. Therefore if you find ripple marks in rocks, you know that the sand for those rocks was laid down in shallow water.

Fossils in such rocks usually represent animals and plants that lived in or near shallow water.

General Problem 3. What Are Fire-made Rocks?

37. How Heat Helped to Make Our Rocks. — You have been studying rocks that were formed from water sediments. Other kinds of rocks, of which *granite* is an example, were formed in the early stages of the earth by melting and cooling. When the hot and partly melted mineral materials cooled and solidified, these harder rocks, which we are now to study, were formed. Rocks formed in this manner are called *igneous* (fire-made) rocks.



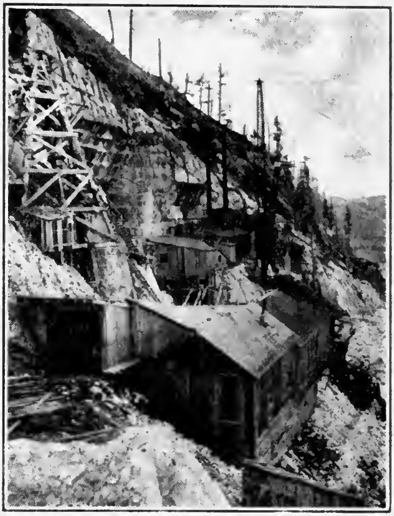
Magnified 8 times

Granite

Can you detect three types of crystals?

In their early period many of the igneous rocks were broken up into small particles by action of the gases and moisture in the air (page 52). The wind and driving rains also played a part in this breaking-up process. The broken materials were carried by streams into the lakes and oceans, where they settled to the bottom and later became sedimentary rocks. By the action of unusual heat and pressure some sedimentary rocks, long after their original formation, were changed in form and appearance. *Marble*, *slate*, and *quartzite* are the results of changes in some sedimentary rocks.

38. Marble, Slate, and Quartzite. — A study of great rock strata (page 66) helps us to understand how limestone is sometimes changed to marble. As layer after layer of rock sediment settled on the ocean bottom, the weight of the upper layers packed and cemented the lower layers into solid rock. Then at a later period the shiftings and sliding of the layers of rock caused such increased heat and pressure that some of the layers were partly melted. When these hot, softened layers cooled, a hard compact rock resulted. Such heat and pressure on limestone gave us marble; on shale, it gave us slate; and on sandstone gave us quartzite. These rocks are therefore fire-made or transformed rocks. They are called *metamorphic* rocks. *Metamorphic* comes from the Greek and means "changed form."



Ewing Galloway

A Marble Quarry

From what rock is marble made?

Similar movements, such as the shifting, twisting, and folding of the earth's crust, occurred when mountains were formed. In some places molten rock or lava forced its way up through cracks in the sedimentary rock and spread out over it. This was another source of heat which frequently changed limestone into marble, shale into slate, and sandstone into quartzite.

Marble is harder and closer grained than limestone, and because of these qualities, it can be polished. It will react to an acid just as limestone does. Mineral impurities in the limestone, which appear as colored markings in the marble, add much to the beauty of marble. Slate is harder and stronger than shale. Quartzite is glassy.

Though marble, slate, and quartzite are fire-made rocks, we must not forget that each came from sedimentary material. This is not true of granite. Granite is a fire-made rock that had no earlier occurrence in water.

QUARTZ CRYSTALS

Quartz particles in granite are not as perfectly formed as these.

39. Granite, the Oldest Rock. — Granite is one of the oldest kinds of igneous rock. It is very hard and compact, and for this reason will take a high polish. The polished granite columns in front of our buildings owe their various colors to impurities which dissolved in the melted rock. These impurities, in the cooling process, assumed queer shapes in which your imagination easily sees animals, trees, buildings, and the like.

The tiny separate grains of granite are really bits of mineral matter (page 78), crystal in shape. The crystals in marble are all alike but those in granite differ from each other. Crystals in granite are of three kinds, — *quartz, mica,* and *feldspar* — and all three varieties are usually to be found in any selected piece of granite. *Orthoclase* is a variety of feldspar.

40. Quartz, Feldspar, and Mica. — *Quartz* is a very common mineral. It has other sources than granite. When found alone, it occurs in beautifully shaped crystals of six sides, like six-sided prisms. The top and bottom of the crystals are shaped like a six-sided pyramid. Due to slight impurities some crystals are beautifully colored. The rarer forms are used as gems for jewelry. You may be familiar with a few of them — the *amethyst, onyx,* and *carnelian.* (Do you know the color of each of these gems?)

Quartz (number 7 in the scale) is the hardest mineral of common occurrence. A sharp edge of quartz will scratch glass. The hard, glassy particles in sand are broken and worn quartz crystals. You can see them with a magnifying glass.

A FELDSPAR CRYSTAL

Compare the shape of this crystal with that of quartz crystals. How do they differ?

Flint is a somewhat impure, dark-colored variety of quartz and breaks with a sharp edge. As it is very hard and causes a spark when struck against steel, these two materials have often been used together in fire-making devices. It was the chief material of the stone implements of primitive man, and was used by the Indians for arrowheads.

Feldspar is a very important mineral found not only in granite but also in great quarry deposits. It has many colors and because of its brittle nature will split into regularly shaped blocks with smooth, shiny surfaces as pictured here. Nearly as hard as quartz, it is not as durable since the carbon dioxide and moisture of the air change it rapidly into a pure clay called *kaolin*. This decomposition (breaking up) of feldspar has yielded a large part of the clay of the soil, some of which is used in the making of pottery.

MICA

What interesting fact about mica is illustrated here?

Mica, a mineral that can be split into thin sheets, is more commonly seen in the form of flakes. Like feldspar it occurs in large quarry deposits as well as in granite. There are black, brown, yellow, and transparent micas. The kind that is nearly colorless and transparent is very valuable, if large sheets can be secured. This kind is frequently used in stove doors for windows. Mica will not burn nor will it conduct electricity. Hence it is often used by electricians as an insulator (a substance that will not carry the electric current).

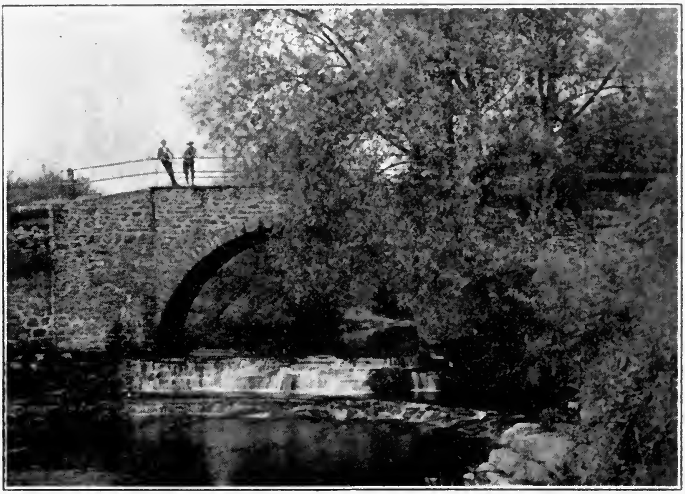
Field Research:

Examine a granite boulder to see if you can discover small pieces of mica. You may be able to dig some out with a sharp-pointed instrument.

Examine a sample of sand with a magnifying lens. You will discover that it contains not only particles of quartz, which largely make up the sand, but also tiny pieces of feldspar and mica.

General Problem 4. What Makes Good Building Stones?

41. Building Stones. — As Nature used immense rock formations to build the earth, so man uses rocks to build great structures.

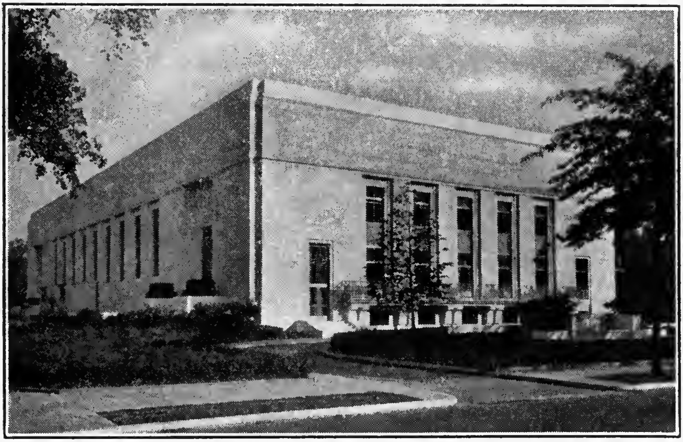


A Limestone Bridge

Limestones are used in cellar walls and upper walls of buildings, in dams, and in bridges. You have learned that many limestones are affected by the action of the air. (What air acid would cause this?) Consequently, only the varieties that will withstand this action are suitable for exposed parts of buildings.

Sandstones are durable and strong, and hence they make good building stones. They are much less affected by the weather than are most limestones, especially if they are cemented with the iron-rust material. Sandstone occurs in red, brown, and gray shades, and these colors adapt it to wide uses for trimming and decorating a building.

Slate is used for stair treads, blackboards, table tops,



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Why is marble desirable for beautiful buildings?

roofs, and similar articles requiring hard, smooth surfaces.

Granite, as you have observed many times, is generally used for decorative purposes about buildings, for monuments, and for columns. Because granite is not affected very much by the weather and is hard enough to take a polish, it is a very useful and beautiful building stone.

Marble is often used for ornamental purposes in corridors, stairways, monuments, and columns. Fronts of buildings are frequently decorated with marble.

Field Research:

Examine an old marble monument to observe the effect of weathering. What acid caused the effect?

To-day many *artificial* building stones are used. Some are very good imitations of natural stone. In your observations, try always to distinguish between those of Nature's manufacture and those which man has made.

Limestones, sandstones, and granites are not only building stones for our homes and other private and public structures, but they are the building stones of our soil. The other kinds of rocks which you have studied in this chapter are also important as soil-building materials. We shall learn something of soil-building in the next topic.

Key Words

acid	granite	prism
carbon dioxide	hardness	quartz
carbonic acid	igneous	quartzite
clay	kaolin	ripple marks
crystal	land cycle	sandstone
decomposition	layer	sedimentary
effervescence	limestone	shale
feldspar	litmus paper	slate
fire-made rocks	marble	soil
flint	metamorphic	stratification
fossil	mica	transparent
grains	mineral	

Key Statements

1. Rocks in layers are called stratified rocks. They were formed from sediment which was deposited in water and afterward compressed and hardened.

2. Heat is caused by layers of rock being crumpled or folded; or by changes in position of the rock layers.

3. Acids will change the color of blue litmus paper to pink.

4. Limestones may be identified by their softness, odor, and reaction to acid. They are composed mostly of broken shells of ancient animal life or of lime deposits from sea water.

5. Marble was made from limestone through the action of heat and pressure. It reacts to acids just as limestone does but is harder and is crystalline in structure.

6. Marble and limestone are affected by the moisture and carbon dioxide of the air, which together form an acid.

7. Sandstone is composed mostly of sand particles cemented together. It is rough and durable but cannot be polished as can marble. It does not react to acids.

8. Fossils are rock-written records of ancient life.

9. Granite is composed of quartz, mica, and feldspar. Orthoclase sometimes replaces the feldspar. Granite is very hard and durable and can be polished. It does not react to acids.

10. Colors in quartz are due to small amounts of various mineral impurities.

11. Feldspar is a mineral which changes to clay as it breaks up.

12. Shale is a thin rock made from clay.

13. Slate is a hard rock made from shale by heat and pressure. It can be split into sheets.

Thought Questions

1. How can you tell whether or not a substance contains an acid?

2. If sand is dropped into water, why will it settle in layers?

3. What substitutes are used for stones? Why are they used in place of the stones?

4. How would you know whether or not a rock was formed of material deposited near the edge of a body of shallow water?

5. Which is better to live in, a stone house or a wooden house? Debate the problem in class.

Projects for Your Science Discovery Book

1. Test various substances with litmus paper to find whether or not they contain acids. List the substances tested, and mark each one that tests for acid.

Note. To make the test, dissolve a little of the substance in a teaspoonful of water and place a drop on the litmus paper.

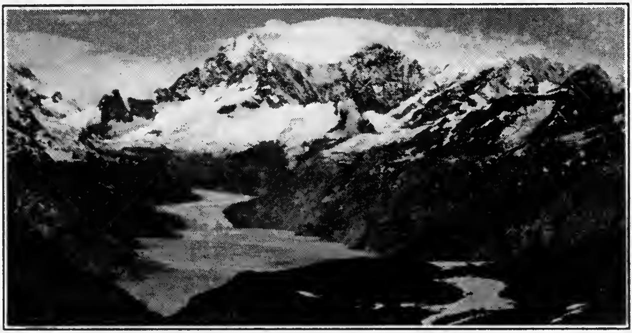
2. State all the ways by which you can identify limestone.

3. List all the things you can think of which we should have to do without if there were no stones.

4. Draw a picture to show just how rocks that you have seen in a gorge were situated. Then write a story telling what you think caused them to form as you found them.

5. Make a drawing to illustrate how sediment is deposited. (See Experiment 4, page 64.)

SURVEY OF TOPIC V



We have studied the water cycle. Here heat causes evaporation, removal of heat causes condensation, and gravity pulls the water back to earth. The rock-soil cycle, that ever-changing process of soils to rocks and rocks to soil, is brought about by the coöperating forces and agents of Nature, one of which you know as water. Are there other forces or agents of Nature which combine to give us soil?

The answer is "Yes." There have been, and are to-day, many soil-makers in this land of ours. With some of them you are familiar — the lowly earthworm or the burrowing woodchuck; others you have read about, or seen in the movies — the wind storms, for example, with their grinding particles of sand; still others you know worked long before the memory of man — the great glacier that moved down from Canada across northern United States, from the Atlantic to the Pacific, and ground and pushed and carried soil into our country. How have these many soil-makers done their work?

TOPIC V

SOIL FORMATION

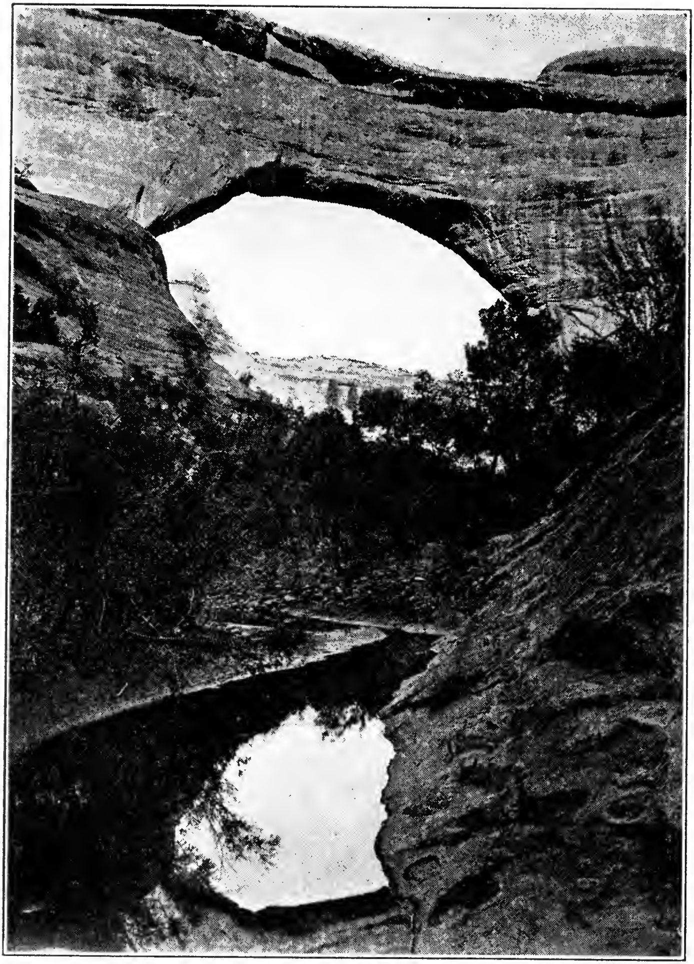
When Spring unlocks the flowers to paint the laughing soil. — HEBER

Do you know:

1. **Whether or not stones grow?**
2. **How freezing water can split a rock?**
3. **Why some soils blow with the wind more than others?**
4. **That sand carried by the wind grinds rock into small particles?**
5. **How a tree can grow out of a rock? How it can live there?**

GENERAL PROBLEM 1. HOW IS SOIL MADE BY WEATHERING?

42. The Soil-making Agencies of Weather. — *Weathering* is brought about by the action of sunshine and storm, wind and rain, acids and oxygen of the air, running water, frosts, and by the work of plants, animals, and tiny organisms. You see, weathering is not really any particular force of Nature but rather a combination of forces. Rocks put up a sturdy resistance to the attack of these forces, but sooner or later, — perhaps it may take centuries, — their resistance is overcome and they are beaten and battered and ground into the dust which forms our soil. *Erosion* (page 48) is the name for this wearing-down process and so we have water erosion, wind erosion, or any other kind of erosion according to the agent which causes the action.

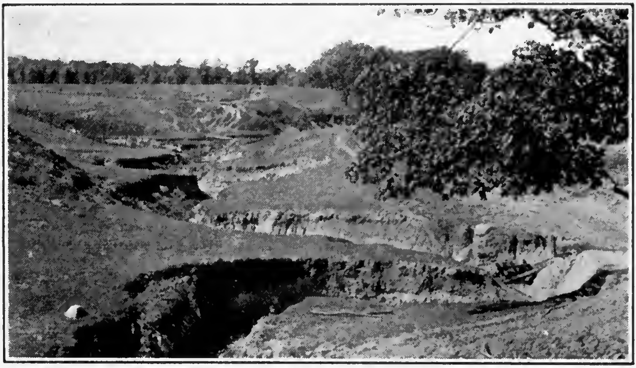


Denver and Rio Grande Western R. R.

AUGUSTA NATURAL BRIDGE, UTAH

Study this picture in order to explain the formation of the bridge. After you have studied about soil formation, explain the relation of this picture to soil formation.

43. Water Erosion. — "A hundred roaring rivers unite to form the Colorado, a mad, turbid stream," so wrote Major John W. Powell, who explored the Grand Canyon in 1869. The water of all these rivers is wearing down that great drainage area at the rate of about five billion cubic feet of sediment a year, and all of this is carried by the Colorado. Running water

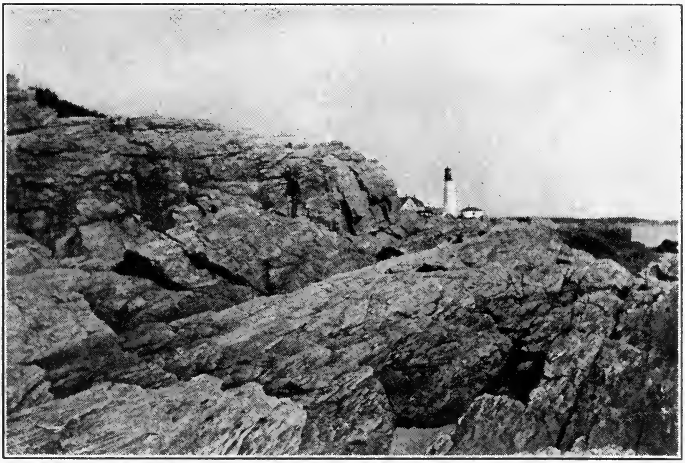


Damage by Erosion

Explain what has happened to this land. What can be done to prevent it?

is continually loosening the soil along its course and carrying the soil particles to lower levels. More slowly but just as surely, running water wears away the hard rock that it touches. It is aided in this work by the particles of soil which it carries along. These particles, we should remember, are very fine bits of rock and so they serve as excellent cutting tools in grinding away the larger rocks with which they come in contact. Large rocks moved by water also cut rapidly.

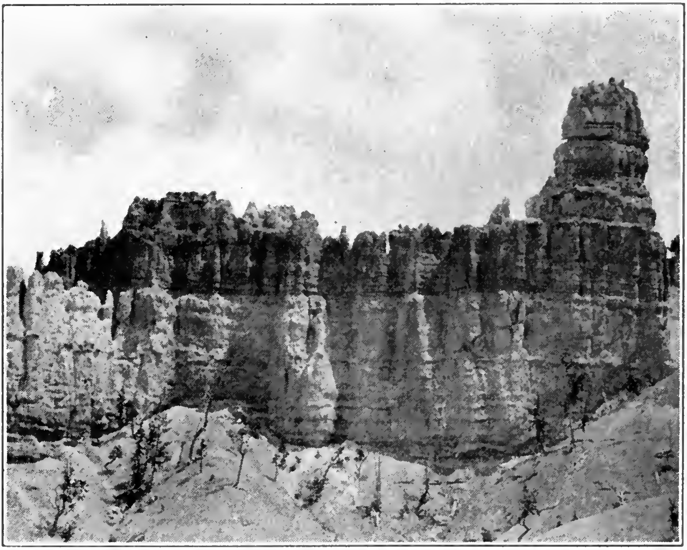
This process goes on indefinitely, owing to the never-ending water cycle which constantly supplies water to the stream and river sources. You have already considered the Grand Canyon with its silent testimony to the power of running water. The deep cuts in the rocky bed tell the interesting story of uncounted years of conflict in which the rock was forced to give more and more of itself to help the river build up the lowlands. The cutting and grinding, and the washing down and



Wind, Water, and Ice Erosion

carrying off of the particles, go on wherever water is in motion. Even the tiny rivulets of rain water help in this business of making soil. The water that soaks into the soil and into rock cracks dissolves minerals of many kinds. These substances are brought to the surface by springs, or are carried out to sea, where they may be deposited to add to the rock-making layers. Water is certainly one of Nature's great agencies of soil-making.

44. Wind Erosion. — Wind grinds rock into soil by blowing small sharp rock particles against rocky cliffs. You have read of sand storms and know that people take to shelter to protect themselves against the cutting action of sand. Man has learned to make this cutting power of sand do work for him by using compressed air to blow sand particles against stone and brick buildings to clean them. Not only are rocky cliffs cut into and



Union Pacific System

THE CATHEDRAL, BRYCE CANYON

Explain how wind and rain have carved the rock. Where do you think the piles of materials came from that are burying the trees?

worn away by drifting sands, but particles carried by the wind are themselves broken into smaller and smaller soil particles. In arid parts of the country, the results of wind erosion are quite plain. In other parts where there is much rain the effect of the wind is overbalanced by the action of water. Wind and water together are powerful partners in soil-making.

General Problem 2. How Are Glacial Soils Made?

45. The Continental Glacier. — Much of the northern portion of the United States and a considerable

The Great Ice Sheets of the Glacial Period

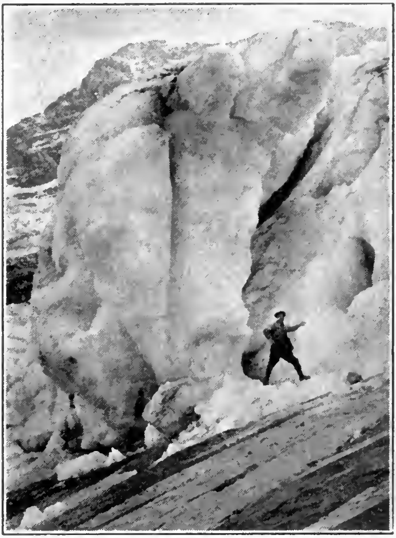
portion of Canada are covered with a layer of soil varying in thickness from a few inches to many feet. This soil had an origin quite different from that of any other soil in the United States.

Twenty-five to fifty thousand years ago, Canada and the northern part of the United States were covered with a great layer of ice, a *glacier*. It varied in thickness from a few feet to hundreds of feet. This broad ice sheet flowed very slowly down from Canada over the southern part of what is now New York State into Pennsylvania, over the border down into Illinois, and *westward* nearly to the Pacific coast.

Trace the edge of the ice sheet on the map.

The great ocean of ice moved with unbelievable slowness, and yet it was ever grinding rock particles into soil and pushing and carrying the soil over these widely scattered areas.

Since the climate is warmer now than when the great glacier did its work, the ice sheet has melted away until only remnants are left in northern Canada. But its work tells the story.



Hileman

THE EDGE OF A GLACIER

The ancient glacier covered so large a part of the continent that it is named a *continental* glacier. The present *Greenland* glacier, much studied by modern explorers and scientists, is also a continental glacier.

Many of the modern glaciers that are now grinding out soil for us are more like narrow rivers of ice flowing down ravines from the tops of mountains. If you are interested in our glaciers of to-day, you can read about the beautiful ones in our Sierra and Rocky mountains. In northwestern Montana we have Glacier National Park, set aside as a playground for all the people. Because these glaciers are available for study, we are discovering a great deal about the activities of glaciers.

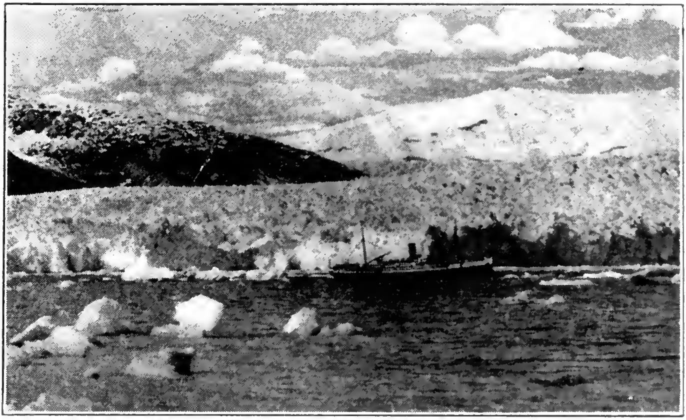
46. Glacier-built Hills. — Much soil and broken rock material which was pushed along by the ancient glacier was left in hills of various shapes and sizes. Some were rounded or oval shaped, while others were deposited in long narrow ridges, lying in the direction of the glacier's movement. Much of the soil material which the glacier carried had been collected in great piles along the margin of the glacier.

As the glacier slowly melted upon its approach to the warmer latitudes, these piles of rocks and other débris were dropped as hills, often into the peculiar positions which are characteristic of glacial *terrain* (a general term applied to any particular area of ground). Whenever this material fell off into a body of water, its particles were sorted as in Experimental Problem 4. Naturally there was no sorting of the particles, if they fell on solid ground. Assisted by the gradual wear and tear from the glacier's movements, the sun's rays finally completed the destruction of the glacier, thus leaving a layer of rich soil in some places and rock-sprinkled hills in other areas.

Field Research:

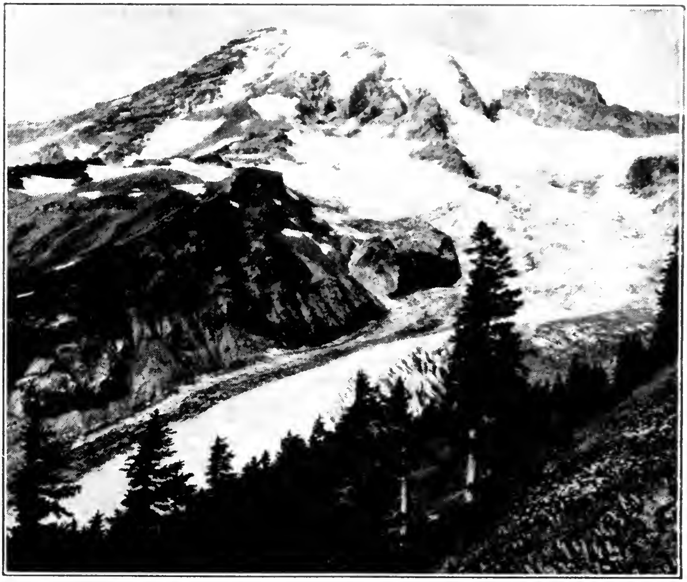
If you live where there is glacial soil, examine some newly cut trenches to observe the size of soil particles. Determine whether it was dropped into water or not.

47. Glacier Writing on Rocks. — In some localities, glaciers scraped over bare bed rock. On these rocks the glacier left its marks in the form of scratches.



Courtesy Alaska Steamship Company

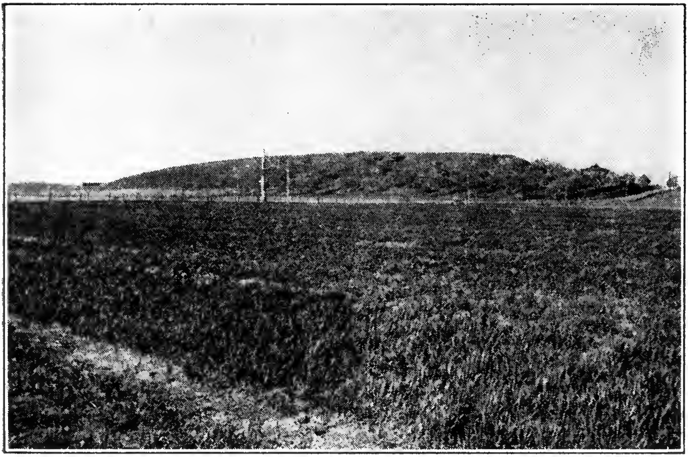
TAKU GLACIER



Courtesy Great Northern Railways

ONE OF THE TWENTY-EIGHT GLACIERS ON MOUNT RAINIER

Explain the cause of wild flowers so near a glacier.



A Drumlin

A glacier-built hill.

Unsorted Glacial Soil

Do you think such soil as this was deposited in water?

All of the scratches were parallel, thus showing the direction in which the glacier moved, and sometimes they were very deep. If some day you find a small boulder polished on one side and showing parallel scratches, you may be sure that you have found a stone which was held frozen to the under side of a glacier and worn smooth by being rubbed against the bed rock underneath. Imagine the great age of such a stone.

A GLACIAL BOULDER

What two things in this picture indicate that the rock was held firmly by the ice?

48. How Freezing Water Makes Soil. — What happens to the water which has seeped into the ground when freezing weather comes? Naturally the water will freeze, and in freezing it breaks things up. You can see how one girl noticed the power of freezing liquids. Read this letter actually written by a pupil of your age. Can you solve her problem?

Dear Miss Russell: —

Why is it when you leave a bottle of milk outside on a frosty night the milk will open the bottle and about a glass of milk will come out as a hard object and will remain on top of the bottle? That happened one night with our milk. Another night the same thing happened and the bottle broke.

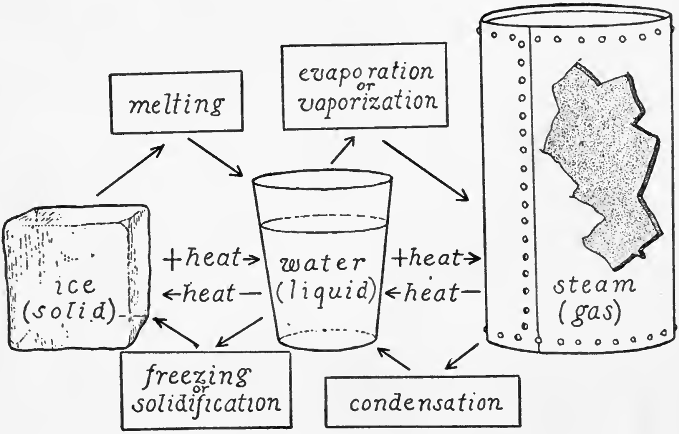
I cannot understand it because I learned that when objects get cooler they contract.

Please answer to-day if there is time. Florence

What Florence learned is correct but there is more to the story. Some substances do contract when they get cooler, just as gases condense when cooled. The freezing of water, however, is an example of what may happen when liquids change to solids. When water or milk freeze (change to the solid state), they *expand.* Therefore a bottle full of milk or water will break when the liquid freezes unless the solid pushes up out of the bottle.

FROZEN MILK
Explain this picture for Florence. Why did the string break?

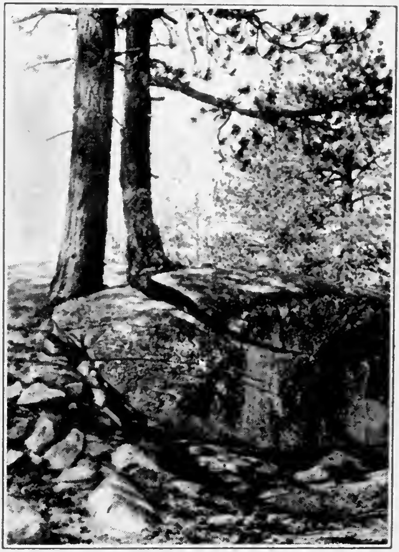
In the same way when water gets into the cracks of a rock and freezes, the expansion will often split the rock. Thus water is an important force which Nature uses to break up rocks and change them into soil.



THE SOLID-LIQUID-GAS CYCLE
Follow the arrows and explain each step in the cycle.

General Problem 3. How Do Plants and Animals Make Soil?

49. Plants as Rock-Breakers. — Roots of plants sometimes grow into the cracks of rocks in their search for water. Then as the roots get larger, they split open the rocks as in this picture. In the same way many rootlets grow into other tiny cracks of the rocks, gradually breaking them into smaller and smaller pieces, suitable to soil purposes.



Rocks Split by Roots

Explain how the tree helps make soil.

50. Animals as Soil-Makers. — The action of water, ice, oxygen, wind, and living plants in breaking up rock material would alone make poor soil. So Nature provides an army of animal workers, from the size of woodchucks to the smallest insects, that literally grind and mix the soil until it becomes fit for plant growth.

Plant and animal materials, living or decaying, are called *organic matter*. Wood, leaves, roots, grasses, and meat are examples of organic matter.

The decaying parts of both plants and animals help to enrich the soil with organic matter (page 27), without which plants would not grow. Acids formed by this decaying matter together with carbonic acid from the air help greatly in the decomposition of rock into

THE WORK OF GOPHERS

The animals burrow just under the surface. How do they help improve the soil?

soil. How this decaying matter helps to make fertile soil is a part of the next chapter.

KEY WORDS

continental	freeze	organic
erosion	glacier	terrain
expand	glacial scratches	weathering

KEY STATEMENTS

1. Weathering is action of wind, water, and other agencies such as air, frost (ice), heat, and so on.

2. Soil comes from rocks which are broken up by the action of the wind, water, air, frost, glaciers, plants, and animals.

3. Millions of tons of soil particles are carried by the waters of our streams every day.

4. Much of the soil of our northern states was made and transported by glaciers.

5. Soil made by ancient glaciers was often dumped in piles or hills along the margin of the ice.

6. The direction of a glacier's movement can be told by the direction of the scratches on the bed rock and by the direction in which the glacier-made hills point.

7. When water or other liquids freeze, they expand.

8. Roots of plants grow into cracks of rocks and split them.

9. Acids from organic decay and from the air decompose rocks.

10. Animals grind and mix great quantities of soil annually.

Thought Questions

1. What is meant by water erosion?
2. What aids does water have in its wearing away of rock?
3. How may water split open a rock? Explain.
4. How can a root break a rock?
5. What assistance is rendered by animals in soil-making?
6. What are the three kinds of matter?

Projects for Your Science Discovery Book

1. Find samples of wind erosion of rock and of water erosion of rock and make a record of your discoveries.

2. Find and report upon evidence of glaciers in your community. Make a diagram to illustrate.

3. Make a list of many substances (materials) which you know. Write the word *organic* after those you think are organic matter, and *inorganic* after the others. Check your opinion with your teacher.

SURVEY OF TOPIC VI

How do you know what kind of soil your garden needs? How do you know what to plant in your garden?

You know now that water, oxygen, wind, plants, and even animals help to make soil. You are going to learn in this chapter and by observing and experimenting that there are as many kinds of soil as there are kinds of rocks; and that the size of soil particles ranges from very small (.0002 inch in diameter — the paper in this book is ten times as thick as that) to the size of marbles.

There is a dark soil and a light soil; a fine soil and a coarse soil. One kind is used for one thing, another for another. What you must do is to learn how to detect one soil from the other; to know what minerals it should contain for plant growth; and to discover to what use soil may be put besides its use as a food for plants.

TOPIC VI

KINDS OF SOIL

It was planted in a good soil by great waters . . . that it might be a goodly vine. — EZEKIEL

Do you know:

1. **Why lawn grass grows better in some yards than in others?**
2. **How to identify sand when you see it?**
3. **Whether or not soils differ in color, texture, and fertility?**
4. **Why the farmer cultivates his crops?**
5. **Why a gardener adds fertilizer to the soil of his garden?**

GENERAL PROBLEM 1. WHAT ARE SOME COMMON SOILS?

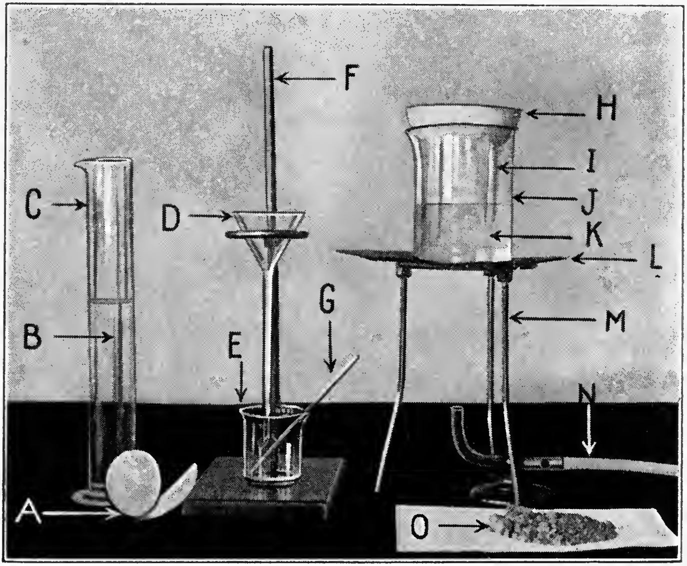
51. Four Common Soils. — There are four common kinds of soil: *sandy* soil, *clay* soil, *loam* soil, and *alkali* soil. This classification is based on the kind of rock from which each soil is made. Each kind of soil has certain advantages over the other kinds. A knowledge of these differences is useful to us. Let us see what they are.

52. Sandy Soil. — Sandy soil is composed mostly of sand grains. If you pour water into a dish containing sand, with a screened outlet at the bottom, you will find that the water readily runs through it. A sandy soil in like manner allows rain to pass down to the roots of the plant, and even to drain out of the soil leaving it dry.

Field Research:

Examine sand with a hand lens to find how sand particles look. Does a magnet attract any of the sand particles? Explain.

If a sandy soil is kept cultivated, not much of the soil water will be lost by evaporation. Like all soils, sandy soil must contain soluble mineral foods for plants to help them grow. The plant food must be soluble



EXPERIMENT 6

Name each article in the picture. Explain the use of the "water-bath" — **H, I, J, K.**

so that the water in the soil can dissolve it and carry it into the roots of plants.

Field Research:

What does "solution" mean? Taste a little salt. Then dissolve a teaspoonful in half a cup of water. Next place the water in a shallow tin and set it on the back of the stove where it will get warm and the water will evaporate slowly. Does the water all disappear? What is left in the dish? Taste of it and note the shape of the little particles. Use a magnifying

glass if you have one. What other substance can you find around home that will dissolve in water? Will not dissolve in water? Prove your statements by experiments.

Experimental Problem 6: *Are there substances in soil that are soluble in water?*

What to use: A handful of soil; a cylinder of water; some filter paper; a water-bath; a funnel; and a Bunsen burner.

What to do: Put a handful of soil into the cylinder nearly full of water, shake it thoroughly, and then allow it to stand two days, or until the water is clear. If the solution does not clear by the end of two days, allow it to stand longer or pass some of the liquid through filter paper. Why did the sediment not dissolve? Carefully pour off a little of the clear liquid and evaporate to dryness over a water-bath.

What happens: 1. Did some particles settle faster than others? 2. Why? 3. Did the soil settle clear or did you have to filter it? 4. What happened when you evaporated the clear liquid?

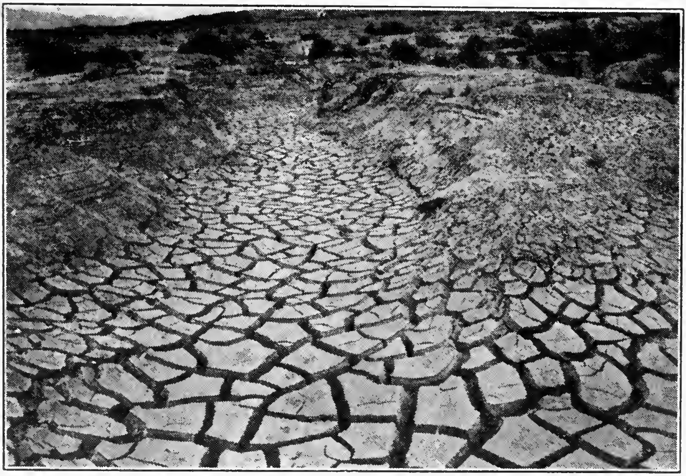
Conclusion: 1. Did you find both insoluble and soluble substances in the soil? 2. How much soluble material was there? 3. Why was it desirable to evaporate the liquid over a water-bath?

Application: Why are soluble substances necessary in soil?

53. Clay Soil. — Clay, we learned on page 82, is pulverized and weathered feldspar. Its tiny particles have a rubbery feeling when pressed between the fingers. This is due to the absence of gritty substances common to other soils. Clay admits water very slowly but holds it well, once it is thoroughly wet.

In drying, wet clay forms a hard, compact mass which makes cultivation difficult and will not allow plant roots to enter. However, clay soil may be rich in plant foods and, when properly mixed with other soils, will yield abundant crops. If the farmer is forced to plant in clay soil, he should cultivate the crops as frequently as the surface dries. Otherwise the soil will harden into heavy cakes with wide cracks between them, and the soil moisture will escape at these outlets.

Soil which is not cultivated has a tendency to settle so that its particles form tiny columns with air chambers between them. These fine, hair-like air chambers



DRIED CLAY MUD DEPOSIT

What do you observe in the picture that produces rapid loss of moisture?

serve as tiny tubes through which the water escapes from the soil by a process called *capillary attraction.* Any very fine tubes will lift water in this fashion, and so are called *capillary tubes.* Soil cultivation breaks up these tubes and smothers them with a dust *mulch* (covering) which prevents the evaporation of the soil water.

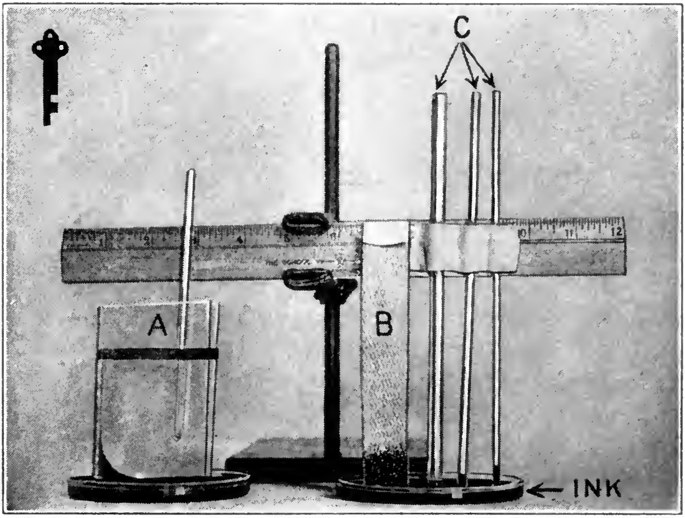
(Key) Experimental Problem 7: ***How will upright, fine tubes affect water in which they are placed?***

What to use: A lamp wick; three glass tubes with small bores of different sizes; two plates of glass; and a basin or shallow glass dish.

What to do: (1) Hang a wick with one end in water. (2) Place the glass tubes upright in a flat-bottomed dish of water. (3) Put two glass plates in a dish of water with the edges at one side together and those at the other side open like a book. Open and close the plates, watching the water between them.

What happens: By drawings and description, tell just what happens in each case.

Conclusion: 1. Did the water travel up the wick? 2. Did the water rise highest in the tube with the smallest bore or the



(KEY) EXPERIMENT 7

Which tube has the smallest bore? Why does the ink rise in the wick?

largest bore? 3. Draw a picture to show how the water rose between the glass plates. 4. Why did it rise that way?

Application of capillary action to soil: Set up an apparatus as in Experimental Problem 8 on page 111. Fill one chimney with dry clay soil and another with ordinary dry garden soil and set them side by side in the same dish of water. Does the water rise into the clay? (It may require 24 hours to 48 hours to obtain good results.)

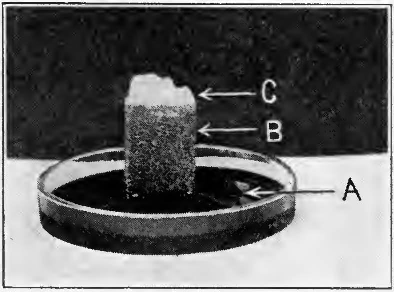
Compare the rate (speed) at which water rises into clay soil with the other soil? What relation is there between the rate of the rise of the water and the fineness of soil particles?

Field Research:

Application of dust mulch to stop capillary action.

Cover one small end of a lump of granulated sugar with powdered sugar; set the lump upright in a shallow layer of red or black ink. Does the ink rise up into the lump? Does it also rise into the powdered sugar?

Using a lamp chimney and garden soil standing in water as in Experimental Problem 8, add an inch or two of fine, dry soil to find out if a dust mulch prevents a loss of water from the soil.



A, Ink; B, Lump Sugar; C, Powdered Sugar

Explain what you see in this picture.

54. Loam Soil. — A soil which is better for gardening than either sandy or clay soil is one which contains a proportion of both sand and clay. Such a soil is called loam soil. Like clay soil, it will hold moisture well, and like sandy soil, it will not cake when dried. This soil can be cultivated more satisfactorily than either the clay or sandy soil. It is porous enough to admit plenty of air for plant growth and generally contains a fair amount of organic matter (page 101) called *humus*.

Humus is decayed plant and animal material. Good soil must contain some humus to enable plants to grow well. Humus provides food for the germ life of the soil. It also helps the soil hold water. Loam soil, because it contains humus, is one of the best kinds of soils for garden and field crops.

Water and soil have a very close relation. In fact, if a small amount of soil that is apparently dry is warmed in a test tube (try it), moisture will be deposited on the cooler part of the tube. It is a fact that different kinds of soils have the same or different capacities to absorb and hold water. This is something a gardener or farmer must know. The following experiment will show you that this is so.

INDIAN PIPES

This picture is used to suggest humus. Study it and then tell why it should be used in this way.

(Key) Experimental Problem 8: ***Do different kinds of soils absorb and hold different amounts of water when saturated?***

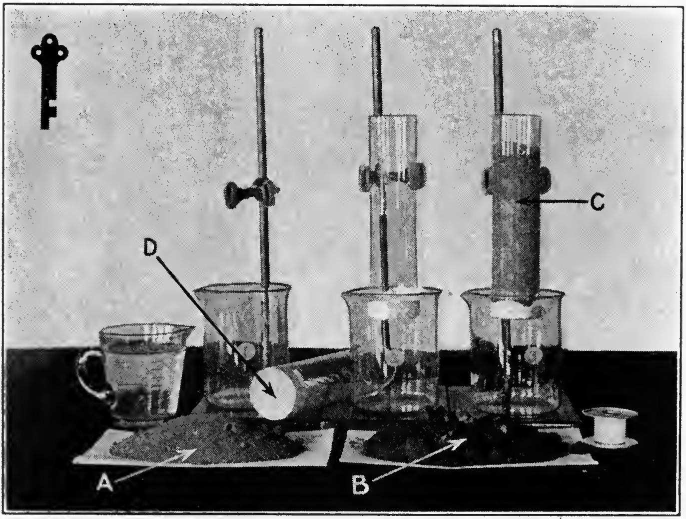
What to use: Samples of sandy, clay, and loam soils; a piece of cheesecloth; three straight-sided lamp chimneys; a measuring cup, a roll of adhesive tape; labels; three dishes; and three ringstands and clamps to support the chimneys.

What to do: Examine the samples of sandy, clay, and loam soils to discover which is composed of the finest particles. Note that the loam contains a considerable amount of humus, which you will recognize by its dark color.

Fasten pieces of cheesecloth to the bottom of all three lamp chimneys by means of adhesive tape — one chimney for each kind of soil to be tested. Label each chimney and fill the three chimneys to the same height with the different soils to be tested. Pack the soil in by slight jarring.

Support each of the chimneys over a dish to catch water. Pour carefully measured amounts of water on to each soil untii the water begins to drip from the bottom. Record the amount of water used for each soil.

After about 15 minutes, measure the drip water from each chimney. The amount of water used, less the drip water, gives the amount of water retained or held by each soil.



(KEY) EXPERIMENT 8

Three kinds of soil, **A, B,** and **C.** Name the other articles and tell the use of each in the experiment.

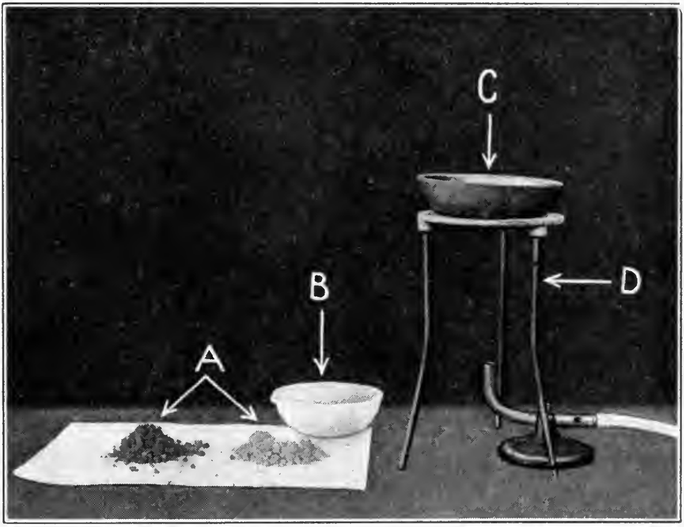
Conclusion: 1. Does one kind of soil hold more water than another? 2. What appears to be the relation of the size of soil particles and amount of humus to the amount of water retained?

Application: From the standpoint of holding water for plant use, which soil do you think is best? Does your experiment prove this?

Since the amount of humus a soil contains, helps soil to hold water, it will be interesting to test soil for humus. Humus is organic matter and will burn and therefore may be detected in a soil by a burning test.

Experimental Problem 9: *Will any part of soil burn?*

What to use: Several samples of soil; an iron dish; an iron tripod; a Bunsen burner; and a cold glass dish.



EXPERIMENT 9

A, soils; **B,** porcelain evaporating dish; **C,** iron dish. What is **D**? What is below **D**? Why is the iron dish used?

What to do: Place a sample of soil in an iron dish and heat it very hot. Do the same with samples of other soils. Observe any color changes and notice whether any fumes are given off. The fumes may be observed by their odor. Hold a cold glass above the heated dish and notice if a mist collects on the glass.

What happens: 1. Describe any color changes. 2. Did you detect the odor of the fumes which came from the burning organic materials? 3. After a time did the odor disappear? 4. Was moisture given off?

Conclusion: 1. Did the soil burn completely as does wood or paper? 2. If not, did some parts of it burn? 3. Did these parts form a small or large proportion of the whole soil?

55. Alkali Soils. — *Alkalies* are mineral salts which are generally soluble. In solution they will turn red litmus blue, — just the opposite of a test for an acid (page 69). Acids and alkalies neutralize each other. Any soil which contains an unusual amount of alkali is called alkali soil. All normal soils are slightly alkaline. Some soils, like those found in the deserts of some of the western states, are almost entirely alkali soils. They were formed by the decomposition of alkaline deposits of ancient oceans. They support very little vegetation and what little they do support is of the desert variety, such as the cactus.

CACTI, DESERT PLANTS

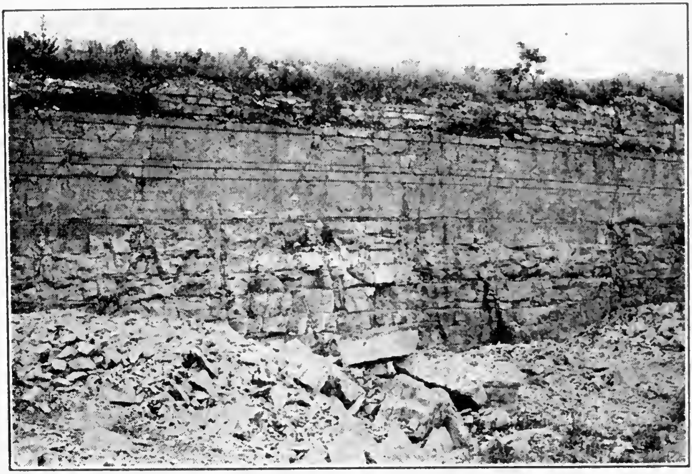
Since deserts lack the necessary supply of water, desert plants have developed special means of conserving water and do not give out as much water into the air as do plants in moister climates.

How do desert plants conserve water?

Some desert soils, however, are very fertile, and when irrigated become very productive.

General Problem 2. What Are the Classes of Soils?

56. Two Classes of Soils. — The scientist divides soils into two general classes, depending upon whether the soil is in the place where it was formed, — *residual soil,* or whether it has been carried from its place of



A Limestone Ledge

Explain the appearance of the layers near the top of the ledge.

origin, — *transported soil.* Residual soil results from the decay of rocks in the place where the rocks were formed. The soil particles near the surface are fine, but increase in size at various depths until finally the original bed rock is reached.

Residual soil contains a good supply of humus (page 110) and *bacteria,* and is therefore a good soil for many crops. *Bacteria* are very tiny organisms, some of which are useful to man while others are disease-producing. They are responsible for the decay of dead animal and plant tissue. When residual soil lacks some particular mineral for plant food, the lack can be supplied by fertilizing.

57. Transported Soils. — Soils are transported by glacier, water, and wind. Glacially transported soil

River Rapids

What evidence can you observe in the picture that explains why the mouths of navigable rivers must be dredged frequently?

(page 95) contains ground-up rock of many kinds and is therefore rich in all the mineral substances which are required for plant growth. When glacial soil is further enriched with the humus deposits resulting from the centuries of plant and animal growth and decay, it is one of the best soils for agricultural purposes.

If you should go into the Sacramento Valley of central California, or along the delta of the Mississippi, or down the basin of the Nile, or even to the flood flats along your own home river, you would surely find areas of level and extremely fertile soil. This soil was gathered from the broken and powdered rocks of the mountains and highlands by the river floods and distributed by them over the lowlands. This river-made soil is also, then, a transported soil.

River soil is composed of exceedingly fine particles which are deposited in layers or overlapping beds. This soil owes its extreme fertility to the fact that it is composed of many different kinds of minerals which have been thoroughly mixed with rich humus washed down from the forest floors of the uplands. River soil, sometimes called *alluvial* soil, is widespread in its occurrence, being found wherever rivers or streams abound.

General Problem 3. What Are the Uses of Soil?

58. A Source of Plant Food. — Two minerals very necessary to plants are *phosphates* and *nitrates*. Phosphates are salts derived from certain acids containing *phosphorus*. Phosphorus is a soft, yellowish, metallic element of waxy structure. Nitrates are salts derived from certain acids containing *nitrogen*. Nitrogen is a heavy, colorless gas which makes up almost four fifths of the air. Soil supplies to plants not only these necessary mineral foods, but it also serves as a reservoir from which the plant takes both water and air. Any soil which does not readily admit air and water is not suited to plant growth.

59. Other Uses. — Some soils are of little use for plant growth unless combined with other soils. Scientists have discovered other ways of using them. For example, vast deposits of certain kinds of clay are used for making pottery and china. Bricks, artificial

BRICK OVENS

Name the substances used for making bricks.

stones, tiling, and similar articles are soil products. Even some of our cleansing preparations are products of alkali soils.

GENERAL PROBLEM 4. HOW IS SOIL CONSERVED AND IMPROVED?

60. Fertilization. — Sometimes a soil may lack a certain mineral which is required for plant growth. The scientific gardener will add the needed substance in the form of a *fertilizer*. Careful and scientific fertilization of soil is a very essential part of good gardening and farming. Growing plants continuously extract minerals from the soil. For example, all plants must have *nitrogen compounds*. (*Compound* is a name given by chemists to substances composed of two or more simple substances. These simple substances are called *elements* and cannot be broken up by ordinary means into still simpler substances. Water is a compound formed from the union of the two elements, *hydrogen* and *oxygen*.)

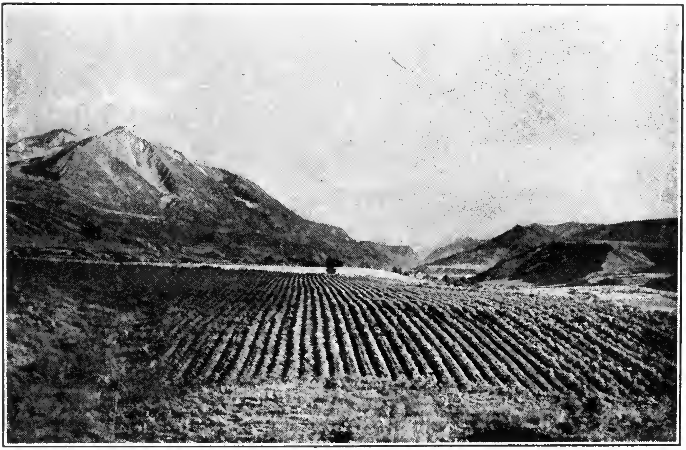
Since plants require these mineral compounds in order to live, man must feed them to the soil with fertilizer if the soil is to continue in turn to feed plant growth; otherwise soil becomes *poor* and plants will be starved for lack of food. Did you ever see a starved plant or tree? A starved tree will have a poor growth of leaves, which are likely to turn color early and drop. The annual new growth at the ends of the twigs will be shorter than it should be.

Some materials in the soil may be replaced through the practice of an annual changing from one crop to another; one crop may add what another crop takes out. This process is called *crop rotation*. A few plants like clover, alfalfa, and peas provide living quarters on their roots for certain bacteria (page 115). These bacteria can take nitrogen from the air and combine it with substances in the soil to produce the nitrogen compounds necessary to plant growth. Crops of clover, alfalfa, and peas are therefore fertilizing crops because they help to supply the nitrogen compounds.

Nature also returns plant food to the soil by the decay of plant *tissue* which becomes mixed with the soil. (Tissue is a general term for the materials which

Rotating Crops

Rye and vetch are often rotated with cotton. What is vetch? Of what value is it to the soil?



Potato Fields in Crystal River Valley, Colorado

Why is the melting snow from the mountains useful in this garden? Is the soil likely to be fertile? Why?

make up the body of any living thing. It is composed of tiny units called *cells*.) But Nature unaided cannot maintain a complete supply of all mineral foods, even when rotating crops are grown year after year on unfertilized soil. Hence gardening and farming, especially of the intensive type, demand some artificial fertilizing.

61. Humus in Soils. — On page 110 we learned that the decayed organic matter in soil is called *humus*. If you have tried to transplant wild flowers from the woods to your garden, you have taken some of the woods soil along. Do you know why? Woods soil is made up largely of decayed leaves. This decayed matter holds moisture and so the woods soil is damp.

PEANUT ROOTS

Observe the small *nodules* on the roots. What use are they to the plant? to the soil? to you?

Most humus in soils is decayed plant material such as leaves, roots, grassy stems, and wood. The farmer adds humus by spreading farm manure, and by planting rye or other seeds in the fall and plowing the green growth under in the spring.

Not only does the humus help keep the soil moist but it furnishes food for necessary soil bacteria (page 115). Some soils formed largely by decay of organic matter are called *muck* soils. They are very rich soils suitable for celery, lettuce, onions, and other small vegetables.

Decaying organic matter in soils produces acids. Soil from the woods, therefore, may be acid to litmus. These are spoken of as *sour* soils, as acids, you know, taste sour. Muck soils may be acid. While acid soils are desirable for growing wild flowers and a few other

LADY SLIPPERS, PINK

What conditions surrounding this plant are important to its welfare?

plants and shrubs, most farm crops require a slightly alkaline soil. Some farm soils become acid, hence the proper amounts of lime (which is alkaline) must be added.

62. Reasons for Working the Soil. — Soil is tilled (cultivated) to keep it fine and to keep the substances in the soil well mixed. Tilling the soil also helps to keep the under portions supplied with air and allows free passage of water to the roots of the plant. Then, too, cultivation not only allows more water to enter the soil, but it helps to hold in water which is already present by breaking up the fine, hairlike air chambers through which water is likely to escape, and smothering them with dust mulch (page 110). Airing the soil

Courtesy Caterpillar Tractor Company

Soil Cultivation

Look for evidence that conservation of soil water may be one purpose of the farmer.

helps the growth of bacteria. Finally, and very important, soil cultivation keeps out the weeds and even destroys certain insect pests.

You have learned by this time that plants and animals have a great deal to do with the formation, conservation, and improvement of soil. In the next topic you will discover that there are harmful as well as useful forms of life in the soil.

Key Words

absorb
alkali
alluvial
bacteria
bed rock
capillary action
capillary tubes
clay
crop rotation
cultivation
fertilizing
glacial soil
humus
loam
muck
nitrates
nitrogen
organic
phosphates
plant food
residual soil
river soil
sandy soil
soluble
transported soil

Key Statements

1. There are four common kinds of soils — sandy, clay, loam, and alkali.
2. Sandy soils allow free passage of water and air but do not retain much water for plant use.
3. Clay soils absorb much water and air but lose it rapidly when the soil becomes hard and cracked.
4. Loam soil, a mixture of clay and sandy soils, has the good characteristics of both.
5. Humus added to soil increases soil value because it aids the soil to hold more water, and supplies bacteria necessary to plant life.
6. Substances to serve as plant foods must be soluble in water. Soils are the chief source of food for plants.
7. Water travels through soil by capillary action.
8. There are two classes of soil — transported soil and residual soil.
9. Soils transported by glaciers and rivers are generally very rich soils.
10. Plant foods must be conserved in the soil by proper rotation of crops with periods of resting. Otherwise fertilizers must be added.
11. Tilling the soil prevents the growth of weeds, helps to prevent loss of water, and maintains free passage of air and water in the soil.
12. Soils differ in the fineness of their particles and in the amount of air and water which each will hold.

13. Soil for good plant growth must be porous enough to allow free movement of water and air.

14. Organic matter in soil is called humus. It is formed by decay of plant and animal substances.

15. Important uses of the soil are to furnish air, food, and water for plant growth.

16. Certain germs (bacteria) help decompose organic material in the soil. Others help to form the nitrogen compounds, necessary for plant foods.

17. Soils that are too acid are corrected by adding just the right amount of lime, or ground-up limestone.

Thought Questions

1. Why is loam soil better garden or farm soil than either clay or sandy soils?
2. What are the advantages of clay for plant growth?
3. Which kind of soil material has the finest particles?
4. Why will working the top soil prevent water evaporating as rapidly as when the soil is not worked?
5. Which soil has the finer (smaller) particles, clay or sandy soil? Explain.
6. Is crop rotation a form of soil fertilization? Explain.

Projects for Your Science Discovery Book

1. Make a list of the various uses man makes of soils, and describe one of them. (Your school or public library will have books which will help you.) Are there any soils near your home which are put to any of these special uses?
2. Test various soils for acidity by mixing a handful of soil with distilled water. Filter and test the clear liquid solution with litmus paper. Report on what you discovered.

SURVEY OF TOPIC VII

Do you remember that we discovered that water is the home of animal as well as plant life? In this, soil resembles water, for soil not only nourishes plant life, but it teems with animal life also, serving as a home for many insects and other small animals. Some of these are helpful to man in his efforts to live; some are exceedingly troublesome.

It is well to discover those that are helpful to plant life, and how they help mankind; and since they are our friends, what means we can employ to conserve them. It is also well to consider how the others, since they are our foes, may be destroyed.

TOPIC VII

LIFE IN THE SOIL

Learn from the birds what food the thickets yield;
Learn from the beasts the physic of the field;
The arts of building from the bee receive;
Learn of the mole to plough, the worm to weave.

— POPE

Do you know:

1. What kind of animals live in the soil?

2. Whether any insects live in the ground? If so, can you name one?

3. Of what use to the farmer the earthworm is?

4. What molds are?

5. What the cutworm cuts?

GENERAL PROBLEM 1. HOW DO SOIL INHABITANTS AID PLANT GROWTH?

63. Work for Each Kind.— Some common living things in soil are *bacteria* (page 115), *molds* (a low form of plant life similar to that seen on stale bread), *earthworms*, *moles*, and *insects* in all their life stages, from the egg to the adult. Larger animals such as woodchucks help to mix the soil by burrowing. Their holes, however, are troublesome to farmers. Each kind of life in the soil has its work to do.

A WOODCHUCK

Is the woodchuck harmful or helpful to the farm?

64. Our Friend, the Earthworm. — Every boy and girl is perhaps more familiar with the earthworm than with any other inhabitant of the soil. You have seen the robin searching for worms. Boys, young and old, have dug them from the garden to use for fish bait. Do you know that the earthworm is a farm plower or soil cultivator? Each one turns over and mixes each year a large amount of soil. Thus the worm is a real servant to the farmer. It mixes surface material with

A Close-up of an Earthworm

What evidence do you see that the worm mixes soil?

that underneath and brings the under soil to the top. This mixing of top and under soil is necessary to the formation of foods which are required for plant growth. The work of the earthworm also helps to keep the soil porous so that air can get in.

The earthworm mixes the soil as it makes its holes. It takes the under soil into its mouth, thus digging a kind of tunnel as it moves along. This loosened soil passes through the worm to be deposited on the surface. Some fine sandy particles from the surface are carried by the worm into the hole to make its nest. Parts of leaves and plants are also taken into the nest. In this way the worm adds organic matter to the soil.

65. Soil Bacteria and Molds. — Bacteria and molds are necessary to soils because they aid the decomposition (decay) of animal and vegetable matter and help to maintain a sufficient supply of nitrogen (page 117)

BREAD MOLD

What use are molds to the soil?

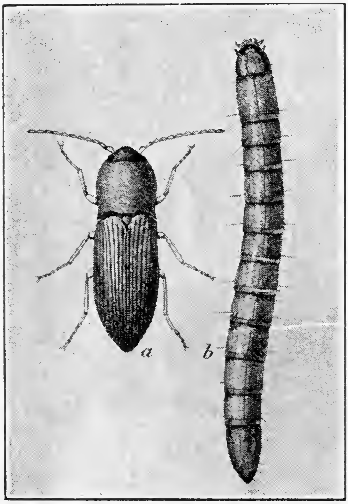
food for plants. Although there is an abundance of nitrogen in the air and in humus, plants are dependent upon soluble nitrogen compounds in the soil for their growth. The nitrogen-fixing bacteria are able to take nitrogen from the air and humus and change it into soluble nitrates (page 117) that plants can use. As we have already learned (page 121), such bacteria live in the roots of plants like clover, peas, and alfalfa. They cause little swellings on these roots called *nodules* (page 121) but do no harm by their presence.

You are familiar with ordinary bread mold, and the mold that occurs on fresh fruits and sometimes on canned fruits.

Field Research:

Place a piece of wet bread in a dish and let it remain undisturbed for a few days. You will be interested to observe the growth of mold under a microscope. Observe the little stemlike filaments (threads) with round heads. Split open a head and observe the tiny seedlike spores.

Molds are a kind of *fungus* as are mushrooms, toad stools, puff balls, and mildews. They are plants that live on other plants or animals, since they cannot make their own food. Molds that cause decay of dead vegetable matter in the soil are helpful but there are many varieties of fungi that live on living plants and cause them to die. In other words, they cause disease in plants as some bacteria cause disease in animals.



WHEAT WIRE WORM

(*a*) Beetle stage, (*b*) larva stage. Why is the farmer interested in this and other insects?

66. Underground Workers.—Although they are sometimes a nuisance in the soil, all the soil inhabitants are grinding and working the soil for the farmer. They may eat some of his vegetables, but they offset such damage by grinding and by keeping up the supply of humus in the soil.

Moles (page 126) burrow just under the surface. You may have seen the long, irregular mounds on the surface of the ground pushed up by moles as they

Amanita Muscaria

This fungus, "toad stool," with its orange-colored "knobs" is beautiful but very poisonous. Are all fungi harmful?

burrowed in search of food. If you know of such a burrow, watch it to see if you can tell when the mole is moving through it. To some extent moles feed upon the tender roots which nourish plant life, but to a greater extent they are enemies of insects. They eat the larvæ (page 22) hatching from the eggs laid by the insects in and about the plant roots. In this way they really protect the plants more than they harm them, even though they do occasionally add variety to their menu by eating a little bark off the roots.

THE "JUNE" BUG
Better called a May Beetle. In what way is it harmful?

67. Small Enemies of the Farmer. — Many insects lay their eggs in the soil. When the eggs hatch out into larvæ which feed on the new and tender roots of plants, the plants are either injured or killed. Some kinds of larvæ crawl out of the soil onto the plant, where they eat the leaves and thus destroy the plant. After a larva has lived a short time, it may spin a *cocoon* (a paperlike or silklike covering for itself) in which it rests awhile before it changes to the insect-flying stage.

THE LARVA OF THE MAY BEETLE
Is the larva more or less harmful than the beetle? Why?

Some of the plant-destroying larvæ which are commonly found in garden soil are the *cutworm*, the *white grub*, the *root maggot*, and the *tomato worm*.

Cutworms are especially destructive to tomato plants, cabbage, and cauliflower, often cutting the stems of the young plants. They also feed on the roots of strawberries, radishes, onions, turnips, and similar vegetables. They are slow-moving, brown worms from three quarters of an inch to one and one half inches long and work at night. The common white grub is the larva of the May beetle. It feeds upon plant roots and is a real pest in meadows and gardens, particularly in strawberry beds.

Tomato Worm
Why is this larva called a tomato "worm"?

The root maggot is a small, white larva less than one half inch in length. As its name implies, it eats the root of plants.

The tomato worm is a large, green pest with horns. He is especially fond of the leaves of tomato and tobacco plants.

These are only a few of the insect garden pests. Do you know any others?

General Problem 2. How Can Soil Life Be Controlled and Conserved?

68. The Good and the Bad. — We have studied enough of the soil life to know that the good must be protected and the bad destroyed. For example, moles and woodchucks should be trapped and killed when they become troublesome. Birds and insects which destroy other harmful birds and insects should be protected so that they may wage their useful warfare.

House Wren on Nest Box

Examine the bird carefully and describe its characteristic appearance. What good are wrens? Do you know their song?

Man's control must not stop with such protection. He must also call to his aid insect poisons, and must be faithful in his cultivation of the soil, for we have seen that such cultivation helps to destroy certain of his insect foes. His use of mulches made from decaying vegetable matter will supply bacteria and molds which are necessary to plant life. Such care will do much towards insuring the success of crops.

If you have been careful in doing the work of the preceding chapters, you know pretty well just what would happen if —

water stopped flowing down hill!

or

water vapor failed to condense when cooled!

or

rocks were too hard to be broken up!

or

there were no life in the soil!

In the next unit you will discover facts about a substance that is all about you, a substance without which none of the processes you have studied could have happened, without which life in the soil could not exist. This all-important material is *air*. The study of it will bring you many surprises and discoveries.

Key Words

bacteria	molds	root maggot
cocoon	mole	tomato worm
cutworm	nitrogen-fixing	white grub
earthworm	nodules	woodchuck
insects		

Key Statements

1. The smallest living things in the soil are the bacteria.
2. One kind of bacteria lives on the roots of certain plants and is able to fix nitrogen of the air into compounds called nitrates. Nitrates are necessary to plant life.
3. Molds, a low form of plant life, help to add organic matter (humus) to the soil.
4. Many small animals (earthworms, insects) and some larger animals (moles, woodchucks, and the like) are continually grinding and mixing the soil.
5. The larvæ of some insects are very injurious to plants.
6. Helpful life in the soil should be conserved.
7. Birds which destroy harmful insect life should be protected.

Thought Questions

1. How is some animal, which you have observed in the soil, useful to the farmer or gardener? Explain in detail.
2. How have you tried to control some harmful insects in your garden?
3. What use are certain bacteria in the soil?
4. What use are molds to the soil?
5. What bird do you know that eats insects and insect larvæ? Describe its life and habits.
6. What do you think is the most important form of life in the soil?

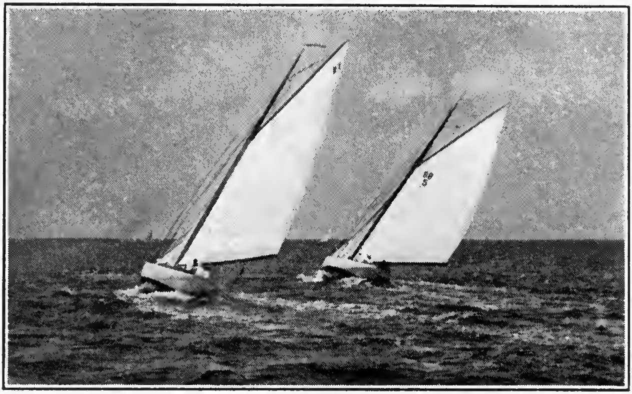
Projects for Your Science Discovery Book

1. Make a special study of the life in the soil of some one insect larva and record your discoveries.

2. Observe two birds that eat insects. Build a nest box for each kind, mount each box properly, and observe results. Report what you discover.

3. Keep a record of how a pair of robins feed their young; what they feed them; how many times an hour; and how many days.

SURVEY OF TOPIC VIII



Air — that great expanse of something between the earth and the distant blue of the heavens! Air — that invisible substance that supports the beating wings of a bird and the man-made ships as they soar, ever higher and higher out of human sight! Air — that something in every snow-laden wind that howls around the house in winter, or in the sudden squall that puffs the sails as the boats dip into each new wave, or in the soft, perfume-laden breeze of early summer!

What is it, where is it, what can it do?

These problems we shall answer by studying what scientists have already discovered, and by making observations and experiments of our own. Thus we shall learn what air contains that makes it necessary above the earth, in the earth, and in the waters of the earth in order that plants and animals may live and grow.

TOPIC VIII

THE OCCURRENCE AND USE OF AIR

And 'tis my faith that every flower enjoys the air it breathes.
— Wordsworth

Do you know:

1. **What air is? Where it is?**
2. **Whether or not you can feel air? Whether you can see or smell it?**
3. **Whether or not air has weight?**
4. **What air has to do with our life on the earth?**

General Problem 1. Where Is Air?

69. Air Activities. — You have been breathing air all your life, yet only when it moves as a wind can you feel it. You have "seen" rapidly moving air pick up leaves and whirl them about. You know that it helps to grind rocks into soil, both by the ceaseless wear and tear of its own movements and by hurling the waves of lakes and oceans into the attack. These discoveries you have made in your study of water, rocks, and soil, and they are evidences that air is real.

Recent investigations indicate that the atmosphere extends outward to great distances from the earth. However the first 100 miles are of most interest to us. As the distance increases, the air becomes extremely rare (or thin).

The composition of air varies at high altitudes. When air rises, it expands because of lowering pressures due to less air above. As a gas expands it becomes cooler. Therefore rising air currents get cooler. This cooling causes moisture in the air to condense, forming clouds. Cirrus clouds are the highest and occur about $5\frac{1}{2}$ to 6 miles above the earth. In other words, cirrus clouds are only a little higher than the top of Mt. Everest.

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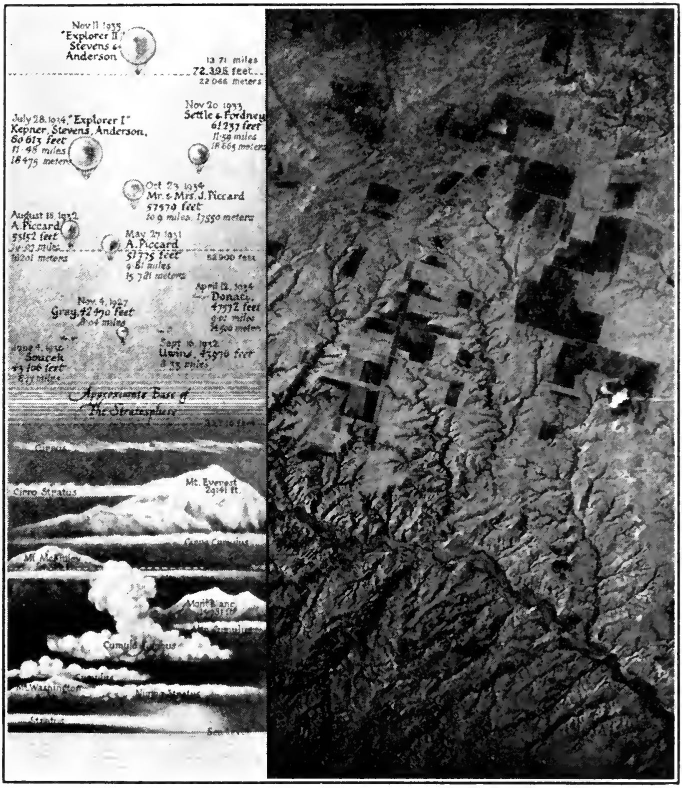
THE GROUND CREW CLOSES IN TO ATTACH THE GONDOLA TO THE BAG

The 36 temporary lines that hold the balloon to the earth are being released gradually. The balloon contains its full quota of helium gas, approximately 250,000 cubic feet.

Since air currents cool as they rise, their ascent becomes slower and slower as this coolness increases. When the temperature drops to 75° to 78° below zero Fahrenheit, they stop rising. Therefore common clouds do not exist above that altitude. The region up to this altitude is called the *troposphere*. The nearly cloudless region above the troposphere is called the *stratosphere*. The air temperature rises somewhat from the top of the troposphere.

The air pressure at the earth's surface is due to the weight of all the air above. At sea level this pressure is equal to that of a column of mercury about 30 inches high. The air pressure rapidly decreases with



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From the Earth to the Stratosphere and Back Again

The diagram shows how cloud forms and mountain peaks mark altitude in the lower atmosphere, and the heights reached by the most important balloon and airplane altitude flights. The shading indicates the density of the atmosphere from sea level to the place the Explorer II reached. From this height of 72,395 feet the camera man took the picture on the right. The geometrical cultivated fields stand out clearly, and in sharp contrast are the erosion channels carved by rain water draining into the South Fork of the White River.

altitude so that at ten miles altitude the pressure is about one tenth as much as at sea level; that is, equal to about 3 inches of mercury. The air pressure is so low even at $3\frac{1}{2}$ to 4 miles altitude that man cannot live higher than that without special aids to breathing. Oxygen tanks and similar devices aid aviators who fly to these heights.

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THE FLYERS HAD AMPLE ROOM IN THEIR FLOATING LABORATORY

The Explorer II carried a gondola nine feet in diameter. Captain Anderson (left) and Major Stevens are shown during a test or "dress rehearsal." Major Stevens is testing the radio instruments which kept the flyers in contact with the earth.

Decrease in air pressure results in a corresponding increase in air speed for the modern airplane.

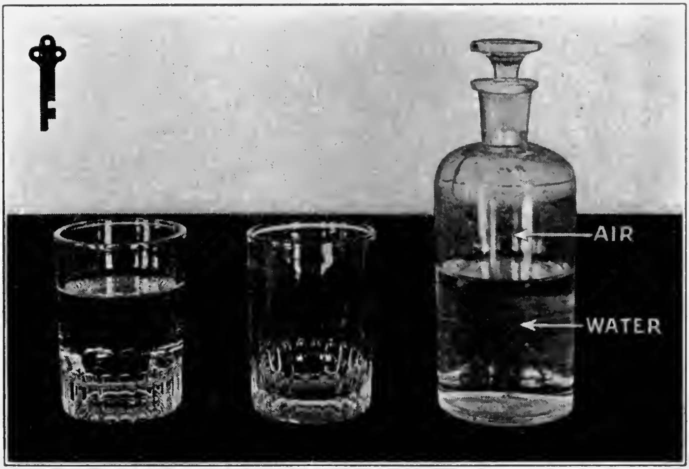
Find out all you can from aviation magazines and books about what is being done to take advantage of this fact.

Air is especially important to plants and animals because it contains *oxygen*, an element which we shall study shortly. It is important, then, that we, as scientists, should discover some of the important facts concerning this very common substance. One of these facts is that water contains air, which makes it possible for animals and plants to live in water. Let us see if we can prove by experimentation that water does contain air.

(Key) Experimental Problem 10: ***Does water contain air?***

What to use: Water; two glasses; and a pint bottle.

What to do: Draw a glass of cold water from the faucet. Does it look milky? After a moment the milky appearance will clear. Allow it to stand for a few moments where it will get warm, then look for bubbles around the sides of the glass. (These bubbles are air bubbles formed from air which had dissolved in the water. The heat released them.) Half fill a pint



(KEY) EXPERIMENT 10

Why is the bottle only partly filled with water?

bottle with cold water. Shake it vigorously for a minute or two and then pour it out into the second glass, where it also will get warm. When it is warm, compare the number of bubbles in the two glasses. Did bubbles appear in both glasses?

What happens: 1. In the second part of the experiment was there air in the bottle as well as some water? 2. In shaking the water, did air mix with it? 3. Did any of the air dissolve? 4. In which glass did you observe the greater number of bubbles to form?

Repeat the experiment, using cold water that has been boiled recently. Boiling drives out any air that the water contains so you can start with water you know contains no air.

Conclusions: Mixing air with the water in the bottle apparently caused the water to dissolve some of the air. The dissolved air separated as bubbles when the water became warm. 1. Did the first sample of water from the faucet have air dissolved in it? 2. Which sample of water had the more air in it? 3. Did the cold, boiled water show any dissolved air when it was warmed? 4. Did this water dissolve air? 5. Make a simple statement about air dissolving in water.

Application: Test samples of water from different sources for dissolved air; for example, spring water, pond water, and fresh rain water. Does the fact that air dissolves in water have anything to do with the fact that some plants and animals live in the water? Explain, after reading section 7, page 11.

Why do you suppose drinking water reservoirs sometimes have fountains?

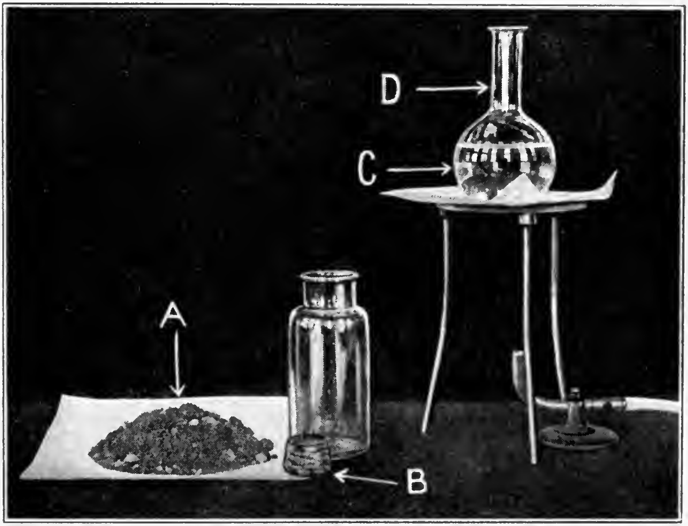
With air above the earth and in the water of the earth, we should expect to find that it even penetrates the earth, mixing with the soil and rocks. Indeed, that is the fact, and air has a very important use in soil even as it has in water.

Experimental Problem 11: *Does soil contain air?*

What to use: A jar of cold, recently boiled water (boiling drives the air out); a wide-mouthed pint bottle with a rubber stopper; and some soil from below the surface of the ground.

What to do: Pack the soil into the wide-mouthed pint bottle until the bottle is about two thirds full. Try to press the soil down about as hard as it was packed in the ground. Now add enough cold, boiled water to fill the bottle so that there will be no air space when you insert the rubber stopper tightly in the bottle. All air has been driven out of the water by boiling. Let the bottle stand with its stopper in place for an hour, or until the next day.

What happens? 1. Did the water soak down into the soil at once? 2. Did you observe any bubbles? 3. If so, what became of them? 4. If any bubbles pass from the soil through the water, how may you be sure that they are air bubbles? 5. Describe the condition after an hour, and after a day. 6. Where did the water go? 7. Could water soak into the soil without pushing out some of the air, if there were any in the soil?



EXPERIMENT 11

A, soil; **B,** rubber stopper; **C,** boiled water; **D,** flask. Why should recently boiled water be used in the experiment?

Conclusion: 1. Did the soil you tested have air mixed with it? 2. Try to estimate as closely as possible what proportion of the volume of the soil the air occupied.

The foregoing experiment not only tells you that there is air in soil, but it illustrates a very fundamental science law, namely, that two substances cannot occupy the same space at the same time.

Can you give more illustrations of this law?

Having discovered where air can be found, our next discovery should be to find out what air is like.

General Problem 2. What Is Air Like and of What Is It Made?

Now that you have proved that soil contains air, you should recall that there are living things in soil to use the air as animals on the earth use it. Then, too, there are bacteria in the soil that " fix " nitrogen of the air for the use of plants. They could not form the nitrogen compounds if air were not mixed with the soil. (See page 129 and explain this last statement.)

70. Air Has Weight. — Air is invisible and yet we are sure that it is all about us. Air has weight and exerts a pressure against all surfaces. Try to prove that air has weight by the following experiment.

(Key) Experimental Problem 12: ***Does air have weight?***

What to use: Balance scales and weights; the inside bag of a football; an exhaust air-pump; a steel-walled, hollow ball containing a petcock; a burned-out electric light bulb; a brass blowpipe; and a Bunsen burner.

What to do: A. Counterbalance on the balance scales the inside bag of a football, flattened out so there is but little air left in it. Next fill it with air and place it on the scales.

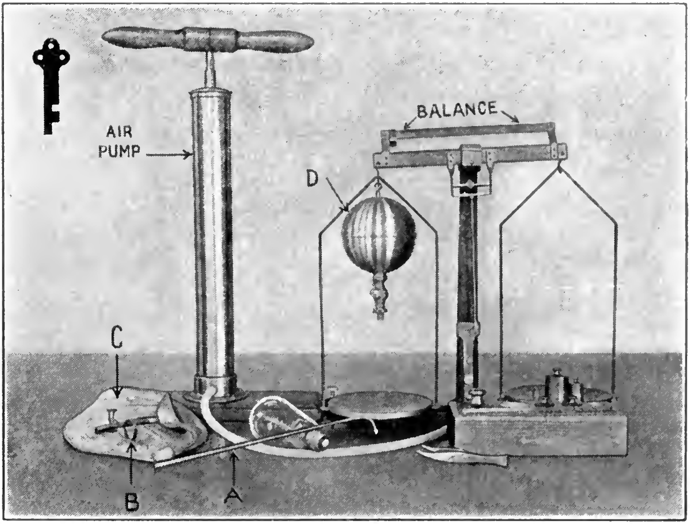
What happens: 1. Is it now out of balance, that is, is it heavier than before? 2. If so, what makes it heavier?

B. Attach the exhaust air-pump to the steel-walled, hollow ball and pump out as much air as possible, then turn the petcock to close the vent. Now counterbalance the ball, after which open the petcock.

What happens: 1. Does air rush in? 2. How can you tell? 3. Does the ball weigh more with the air in it?

C. You will need your teacher's help with this part of the experiment. Obtain a burned-out electric light bulb. Counterbalance it as you did in the other cases. Now with a blowpipe, heat a small area on the side of the bulb.

What happens: As it gets hot and the glass begins to soften, watch closely to see if the soft glass bends in or out. 1. If it is bent, what do you think is exerting the pressure? 2. Is the pressure being exerted from the outside or the inside? Continue heating the spot until a hole is pushed through the glass. 3. Is the bulb still in balance or does it now weigh more than it did before? 4. If so, why? 5. Did air enter the bulb or leave it once the hole had been made? 6. How can you be



(KEY) EXPERIMENT 12

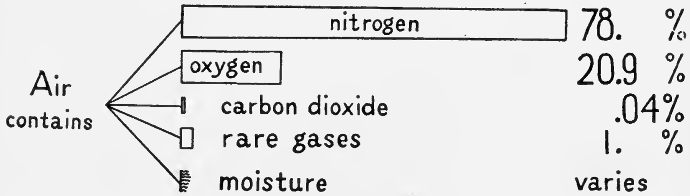
Learn the names of each piece of apparatus from this list: **A,** blowpipe; **B,** clamp; **C,** rubber bag; **D,** hollow steel ball. What other articles are shown? Tell the use of each in this experiment.

sure of this? (Note the way the glass is bent at edges of the hole.)

Conclusion: 1. Do you think air has weight? 2. If you performed part C, what else can you say about air?

Application: The electric bulb in the beginning had no air in it. To such an empty space as this, the scientist gives the name *vacuum.* Atmospheric pressure will fill a vacuum unless the walls about the vacuum are strong enough to resist such pressure. When you used the air-pump on the steel ball, did you produce a vacuum within the ball? Why did the ball not collapse?

71. A Mixture of Gases. — Air is a mixture of several simple gases. You cannot see or feel these gases but they are of great importance to human life. About one fifth of the air is made up of *oxygen* and almost four fifths of it is *nitrogen.* (Scientists give the proportion more accurately as 20.9% oxygen and 78% nitrogen.) Then there is a very small amount of several other substances, two of which, *water vapor* and *carbon dioxide* (page 69), you may prove by experiment to be in the air. In addition, we can always find dust particles in



Composition of Air by Volume

the air, though, strictly speaking, they are not a part of the air but exist as impurities in it.

72. Oxygen. — Both land and water plants and animals must have air in order to live (problem on page 12). Oxygen (O_2) is the part of the air which by its action helps to supply all body cells (page 121) with energy. When the air is taken into the body, the oxygen is separated from the air by certain organs (lungs and capillaries) and carried to all parts of the body. The parts of the air not used by the body are carried out as the breath is exhaled.

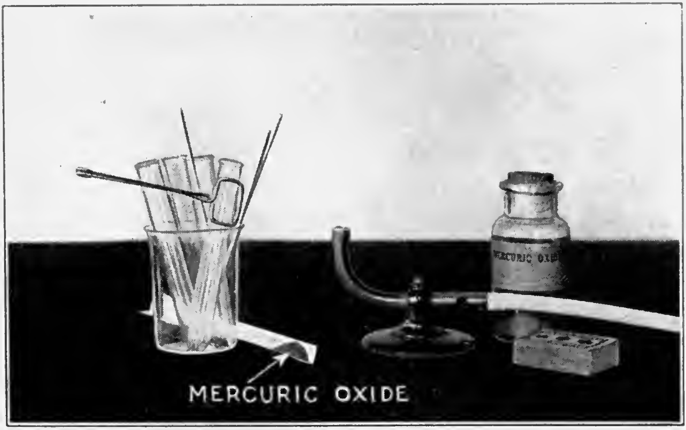
We can actually prepare some pure oxygen to find out what sort of a substance it is. Here is one method:

(Teacher's) Experimental Problem 13. — *How can oxygen be obtained from mercuric oxide and what is it like?*

What to use: A 6-inch test tube and holder; a Bunsen burner; a small jar of oxide of mercury, and several hard-wood splinters.

What to do: Place about a quarter of a teaspoonful of the mercuric oxide in the bottom of a glass test tube. A convenient method of doing this is shown in the picture.

Hold the test tube with holder in a nearly horizontal position. Place the closed end containing the red powder over the flame of the Bunsen burner. Heat the tube hot enough to turn the



EXPERIMENT 13

This apparatus includes a test tube clamp and hard wood splints. Find them in the picture. The folded paper serves as a shovel to place the mercuric oxide in the test tube.

red powder black; then put a glowing splinter within the mouth of the tube. Now try the glowing splinter test in a test tube of air.

What happens: 1. When you inserted the glowing splinter in the test tube containing the hot oxide, what was the effect? 2. What was the effect in the test tube of air? 3. Could you see the gas which formed above the oxide? 4. Could you smell it? 5. What freed it from the mercuric oxide?

Conclusion: The gas which formed above the mercuric oxide when it was heated was oxygen. You should be able to tell its color, odor, taste, and whether or not it supports burning.

The deposit on the sides of the test tube is mercury. It can be scraped out onto paper and its properties observed.

73. Nitrogen. — Nitrogen (N_2) is also colorless, odorless, and tasteless, but unlike oxygen, it does *not* support combustion. If a burning splinter is placed in pure nitrogen, it will go out. Nitrogen regulates the speed of combustion by diluting oxygen, just as water dilutes strong coffee. You can see, then, its importance in the air. If the greater part of air were oxygen, which is responsible for rapid burning, what would happen to this world?

74. Carbon Dioxide. — Carbon dioxide (CO_2) occurs in very small amounts in the air, about four parts in ten thousand parts of air. It too is odorless and colorless. How then can we distinguish it from the other gases in the air, and make sure of its presence? Try the following experiment:

Experimental Problem 14. — *Is carbon dioxide present in the breath and in the air?*

What to use: 2 small bottles with stoppers; a small bottle of clear limewater; and a piece of glass tubing, about 10 inches long.

What to do: Partly fill one bottle with limewater. Using the glass tube, blow your breath into the limewater. Now cleanse this bottle and quarter fill it with clear limewater. Put the same amount of plain water in the other bottle. Put in stoppers and shake each bottle. Watch for the liquid to change in appearance.

What happens: 1. When you breathed through the tube into the limewater, did a milky substance appear in the liquid? 2. Did the limewater become milky? You would have to force a large amount of ordinary air through the limewater to produce the same appearance that a small amount of your breath did.

Conclusion: The fact that the milky substance forms in both cases where the limewater is used proves that there is something in the air that is also present in the breath. The gas in the air and the breath that affects limewater in this manner is *carbon dioxide.* What did the difference in appearance between the two liquids tell about the amount of carbon dioxide in the air?

EXPERIMENT 14

Calcium hydroxide is the chemist's name for limewater. Why are two small bottles needed?

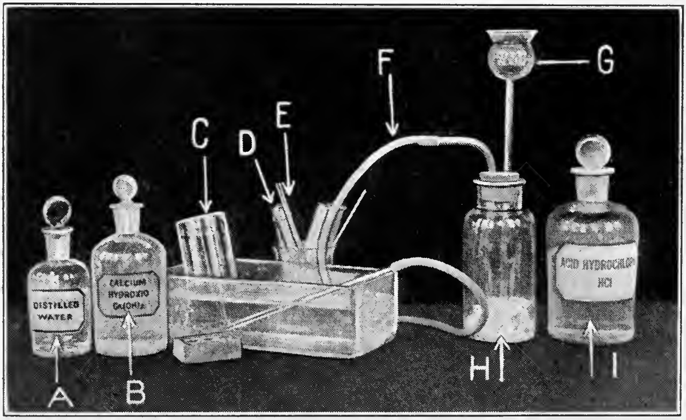
Experimental Problem 15. — *How can carbon dioxide gas be made, and what properties does it possess?*

What to use: A 12-oz. wide-mouthed bottle; a two-hole rubber stopper; a thistle tube; an exit tube; 2 feet of rubber tubing and a glass tube 10 inches long to fit; several test tubes; several small pieces of marble; dilute hydrochloric acid; hardwood splints; blue litmus paper; a bottle of limewater; a bottle of distilled water; a small wide-mouthed bottle; and a shallow pan or glass dish of water.

What to do: (A) Equip the wide-mouthed bottle with the thistle tube and an exit tube as shown on page 152. Put a few pieces of marble in the bottle. Insert the stopper with the thistle tube and exit tube attached. Through the thistle tube pour enough of the acid into the bottle to cover the lower end of the thistle tube.

(B) Fill the small wide-mouthed bottle with water and invert it in the pan of water. Insert the exit tube into the mouth of the inverted bottle and collect the gas by displacing the water. When the bottle is full of gas, remove it and insert a burning splint into its mouth. Try the same test with a bottle containing nothing but air.

(C) Now allow some of the gas to bubble up through a test tube of distilled water. Smell of the bubbles as they come up.



Experiment 15

G is a thistle (or funnel) tube. What is it for? Name all the other articles and substances in the picture and tell their uses.

(D) Hold the exit tube in a test tube of water for a few minutes, allowing the gas to bubble up through the water. Then test the water with blue litmus paper — the kind you used to test for acids on page 69.

(E) Finally, pass some of the gas through a tube of limewater and watch carefully for any changes in the limewater.

What happens: 1. What action took place when you poured the acid into the bottle? Compare this with the acid test on limestone and marble (pages 69 and 80). 2. Compare the results of the burning splint thrust into the bottle of gas with those when it was thrust into the bottle of air. 3. Did the bubbles of gas have an odor? 4. After the gas has bubbled up through the distilled water, did the test with litmus paper prove the presence of acid? Is the gas soluble in water? Explain your answer. 5. What did you observe when the gas was passed through a tube of limewater?

Conclusion: From your observations of this gas, carbon dioxide, you should be able to tell how to make it and what *properties* it possesses; that is, its color, its odor, whether or not it is soluble in water, and whether or not it will support combustion. Be sure you are familiar with at least one test for carbon dioxide.

What is distilled water?

75. Water Vapor. — We often use the expressions "the air seems close" or "the air is moist." These expressions mean that there is moisture (water) in the air. The following experiment will show that air contains moisture.

(Key) Experiment 16

Why is the ice used? Could snow or very cold water be used instead of the ice and water?

(Key) Experimental Problem 16. — ***Does air contain moisture?***

What to use: A dry glass and some ice water.

What to do: Be sure the glass is perfectly dry, then fill it with ice water and place it on the table or bench.

What happens: 1. Does a film of moisture soon appear on the outside? 2. Where does this moisture come from? It could not have come through the glass from the water inside.

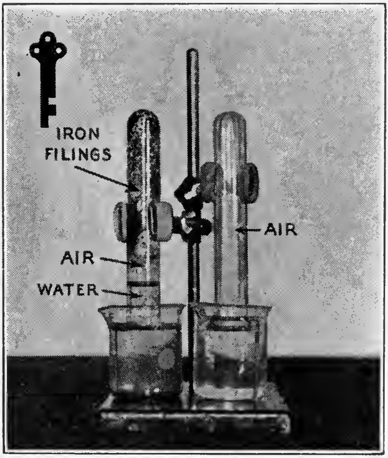
3. Could it have come from the air on the outside of the glass? You could not see the moisture until the ice water chilled the

glass. You know that the moisture of the air will become condensed (page 16) to tiny drops when cooled. 4. What use is made of the second glass of water?

Conclusion: Now tell briefly how you know that air contains moisture.

General Problem 3. What Is Oxidation?

76. Why Metals Rust. — Why does iron rust? There must be something present in the air that causes this slow destruction of metals.



(Key) Experiment 17

Did water rise into one test tube and not into the other? Why? Why did the water rise to a certain height and no higher?

(Key) Experimental Problem 17. — ***How much oxygen does air contain and will it rust iron?***

What to use: Two large test tubes; iron filings; a dish of water; a ringstand and clamp; a beaker; and several hardwood splinters.

What to do: Dampen the inner walls of one of the test tubes. Then put into the test tube some clean iron filings. Some of the filings will stick to the wet inner surface of the sides of the tube. Now invert the tube over a dish of water, and lower it into the water until the water levels are the same inside and outside the tube. Mark this level. Now lower the tube half an inch, fasten in position, and leave for 24 hours.

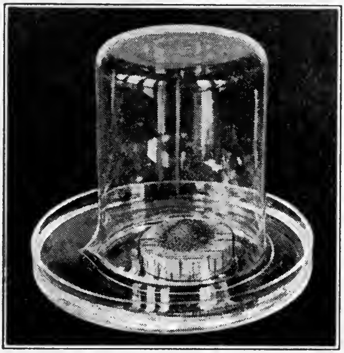
Do the same thing with the second test tube except to omit the iron filings. (The experiment with this second tube is to serve as a "control"; that is, to prove that whatever happens in the first tube is due to the iron.)

What happens: At the end of the 24 hours, readjust the water levels. 1. Has the iron turned brown in color? If so, you will recognize the iron rust. Observe carefully that the water has also risen in the test tube to a higher point than the level originally marked. 2. Did this happen with the control experiment? Evidently the iron has combined with something in the air. 3. Estimate how much of the air was used up by the iron. The rising of the water into the tube and the change in color of the iron shows that the iron has taken something out of the air which was in the tube. 4. Does the part of the air which is left support combustion? (Try the glowing splinter test.)

Conclusion: 1. What gas of the air was responsible for the iron rust? 2. What proportion of the air did this gas occupy? 3. What proportion of the air was left in the test tube containing the iron filings?

You have discovered that the oxygen in the air will unite with iron filings to form rust. When oxygen unites with another substance, the process is called *oxidation.* If the process requires some time for completion, as in the case of the filings, it is called *slow oxidation.* When the process is speeded up by the application of heat, *combustion* or burning results. When a substance loses its identity, that is, when it cannot be distinguished by certain properties by which we have learned to recognize it, it has undergone a *chemical change.* Oxidation is a chemical change.

77. Moisture and Oxidation. — Is there any other substance which aids oxygen in forming iron rust? How about old pails and metal containers that are left outdoors exposed to all sorts of weather? They rust more quickly than those in the house, do they not? Try the following experiment and compare your results with those reached by the preceding one.



EXPERIMENT 18

Why is the cork with its iron filings placed on water and covered with the beaker?

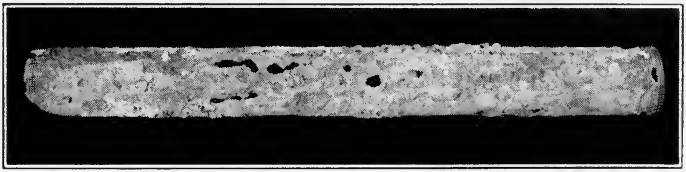
Experimental Problem 18: *Does moisture assist rusting?*

What to use: Some dry iron filings; a flat cork; a dish of water; and a large beaker.

What to do: Place the dry iron filings on the cork afloat in a basin of water. Then put the beaker down over the cork and filings.

What happens: Compare the rate at which the iron rusts in this experiment with that of the preceding one.

Conclusion: Does moisture help oxygen in the formation of rust?



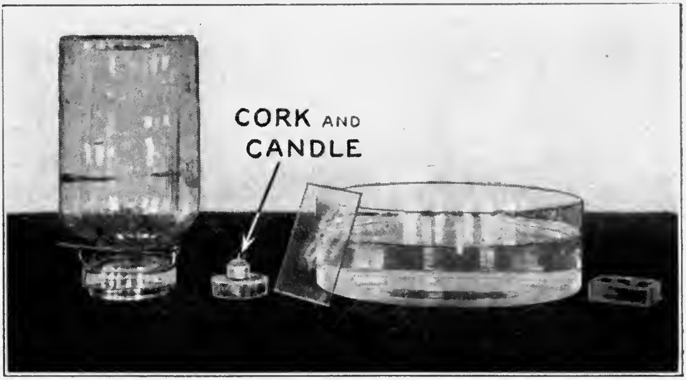
A RUSTED WATER PIPE

What conditions cause so much rusting?

78. How to Prevent Oxidation of Metals. — Gold and silver offer no attraction to oxygen and will not *oxidize* (combine with oxygen). Nor will nickel and tin rust as readily as iron. Such metals are therefore used to plate other metals which oxidize more easily. In time even nickel and tin will oxidize, but the oxides thus formed serve to protect the metals which they cover. Iron rust is coarse and easily falls off the metal.

Gutter pipes, pails, and many other water containers made of iron are often coated with zinc to prevent rusting. Zinc-coated iron is known as *galvanized iron.* You should be able to describe other common ways of preserving metals. The annual loss of metals, especially of iron, by rusting (or oxidation) represents millions of dollars. Science teaches you how to do your share in preventing such losses.

79. Burning Substances. — All your experiments with oxygen really have to do with burning. Burning is an activity with which you have always been familiar. It is now your problem to find out by experiment whether oxygen is necessary for burning. Before you begin this new experiment, you should review your experiments with oxygen and pick out the facts that may bear on this new problem.



EXPERIMENT 19

Explain the use of each article in the picture.

Experimental Problem 19: *Is oxygen necessary to burning?*

What to use: A short candle; a large, flat cork; a glass plate; a dish of water; a wide-mouthed (32 oz.) bottle or fruit jar; and matches.

What to do: Set the candle on the cork, floating in the dish of water. Light the candle and invert the wide-mouthed bottle over the candle so that the mouth of the bottle is just under water. You know that the candle will burn until it has used up the oxygen. Allow it to do so. Now cover the mouth of the bottle with a glass plate while still under water, take it up, and stick a burning match into the bottle.

What happened: 1. Did the candle go out? 2. Did water come up into the bottle? 3. Why? 4. Did the match burn in the bottle after the oxygen was taken out?

Conclusion: Is oxygen necessary for burning?

80. Plants Need Oxygen. — At the beginning of this topic you read that plants and animals need oxygen (air). We do not need to prove the fact so far as animals are concerned, but we may need to do so for plants. The following experiment will show that plants need air.

EXPERIMENT 20

Why is it a good plan to soak the seeds overnight? Why is only one bottle provided with a stopper?

Experimental Problem 20: *Is oxygen necessary to plants?*

What to use: Germinating (sprouting) seeds (peas or beans that have been soaked overnight and allowed to start growing); two wide-mouthed bottles, — one with a cork to fit.

What to do: Place some of the seeds in each of the two wide-mouthed bottles. Leave one open and close the other with the cork. Observe for several days.

What happens: 1. Do the seedlings (little plants) continue to grow in both bottles? 2. If not, in which did they stop growing?

Conclusion: Do seedlings need the oxygen of the air to keep them alive?

General Problem 4. What Makes the Wind Blow?

81. Winds. — Sometimes air moves, and then we are more conscious of it. Warm air moves upward and cooler air rushes in to take its place. So air is set in motion. Air in motion is called *wind.* An experiment will help you to understand how a wind starts.

Experimental Problem 21: *How does a wind get started?*

What to use: A lamp chimney; a candle; and a joss stick (or roll of paper).

What to do: Place the lamp chimney over the lighted candle. Keep the chimney up off the table a little distance (one quarter inch) by resting it on two sticks. Light the joss stick (or roll of paper) and hold it near the space between the table and chimney.

Experiment 21

Why is the chimney placed on the two sticks?

What happens: What happens to the smoke from the joss stick?

Conclusion: What conclusion can you draw from observing the movement of the smoke from the joss stick through the chimney?

Application: Suppose the sun heats the ground and air very hot in a certain locality. 1. Do you think the air over the place would rise? 2. Would other cooler air move in to push the warm air up? 3. Does this suggest a cause for winds?

Other observations: (A) You have watched a bonfire and noticed how the sparks are carried upward. You have observed also that the hotter the fire the higher the sparks rise. Why?

(B) To tell the direction of a slowly moving current of air, wet the forefinger and hold it above the head. 1. Does one side of the finger feel colder than the other? If so, the wind is coming from that direction. 2. Can you explain why the finger feels cooler on the windy side? (See Key Experimental Problem 2, page 15.)

Anything that moves against something else produces friction, and friction produces heat. Try rubbing your hands together rapidly. Do they get warm? Perhaps you have started a fire by whirling one piece of wood rapidly against another piece. The friction caused heat enough to ignite the kindling to start the fire.

Why do you suppose a "shooting star" is so bright? Do you suppose the "shooting star," which is a piece of solid matter flying at a tremendous speed through our outer atmosphere, is really heated hot enough by friction with the air to cause it to give out light?

Suppose you keep these things in mind the next time you see a "shooting star" — better called a meteor — and try to explain what makes it so bright.

You have already discovered that the oxygen of the air has a very important relation to your well-being. Do you think moving air has any relation to your comfort or health? This will be discussed in the next topic.

Key Words

breathing	meteor	tissues
burning	oxidation	troposphere
carbon dioxide	oxygen	vacuum
change (chemical)	pressure	vapor (water)
combustion	stratosphere	wind

Key Statements

1. Air is a mixture of gases and contains impurities. It is found all about us and in soil and water.

2. Air in motion is called wind. Air exerts a pressure against all surfaces.

3. Objects passing through air at very high speeds are heated by friction.

4. Air contains 20.9% oxygen and 78% nitrogen. Oxygen is necessary to combustion and to life in plants and animals.

5. Nitrogen in the air prevents very rapid burning of most combustibles.

6. Wet iron will unite with oxygen more rapidly than dry iron. In either case iron oxide is formed. When oxygen unites with another substance, the process is called oxidation.

7. A bottle of air from which the oxygen is removed will not support combustion. Most of the gas left is nitrogen.

8. Rusting of metals may be prevented by coating them with paint or with a thin coat of metals which will not easily oxidize, such as tin, zinc, copper, silver, and gold. All such coverings except silver and gold will oxidize to a slight degree, but the oxide thus formed is very fine grained and will protect the metal.

Thought Questions

1. How can water contain air? *Hint:* See Experimental Problem 10, page 143.

2. Why are the exposed portions of wooden buildings usually painted?

3. Why are iron spoons not suitable for table use?

4. How is the nitrogen in the air useful to us?

5. Is there any relation between air pressure and the ability of an airplane to stay in the air? This is a rather difficult question, but the answer will make an interesting report for the class.

Projects for Your Science Discovery Book

1. Make drawings to show exactly what you did, step by step, to prove that oxygen is to blame for iron rust.

2. Make a list of a dozen metallic objects which you know will rust unless they are given proper care. In each case explain how to protect and preserve the object.

3. Carbon dioxide may be released by the union of baking soda and vinegar (or sour milk) or simply by heating baking soda. Devise your own method of capturing and testing some of the gas thus released, and record your experiment.

SURVEY OF TOPIC IX

Ewing Galloway

"Heads up, chests out! Slowly — inhale, exhale; inhale, exhale!" Arms are thrown wide to open lungs to the spicy, morning air, as these boys take their setting-up drill, breathing in and out to slow, even counts.

What good is accomplished by these breathing exercises? Let us consider. We have learned what air is made of and how necessary it is to life of every kind. Now we must learn how to use this air to our greatest advantage. We shall soon discover that air can be too dry or too warm or too stale and so become a menace to our health. And, alas, we shall also learn that we ourselves, through carelessness, can cause air to become a menace to those around us. We shall discover what relation that bugbear "cold-in-the-head" has to air, good and bad; and we shall learn some simple rules of health to apply to-day, to-morrow, and every to-morrow the rest of our lives.

TOPIC IX

AIR AND HEALTH

The cool fresh air whence health and vigor spring. — GEORGE ARNOLD

Do you know:

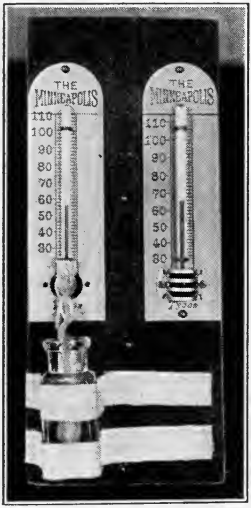
1. **Why outdoor air is better for your health than indoor air?**
2. **What is the best average temperature for indoor air?**
3. **How to breathe properly?**
4. **Why deep breathing helps to make you healthy?**
5. **How you caught your last cold?**

GENERAL PROBLEM 1. WHAT IS GOOD AIR AND BAD AIR?

82. Good Air. — We know that fires will not burn without oxygen; we have learned that plants and animals must have oxygen to breathe. Putting two and two together, then, we know that air which has a good supply of oxygen is necessary to healthful life. We know further that outdoor air contains 20.9% of oxygen (page 148). This is just about the right proportion to support life most efficiently. We know too that outdoor air also contains 78% of nitrogen, a very small amount of carbon dioxide, and about 1% of rare gases.

However, scientists tell us that even under the most crowded conditions in a house or public building the amounts of oxygen, nitrogen, and carbon dioxide will not vary enough to make the air indoors unsafe to breathe. Therefore, there must be other causes underlying good air. Out-of-doors the air is constantly in motion, mixing and cleaning itself. It contains a suitable amount of moisture and the temperature variations are favorable. It also has the benefits of sunshine.

Good indoor air, then, is air that has gentle motion, proper amount of moisture, and proper health temperature — 65° F. to 69° F. It should be free from dust and objectionable odors.



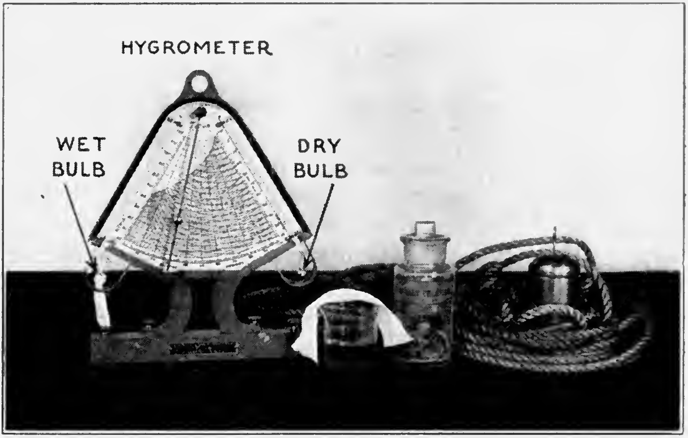
A Hygrometer Made by A Seventh-Grade Boy

A *hygrometer* is an instrument used to measure the relative amount of water vapor in the air.

From your knowledge of combustion, breathing of animals, and the work of plants, can you give reasons why the amounts of oxygen, nitrogen, and carbon dioxide in the air remain nearly constant?

83. Humidity. — The water vapor of the air is called *humidity*. Warm air can absorb and hold more moisture than cold air. Therefore, in the experiment on page 153, when the air touched the cold glass it was chilled. The excess moisture was condensed and became separated from the air in visible drops of water. If you had then poured some warm water into the glass, the film of moisture would have disappeared. Explain this result.

The "weather man" always refers to the humidity as *relative humidity*. He means that the moisture in the air at any one time is measured by what the air would contain if it held all it could. The air in deserts contains very little water vapor while the air near seacoast regions and swamps is very full of it. The proper relative humidity is an important factor in our health and should be carefully maintained in our homes and public buildings. A relative humidity of 40 to 60 per cent is considered healthful. (See the table in the



EXPERIMENT 22

What keeps one bulb wet? The beaker contains a pink cobalt chloride solution. Name all the articles and tell what each is for.

Appendix.) Watch the weather reports in the newspapers to find what the relative humidity of your locality is day by day. The amount of moisture in air where you live varies from day to day in fair weather, in storm, and in drought. Experiment 22 proves this.

Experimental Problem 22: *Does the humidity in the air vary from day to day?*

What to use: 20 to 30 ft. of ¼-inch manila rope; a piece of white cloth; a solution of cobalt chloride; a hygrometer; a two-pound weight; and a beaker.

What to do: (A) Suspend the small-sized manila rope between two trees or posts 20 feet or more apart, and observe the tightness or slackness during a period of several days.

(B) Using the beaker, stain the piece of white cloth with the cobalt chloride. Dry it and observe its color changes day by day.

(C) Learn how to read some form of hygrometer.

What happens: 1. Did the rope change in length on wet and dry days? 2. Did the colored cloth change its color on wet and dry days? 3. When the hygrometer showed high relative humidity, was the rope slack or tight; the colored cloth pink or blue?

Conclusion: Does the amount of moisture in the air vary from time to time?

Applications: You can use the rope not only to show that the moisture varies but you can use it as a hygrometer.

Hint: Hang the rope by one end with a small weight on the other. Measure the height of the weight from the ground from time to time. If you are ingenious you can make an indicating pointer and scale which will automatically show variations in the amount of moisture.

84. The Skin and Humidity. — Your skin is a hygrometer and *thermostat* (temperature regulator) combined. Through the pores of the outer layer of the skin the sweat glands (see the diagram, page 37) pour out about one quart of water each 24 hours, carrying various waste matters from the body. When the water evaporates from the skin, it absorbs heat and makes the skin feel cooler, just as the evaporation of water from the wet bulb of a hygrometer cools the bulb, and causes the mercury to contract, as you discovered in the above experiment.

When the air is very dry, the water from perspiration evaporates so rapidly the skin may really feel cold and so the little pores close up to prevent too rapid a loss of water. This in turn helps to prevent the body from becoming chilled. If a person with damp or wet clothing stands in a wind on a cold day, even this action of the skin may not prevent a chill.

Can you explain the chill which you sometimes feel just after a swim?

Because of this cooling effect by evaporation of moisture from the skin, a living room has to be kept at a higher temperature if the air is dry than if it contains the proper amount of moisture. Hence to save fuel in the heating season indoors, the air inside should be supplied with plenty of moisture (see page 153).

On the other hand, air that contains too much moisture prevents or slows down evaporation of water from the skin. This may prevent, to some extent, the desirable cooling off of the body. In such a case, the air may seem too warm and stuffy. If the flow of perspiration through the pores is interfered with for any length of time, the body functions are affected and the person may feel sick or feverish.

Field Research:

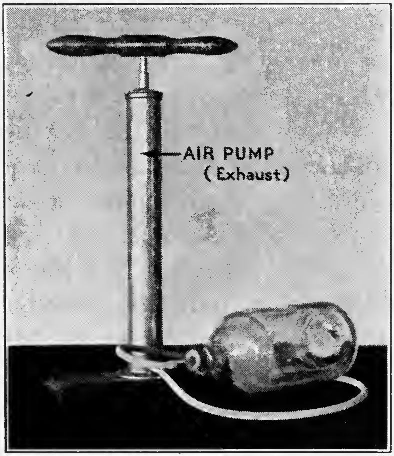
Go to your hardware or furniture store to see how many kinds of humidifiers the merchant has for sale. List them and describe them to the class.

85. An Artificial Fog. — The moisture in the air is an invisible gas except when condensed as in the formation of dew, fog, or clouds. Since rapid expansion of air cools the air, a fog may be caused in a bottle by reducing the amount of air in the bottle and thus allowing the remaining air to expand. Let us try this out in an experiment.

Experimental Problem 23. — *How can fog be made?*

What to use: A large glass bottle with one-hole rubber stopper; a glass exit tube; an exhaust air pump; some chalk dust; and a heavy-walled rubber tube.

What to do: Insert the rubber stopper with its glass exit tube into the neck of the bottle. Make sure all is air-tight. Now by two or three rapid strokes of the pump draw out some air. If fog does not then appear in the bottle, put in some of the chalk dust and exhaust again.



EXPERIMENT 23

What temperature change occurs in the air when it is caused to expand quickly?

What happens: Tell just what happened at each step of the experiment.

Conclusion: What is one cause of fog?

86. Bad Air. — Unusual amounts of dust, smoke, and poisonous or unpleasant gases, lack of moisture, too much heat, and too little air movement are faults of bad air. Usually such air is found indoors, in poorly ventilated and poorly lighted rooms. Gases from automobile engines, smoke from factory furnaces, dirty streets and decaying rubbish, stagnant water and decaying vegetation, poor sewage systems, and poor heating plants are all causes of bad air. We know how such evils may be avoided and so we should be constantly on the alert against them. The automobile motor is an especially dangerous source of air contamination. Its burning gases produce another form of gas, *carbon monoxide*, which is very poisonous. This gas has no odor nor color and so its presence is not easily detected. Therefore gasoline and oil engines should not be operated where there is not a constant and strong circulation of fresh, clean air. Tobacco smoke in the air is objectionable to many people.

87. How to Keep Good Air Good. — It is not much of a problem to keep outdoor air good, but people grow

A Busy Manufactory

How is this plant affecting the air? Is it wasting anything?

very careless in keeping the indoor air good. It is important that our clothes, shoes, bodies, teeth, and breath be kept clean so that offensive odors may not accumulate in the indoor air. Poorly ventilated schoolrooms, theaters, and other public meeting places are likely to have unwholesome air, particularly during the winter months.

Cleanliness and ventilation will help much to prevent the accumulation of foul air, but one other condition is very necessary to the complete purification of air, — the action of sunlight. You may take every precaution to have the air in your home clean, cool, moist, and circulating, but if it has not been exposed to the direct action of sunlight, it will not be so beneficial as outdoor air.

ARTIFICIAL DESERT — LUXURIANT PLANT GROWTH

What air conditions are needed to make plants grow in such different ways as they do here?

There is one way to assure good indoor air and that is by a constant interchange of indoor air for outdoor air. This interchange may be accomplished by artificial means of ventilation or by the more common method of opening windows and doors as the weather permits. In either case the important thing is to have the operation performed frequently enough that the building has a supply of fresh air at all times. You cannot do your best at work or play, if you spend much time in bad air.

Modern heating and ventilating systems are now available for homes, schools, and other public buildings, by which the air in a room is kept in proper motion, at the proper temperature and humidity, and free from dust and odors, winter and summer. This automatic system of supplying healthful air to buildings is called *air conditioning* and is one of the most important of the contributions of modern science to man's comfort and welfare.

88. Bad Air Means Poor Health. — Overheated air, air which is too dry, or air which becomes stagnant next to your body will make you feel dull and sleepy and likely as not give you a headache. Continual doses of such air will give you flabby muscles, stooped shoulders, and a thin chest. You will be slow of movement, lazy in spirit, and easily conquered by disease and sickness.

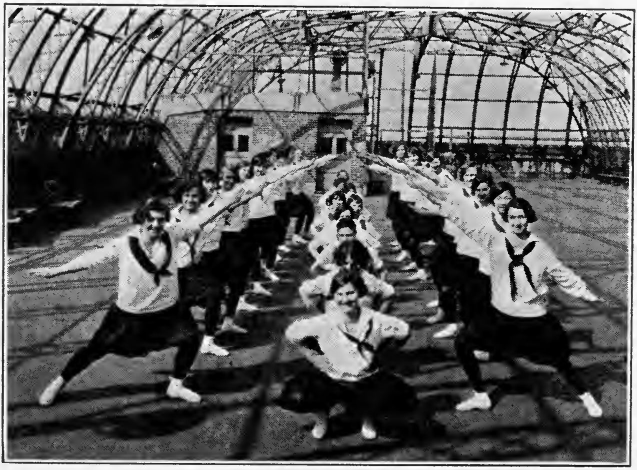
Field Research:

Make a study of the air conditions in your home and tell what they are and how, if possible, they may be improved. Let someone in the class also report on the air conditions of your school with suggestions for remedying any faults which may exist.

General Problem 2. Does Proper Breathing Promote Health?

89. Deep Breathing for Health. — Unless all the breathing muscles are constantly used, some of them may grow weak after a time and fail to do their work properly. One may become hollow chested by not exercising the chest muscles sufficiently in breathing.

You should regularly practice deep, strong, uniform breathing so that every tiny air sac in the lungs may be filled with good fresh air. In this way you not only obtain a sufficient supply of oxygen, but you can enlarge your chest cavity and increase your chest measurement. Breathe as most people are inclined to do when reading and then take a deep breath and notice the difference.



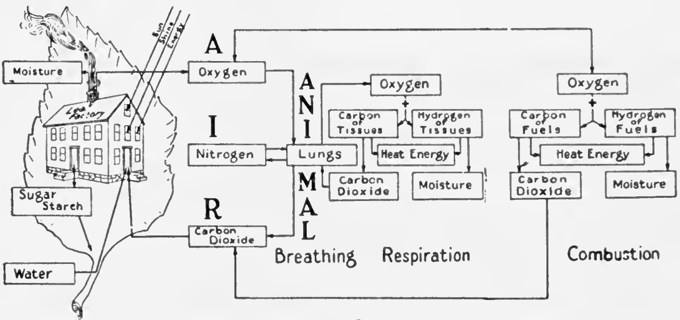
A Good Place to Exercise

Why is it important to take breathing exercises out-of-doors if possible? Why should the windows be open if you exercise indoors?

Complete use of the lungs helps to ward off diseases. Oxygen and proper amounts of exercise, food, and rest are foes of disease. Not only may serious lung disease be prevented to a large extent by careful attention to breathing and exercise, but colds, sore throat, and similar troubles may be avoided by the same means. You can do much to keep well by breathing properly. Good exercise stimulates deep breathing.

90. Exercise and Breathing. — Every time a muscle is moved, body cells (page 121) are doing work, and they need fuel and oxygen to furnish *energy* for the work. The material of which the body cells are made and the food which we eat are the fuel to supply the needed energy. But this fuel and the worn-out cells are oxidized, that is, burned by the oxygen which we inhale.

When cells are worn out, they must be replaced. Food containing *nitrogen* furnishes the material for



OXYGEN CYCLE

Trace the cycle of oxygen in the leaf, in breathing by animals, in animal respiration, and in combustion. How does each differ from the others? What similarities do you find?

building new cells, and the work of making the new cells requires energy. Oxygen is needed to produce the energy. Here then is another of Nature's cycles. Body cells require energy to do work and in doing work they become worn out. Food furnishes the materials for new cells and for the burning by oxygen of the worn-out-cells, and the energy to build the new cells.

Foods are classed as energy foods and tissue building and repair foods. Many foods contain both classes of materials.

Energy Foods	Tissue Builders
Starches	Lean meats
Sugars	White of egg
Fats	Fish
Yolk of egg	

The above foods are examples of energy foods and tissue foods. The tissue foods all contain *proteins* (food containing nitrogen). Many vegetables contain a good per cent of protein as well as starches and sugar, which are energy foods.

Breathing is the method by which oxygen is brought into the lungs to the blood and the waste carbon dioxide gas is released. The entire process of breathing, including the use of oxygen in the body to furnish energy and heat from food, and the formation and discharge of the waste gases, is called *respiration.*

Various forms of exercise call for more energy, and therefore more food than is required when we are resting or doing ordinary kinds of work. This additional energy can be produced only by furnishing an additional supply of oxygen to burn the food. The oxidation of food releases the energy.

Experimental Problem 24. — *How does strenuous exercise affect our breathing?*

What to use: A watch with a second hand; two pupils.

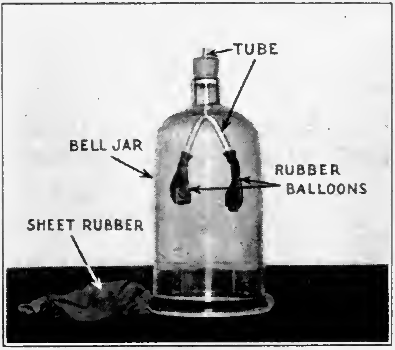
What to do: Let one pupil be the "doctor" and a second pupil be the "patient." Proceed as follows:

(A) Let the "doctor" count for one minute the number of breaths of the "patient." (B) Let the "patient" run up and down stairs or swing his arms and otherwise exercise for a few minutes. (C) Let the "doctor" again count the number of breaths for one minute immediately after the exercise. (D) After a period of quiet rest, let "doctor" and "patient" exchange positions and repeat the experiment.

What happens: 1. Did the exercise cause a change in the "patient's" rate of breathing? 2. What was the normal rate? 3. What was the increased rate?

Conclusion: What is the effect of exercise on the rate of breathing?

Suggested Experiment: Have a second "doctor" count the *pulse rate* of the "patient" before and after the exercise. Tell what the "doctor" finds out about the pulse rate before and after exercise.



HOW WE BREATHE

Tie the rubber sheet on the bottom of the bell jar and then stretch it down. Will air be sucked in or pushed in? By what? What big muscle of your body is represented by the rubber sheet?

Anything that interferes with any stage of the process of respiration, such as improper breathing, poor air, lack of food, lack of exercise, lack of rest, makes one feel ill and reduces his energy to think, to work, or to play, and to ward off disease.

91. Artificial Respiration. — When for any cause, for example, an electric shock, lightning stroke, near drowning, asphyxiation from illuminating gas, suffocation from exhaust gas of automobiles or from defective stoves, and similar cases of smothering, a person's breathing is stopped or nearly stopped, artificial respiration must be resorted to quickly.

Every boy and girl should know by *actual practice* how to produce artificial respiration, for it may be the means of saving a life. Learn how to do it. Then practice it in your gymnasium under the direction of your physical instructor and out-of-doors with your scout leader or a nurse or physician.

Help your science teacher demonstrate resuscitation to your class.

In case of need you must be ready to act at once. Send for help, if possible, but start the artificial breathing before other assistance comes. Every second is precious. Don't give up for at least four hours. Keep at it until natural breathing starts.

What to Do

First. — Remove any obstruction from the mouth or throat, such as gum, candy, or food.

Second. — Place the patient on his stomach, with his face to one side. Stretch one arm out straight over the head. Bend the other at the elbow so as to rest the patient's face on his forearm. See that his nose and mouth are not covered.

Third. — Straddle the patient with your knees just below the patient's hips. Bend forward and place your hands, palms down, on the small of the patient's back over the lower ribs.

Fourth. — Press down gradually and firmly, bringing the weight of your body into the pressure while you count slowly *one — two — three.*

On the third count quickly remove the pressure. Rest while you count *four* and *five*, then start over again.

Keep the motion going regularly, keeping time with your own breathing.

"PRESS — one — two — three — RELEASE. REST — four — five."

92. Nose-Breathing. — To protect yourself from disease you should not only breathe deeply but you should breathe through the nose. You have learned that air contains dust. Some of the dust particles are sharp and ragged. If they get into the delicate air passages, they may cause scratches or little sores. These tiny scratches may become the lodging places of disease-producing germs.

There is nothing in the mouth to prevent the dust from getting into the delicate air passages, but the passages of the nose are lined with small hairs, so that dust is almost entirely prevented from passing along with the air to the lungs. Dust is even swept back, as it were, to the gateway of the nose passage, where it may be removed by cleansing the nose. Consequently, if you habitually breathe through the nose, you are less likely to have sore throat, tonsillitis, colds, or tuberculosis.

There is another important reason why you should breathe through the nose. The air, in passing through the winding passages of the nose, is warmed nearly to body temperature before it reaches the lungs. Mouth-breathing does not allow enough time for the air to be thus warmed.

Field Research:

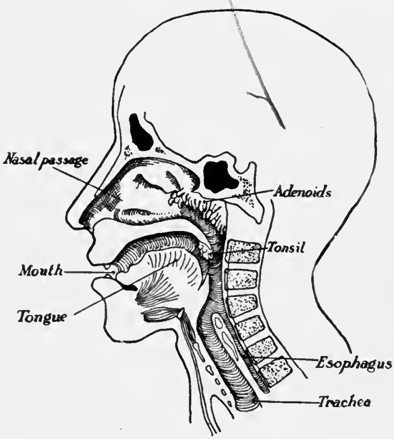
Heat some water to body temperature (about 98.6° F.) and put your finger in it to find how much warmer it is than the air or water at room temperature. This simple test shows how necessary it is that air should be warmed to your body temperature before it is allowed to pass to the lungs.

The lungs are not suited to withstand the shock which contact with cold air would inflict upon them. Not only should the air be warmed, but it must also be moist, since dry air in the lungs would soon tend to wither the delicate tissues (page 121) of the lungs. Dry tissues would make it difficult for the exchange of gases (oxygen and carbon dioxide) to take place between the lungs and the blood. So when air passes through the nasal passages, it absorbs quantities of moisture from the lining and thus it is moist when it reaches the lungs.

Field Research:

Find out some of the best methods for increasing the humidity of the air in your schoolroom and home.

93. Obstructions in the Nasal Passages. — Obstructing growths that are sometimes found at the base of the nasal passages are called *adenoids*. Severe cases of adenoids cause mouth-breathing. As adenoids obtain a foothold in the throat or nasal passage of a young child, they may grow large enough to cause trouble with hearing as well as with breathing. Proper medical care and regular physical examinations will prevent such troubles and give every child the opportunity for good health to which he is entitled.



THE HEAD
Why is it important to inhale through the nose?

94. Proper Care of the Mouth, Throat, and Nose. — Perhaps you have observed and read enough to enable you to take proper care of your nose, throat, and mouth. Such care will include means to prevent dust and germs from getting into your lungs.

The nose should be cleansed with a clean handkerchief carefully and regularly. In blowing the nose be sure to blow separately from each nostril. Do not blow from both nostrils at the same time since you may cause injury to the ears by forcing air or liquid from the throat into the little canals which run from the throat to the ear. These canals are the parts of the ear which are sometimes affected by adenoid growths. Injury to the canals leading from the ears is likely to cause infection in the ear.

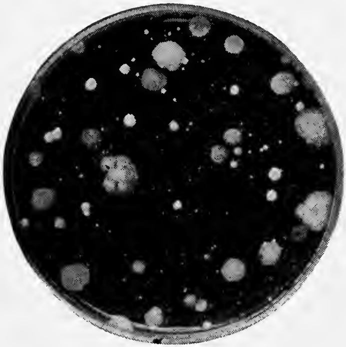
The mouth is so closely related to the air passages that it is important for you to clean your teeth and rinse out your mouth regularly. Such action not only preserves your teeth and helps to keep your breath clean but also makes for good health.

95. Respiratory Diseases. — Diseases connected with the organs of breathing are called *respiratory diseases.* The most common of these diseases is the ordinary "cold" located in the head or in the throat (sore throat). In such cases the breathing passages become clogged with germ-filled *mucus.* *Mucus* is a somewhat sticky fluid which coats the walls of the air passages. When a person afflicted with a cold sneezes or coughs, the germs are widely scattered unless the sneezing or coughing is done into a handkerchief.

96. The Common Cold. — The common cold is a danger signal no one should fail to heed. It keeps boys and girls out of school more days than any other disease. It has been found that every 1000 pupils lose a total of 1860 school days out of each school year of 180 days. This would be the same as 10 school years for one pupil.

In other words, on the average, each pupil loses two days out of school each school year. In twelve years of school this means nearly five weeks. Even whooping cough, which is thought of as a child's disease, keeps the 1000 pupils out of school only about 346 days. Other common preventable diseases and ailments together result in a loss of 5745 days (nearly 32 years for one pupil) of school time for the 1000 children each year.

Two courses are open to you if you wish to avoid sickness; first, to find a cure if you get sick, and second, and the more important, to prevent sickness. If a cold catches up with you, it is best to see the doctor. In any event, make sure you do not spread your cold to anyone else. Use your handkerchief (or better still, prepared paper tissue that may be burned) to protect others if you cough or sneeze, and for cleaning the nose and throat. Keep your fingers out of your mouth. Wash your hands and face thoroughly, using plenty of good soap, before you eat. Take plenty of rest, eat sparingly but drink water freely, six to eight glasses a day.



Bacteria Colonies

What conditions hasten the growth of bacteria?

To avoid colds, protect yourself against anyone who has a cold. Take plenty of outdoor exercise. Guard against indigestion by eating properly balanced foods. Do not eat too much of any food, especially sugar and candy. Drink your fill of water at regular intervals. Be systematic in your daily habits. Get sufficient rest. Keep clean. Remember, any disease that can be cured can be prevented.

Diphtheria, *bronchitis*, *pneumonia*, and *tuberculosis* are all respiratory diseases. It is your responsibility not to distribute the germs, if you happen to have a respiratory disease which breeds germs. In such cases keep a good supply of handkerchiefs on hand and use them. Be careful not to shake the handkerchief or place it where it will leave germs to be transferred to other people. Then, too, be considerate of the rights of others when you have occasion to expectorate. Sidewalks, street cars, and similar public gathering places are too frequently made dangerous disease spreaders by carelessness in this matter. Many people are ignorant about the dangers of these habits, while others who know better are simply thoughtless. Don't hesitate to rebuke anyone who sneezes or coughs in your face, but be sure you practice what you preach.

97. Tobacco and Alcohol Interfere with Respiration. — You have learned how vital the process of respiration is to the well-being of your body, and that any interference with it has an ill effect on the body. Any poison taken into the body will cause serious results. The boy or girl who uses tobacco is taking a poison. Both alcohol and tobacco are enemies to good health if their use becomes a habit. Tobacco smoke will injure the delicate tissues of the air passages. It is especially dangerous to growing bodies. With many children tobacco is a handicap both to physical and mental powers.

Alcohol taken into the stomach interferes with *digestion,* a process closely related to respiration. Absorbed into the blood, it paralyzes the white corpuscles and thus weakens the body resistance against disease germs. In these and other ways the use of alcoholic beverages interferes with respiration and other vital processes. Thin chest, short height, dull minds, poor eyes, lazy muscles, and other similar weaknesses can frequently be traced to the early use of these two *narcotic* poisons, tobacco and alcohol. Keep away from them!

THE LOW COST OF HEALTH

We hear very much of the high cost of living, but we overlook the fact that many of the best things of life can be had for nothing.

It costs nothing to stand up and walk and breathe properly.

Fresh air in the home is free.

There is no expense to taking a few simple exercises every morning.

It costs nothing to chew the food thoroughly.

It costs nothing to select the food best suited to the body.

It costs no more to stop using patent medicines.

It costs nothing to have a cheerful happy disposition, and stop having grouches.

These things cost nothing, yet they will bring content and reduce the doctor's bill to nothing a year — for you.

Inland Safety Bulletin.

Key Words

adenoids
alcohol
carbon monoxide
energy
food
humidity
hygrometer
lungs
mucus
protein
relative humidity
respiration
respiratory diseases
skin
tobacco
ventilation

Key Statements

1. Deep breathing is a good ally to have in the fight with disease.

2. Good exercise stimulates deep breathing and deep breathing helps to supply the energy for good exercises.

3. Tobacco contains narcotic poisons which injure the delicate tissues of the throat and lungs. Both tobacco and alcohol are habit-forming drugs which act as handicaps to clear thinking and to happy living.

4. Adenoid growths interfere with breathing and so with the general health. Excessive adenoid growths are likely to interfere with proper mental and physical development.

5. Air taken in through the nose is cleansed, warmed, and moistened; it is safer for breathing than air taken in through the mouth.

6. Colds are contagious and so their germs should not be scattered by unguarded coughing or sneezing.

7. Colds may be prevented largely by proper diet, regular habits, exercise, and rest.

8. Air indoors should be kept at a temperature of about 68° and at a relative humidity of 40° to 60°. It should be kept moving and should be regularly exchanged for a fresh supply of outdoor air. This may be accomplished by proper ventilation.

Thought Questions

1. Why does moving air feel cooler than still air?

2. Can you suggest a reason why the amount of moisture in the air varies so much more than the amount of oxygen in the air?

3. Why must dry air be warmer than moist air to be comfortable?

4. Why will too much moisture in the air cause discomfort?

5. What good effect does sunshine have on air?

6. How does bad air affect the health? Is outdoor air always pure?

7. Why is dew more likely to form on a clear night than on a cloudy night?

8. Why do the furniture joints open up in houses heated with dry air?

9. Why do our house doors close properly at one time and not at another?

Projects for Your Science Discovery Book

1. Examine under the miscroscope a piece of onion skin, a tiny piece of meat, a bit of tissue from the inside of your cheek, and a drop of blood as examples of different forms of cells. Make drawings of the various cells.

2. Make a list of what you should do to avoid colds and what to do if you are unfortunate enough to get one. Can you determine how you happened to get your last cold?

3. To prove that germs are carried in the spray from a sneeze or cough, you can perform the following experiment:

What to do: Prepare two culture dishes with a germ food nutrient. Let a person cough into one of them. Keep the other closed for a control. Place both dishes, covered, in an oven and keep at body temperature (98.6° F.) for 24 hours. Then examine the plates.

Result: The " control " should not show any colonies. The other plate will show a colony for every germ spattered on it.

Write up the experiment and its results.

4. By the use of burning joss sticks, make a study of the air currents in your living room and illustrate what you discover.

5. Make a study of colds in your family and report your results. How many colds per year does each member of your family have? How long does the cold usually last? What are the circumstances under which the first to get a cold contracts it? How soon after one gets a cold does the second, third, and so on, get it? How is it transmitted from one to the next? How could the transmission of the cold from one to the next have been prevented?

UNIT IV. FIRE

LOOKING AHEAD INTO UNIT IV

Boy and Girl Scouts must be able to start a fire for cooking, using only one match. Can you do that? To do it, you must know the principles of fire building; otherwise you are very likely to fail.

But building a fire is only the beginning of a series of skills and knowledges you must possess if you are to understand and control fire to your best advantage. In this unit there are provided many problems, the mastery of which will give you the power that goes with skill and knowledge.

Fire to-day is so commonplace that many people take it for granted. Strike a match and, behold, the fire blazes. It was not always so. The famous Greek thinker, Aristotle, observed many facts about fire, but it was not really understood until the great French chemist, Lavoisier, explained to the world in 1774 that fire results from the union of certain substances with oxygen.

SURVEY OF TOPIC X

Keystone View

Water, Earth, Air, and Fire! Four great servants of Nature that, from earliest times, have been recognized, feared, and worshiped by man. From ignorance as to the causes of floods, earthquakes, hurricanes, and the licking red flames of fire arose the superstitions of ancient peoples.

In the early history of our own country, fire played its part. Around the camp fires the chiefs of powerful Indian tribes used to meet in weighty council; and solemn ceremonies around those same camp fires marked all the important events of Indian life.

It was only when man learned what fire was that the fear of fire was stilled; in its place came the knowledge to use fire for his own comfort: for bodily warmth when winds were chill; for cooking of foods to make them more palatable; for distilling and purifying liquids; and for melting and shaping metals. Thus fire the fearful became fire the helper and friend.

TOPIC X

FIRE — FRIEND AND FOE

Not without fire can any workman mould
The iron to his preconceived design,
Nor can the artist without fire refine
And purify from all its dross the gold.
— MICHAEL ANGELO

Do you know:

1. Whether early man knew anything about fire?

2. Whether man has always made the same use of fire which he makes now?

3. How to start a fire without a flame?

4. How the Indians started a fire?

5. Some very unusual service to which fire is put?

GENERAL PROBLEM 1. WHY DID EARLY MAN WORSHIP FIRE?

98. Early Knowledge of Fire. — Primitive man seems not to have known much about fire. He undoubtedly had seen lightning set timber on fire and perhaps had witnessed the destructive work of volcanic flames. But what little he did know about fire made it an object of terror to him, — some powerful god whom he must worship, if he were to escape its anger. Early man worshiped many of the forces of Nature because he did not understand them.

As the years went on, this superstitious worship of fire gave way to reason. Men began scientifically to study the causes of the curious marvels of Nature. They discovered that the " burning springs," so strange and terrible to primitive peoples, were nothing but streams of burning *natural gas.* Various other wonders of Nature, which formerly had terrified mankind, became objects of scientific interest and practical use.

Courtesy U. S. Forest Service

THE EFFECT OF LIGHTNING

This picture was taken just thirty seconds after the tree was struck. Are fires by lightning preventable?

The stages in man's progress during which fire changed from a terrifying object of worship to a much-used friend show that the use and control of fire is chiefly responsible for our present civilization. From the time when some hard-pressed savage seized a burning brand to drive away wild animals, down to our day, with its widespread use of fire, man has continued to learn more and more of the value which properly controlled fire may have for him. He is also discovering at great cost how much of an enemy uncontrolled fire may be.

GENERAL PROBLEM 2. HOW HAS FIRE-MAKING PROGRESSED?

99. The First Lessons. — Man first learned to make fire probably in the same way that campers or scouts do it to-day. He would rub or twirl a dry stick of wood on a bit of dry tinder until the heat caused by the *friction* would set fire to the tinder. After this marvelous discovery he made rapid progress in his knowledge of how to make fire serve him. He took the greatest care that a fire once started should not go out, because the friction method was so slow and laborious.

A First Lesson in Fire-Making

In this day of easy fire-making, why does a Boy Scout learn so slow a method?

In time came the *flint* stage of fire-making. A spark was produced by striking a piece of flint (page 81) against some hard object and the spark was directed so that it ignited dry tinder. This method was much quicker than the friction method. Consequently fire became more and more an aid to man's work. It had ceased to be an idol because people began to understand it. The next important step came within the memory of recent generations. In 1836 the first practical *friction matches* were made at Springfield, Massachusetts, by Alonzo Phillips. Earlier forms of the match had been developed but did not have widespread use. Since Phillips' discovery, the improvement has been rapid, so that now fire has become our easily summoned servant.

General Problem 3. What Are Some Uses of Fire?

100. Fire for Warmth. — Fire gives us heat and heat adds innumerable comforts to our lives. Do you remember the story of how Washington and his men suffered at Valley Forge for want of fire? Have you ever suffered from the lack of heat? What remarkable progress has been made in the methods of heating our homes since the time of the smoking fire in the cave or wigwam! Better methods of heating have resulted in improved health and greater comfort and in the advance of civilization.

101. Fire and Foods. — The cooking of food was one of man's early uses of fire. The process made it possible not only to increase greatly the variety of foods but also made them more easily digested. Along with such improvement came a natural decrease in the spread of disease and sickness. (Can you tell why?) Then, too, through his experiments in cooking, man learned to apply the power of heat to other materials besides food. We shall study a few of these other applications.

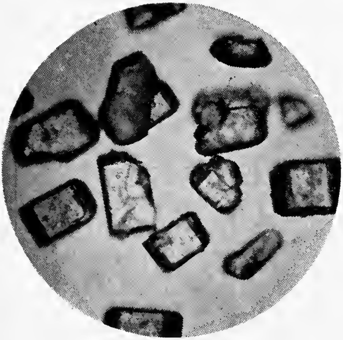
102. Fire and Liquids. — Not only does fire warm us and cook our food but by its help we are able to separate solids from liquids in which they have been dissolved.

Washington at Valley Forge

What evidence do you see that these men suffered for lack of warmth?

A Camp Cooking Fire

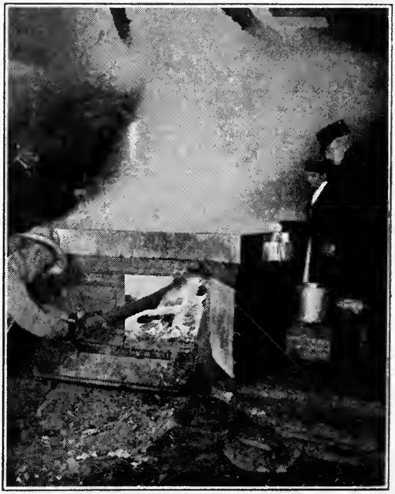
Study the picture to note precautions taken to prevent the spread of the fire and to conserve the heat for cooking.



Salt Crystals
How can you make such crystals?

Field Research: Make a solution of salt in water and then try to separate the salt by evaporation of the water by heat (page 12). What physical property of the salt and of the water makes this separation possible?

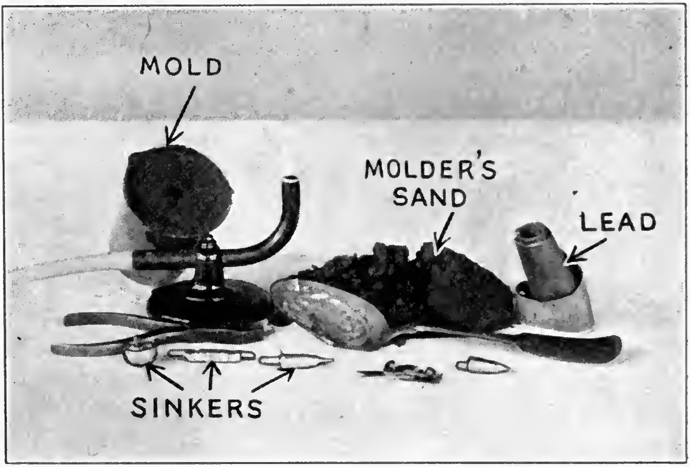
We can also separate liquids which may be mixed with each other. For example, by heating the crude oil which Nature has stored in huge underground reservoirs, we are able to secure gasoline, kerosene, and many kinds of lubricating oils. The saps of certain trees, if treated in similar fashion, provide us with many useful products, such as maple sugar, turpentine, and rubber. This process of heating liquids to get other liquids and solids is called *distillation*.



Making Maple Syrup
Explain this picture. What improvements have been made over this method?

Still other purposes require the application of heat to liquids. The milk which you drink was probably heated at the dairy before it was delivered at your door, sealed and ready for your use. This process, known as *pasteurization*, results in the killing of any dangerous germs which may be in the milk.

103. Melting Metals. — Fire makes possible the melting and shaping of metals. The following demonstration will illustrate how melted metals can be molded into required shapes for use.



EXPERIMENT 25
Which melts at the lower temperature, the iron spoon or the lead?

Experimental Problem 25: *How can fishline sinkers be made by molding lead?*

What to use: A quantity of old lead; some molders' sand (fine sand and clay); a pair of pliers; two small, steel staples; a large iron spoon; a knife; and a Bunsen burner.

What to do: Decide how large a sinker you want to make; then with your finger or pencil make a hole in the slightly dampened molders' sand, hard-packed in a box.

Put a few pieces of old lead into a large *iron* spoon with a long handle. Hold the bowl of the spoon over a flame until the lead is all melted. Then carefully pour the melted lead into the sand mold. Watch out for spattering, which may occur if the sand is too moist. Pour in enough lead to fill the hole. Before the lead has hardened, stick the points of the staple (held with pliers) into the melted metal. Hold it steady, while the lead hardens. ***Caution: Be very careful not to spill any of the hot lead on yourself or the floor.***

Allow the lead in the sand to cool and then remove it from the sand. If you have placed the staple properly, the points will be embedded in the lead, leaving the bend sticking out, to which you can tie a fish line. With an old knife you can smooth and finish the surface of the metal.

If your first trial does not result satisfactorily, melt the sinker and try again.

What happens: 1. How long did it take to melt the lead in the spoon? 2. Did a film form on the surface of the melted lead? 3. If so, what color was it?

Conclusion: When lead is hot enough to melt, it also is hot enough to combine with the oxygen of the air. The chemist calls the substance formed by this action *lead oxide.*

104. Extraction of Metals from Ores. — Have you ever read of the time when man used crude implements of stone? You can easily imagine how imperfect his work was with only the aid of such crude tools. After he discovered the value of fire, he learned to use it to extract metals from ores and to shape them into much more efficient tools. To extract a metal from its ore, the ore is mixed with charcoal (carbon) and heated. The oxygen of the ore combines with the carbon and the metal is left free. When you heated mercuric oxide to get oxygen, you also obtained a metal, mercury. Mercury readily lets go of oxygen, so the carbon was unnecessary. Let us see how to separate lead from its ore, lead oxide.

Experimental Problem 26: *How can lead be extracted from its ore?*

What to use: Some powdered wood-charcoal (carbon); an asbestos sheet; a Bunsen burner; a hammer; a knife; and a small amount of lead oxide.

What to do: Mix a small quantity of the charcoal with some of the lead oxide. Place the mixture on the sheet of asbestos and then heat with the blue flame of the Bunsen burner. Hold the burner so that the flame will play down on the mixture. Continue heating until you obtain a small pellet of metal, about the size of a pea seed.

EXPERIMENT 26

Does red-hot carbon have an attraction for oxygen? How do you know?

When the pellet is cold, remove it from the charcoal and scrape it with a knife. Does it look like lead? How does it differ from the lead oxide with which you started?

Place the metal on a piece of iron and hammer it. Does it flatten out? Try this test with a piece of metal which you know is lead. Do they act alike in this respect? Try to mark on paper with each sample of lead.

What happens: Did you obtain the *metal*, lead, from the *powder*, lead oxide?

Conclusion: 1. Tell how to extract a metal, like lead, from an oxide. 2. What is the use of the carbon? 3. How is lead different from lead oxide? 4. Find out the name of the lead ore from which most of our lead comes; the ore from which iron comes; the ore from which copper comes. 5. Are lead, or iron, or copper ever found as metals in nature? 6. Is gold?

The oxygen which was in the lead oxide combined with the heated charcoal and formed carbon dioxide. To learn this secret of extracting metals from ores took many ages of painstaking observations and experiments. Think of some of the metal appliances in your home. There would be no such utensils if there were no fire by which to extract metals from ores.

105. A Blessing and a Curse. — Fire, properly handled and controlled, is one of our greatest blessings, but in careless hands it becomes a source of danger to property and life. The match has made fire so easily available that thoughtless smokers and careless children frequently offset the good of fire by wrong control of it. (Give several examples of such carelessness.) In the next topic we shall study combustion and its products in order that we may be able to control fire and make the best uses of it.

Key Words

charcoal	flint	molding
cooking	friction	ore
distillation	heat	pasteurization
extract	matches	tinder

Key Statements

1. Ignorance is the root of superstition.
2. Knowledge drives away superstition.
3. Early man started fire by friction and later by use of flint.
4. The invention of the match made fire a prompt servant to man.
5. With means of starting fire and knowledge of some of its uses, civilization progressed rapidly.
6. Fire has long been used to give warmth, prepare food, heat liquids, and refine metals. It has innumerable other uses to-day.

7. Fire under control is used to man's advantage, but let loose it brings ruin.

Thought Questions

1. What is meant by *superstition?*
2. Why has knowledge of fire been an aid to progress?
3. What are some improvements over early methods of using fire for warmth?
4. Why are some foods cooked?
5. What is done to refine liquids and metals?
6. Why did fire make a change in the kinds of tools which man uses in his work?
7. In what ways is fire necessary to the making and use of automobiles? This is a catch question; think it over very carefully before answering.

Projects for Your Science Discovery Book

1. Find out how the Indians heated their wigwams and how the Eskimos keep warm to-day. Then compare their methods with yours and write a short story telling of some advantages of modern heating methods.
2. Find out what you can about the habits and physical characteristics of savages who eat their food raw. Do they eat a great variety of food? Are they afflicted with certain diseases more than are people who eat cooked foods? Make a record of your investigation.
3. List all the ways you can think of in which fire plays a part in your use of liquids.
4. Write an account of the following metals and the ores from which they come: lead, iron, copper, gold.

SURVEY OF TOPIC XI

It is a crispy, cool autumn evening on the lake shore. The camp fire is a mass of glowing embers. A few more sticks are added. A cloud of smoke rises, and is blown into your eyes and nose. Then the sticks burst into flames, and queer shadows flicker on the trees behind. Why is it that there is sometimes smoke and sometimes red and yellow flames? Where has stick after stick which fed the flames gone? Why are only gray ashes left?

There are other questions, too, about fire: Why is it hot? Will every substance burn? Why do we usually use paper or kindling wood to start a fire? Once more the scientist answers you, and in the succeeding pages you will learn the many facts about fire which have made possible the use of fuels — coal, oil, gas, and wood — to turn our great wheels of industry, and to transport us, warm us, cook for us, and light our darkness.

TOPIC XI

COMBUSTION AND FUELS

We sat the clean-winged hearth about,
Content to let the north-wind roar
In baffled rage at pane and door,
While the red logs before us beat
The frost-line back with tropic heat.

— WHITTIER

Do you know:

1. **Why a substance must be hot to burn?**
2. **Why some substances do not burn?**
3. **Whether fire is possible without air?**
4. **What fuels give the most heat?**
5. **What substances burn most easily?**

GENERAL PROBLEM 1. WHAT ARE THE CONDITIONS FOR COMBUSTION?

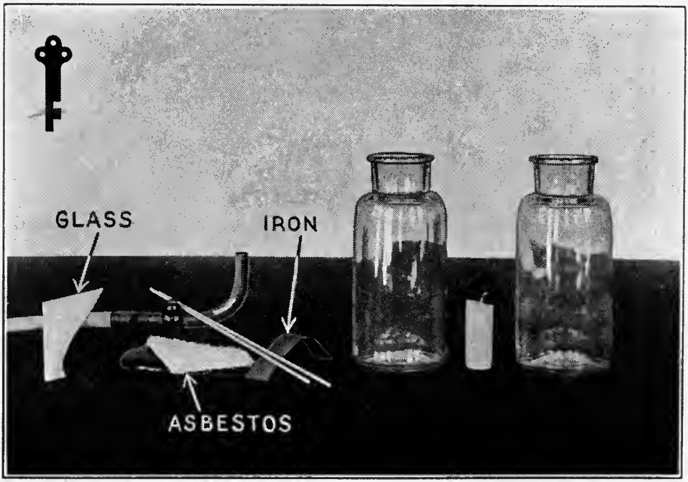
106. Combustible and Non-combustible Substances. — By observation and study of fire, men learned, as you have, that some substances would burn and others would not burn. Substances that will burn are called *combustible* substances. You are familiar with many combustible substances like wood, paper, coal, and gas. Likewise you know that many substances, such as water, rock, brick, and asbestos, are *non-combustible.* Let us discover just what conditions are necessary to combustion.

Try the following experiment to find out if heat, in addition to oxygen and a combustible substance, is required to start combustion.

(Key) Experimental Problem 27. — ***Are air (oxygen), heat, and a combustible substance all necessary to start combustion?***

What to use: Two 12-ounce wide-mouthed bottles; a candle; small pieces of glass, iron, and asbestos; a Bunsen burner, and hardwood splinters.

What to do: A. Invert the wide-mouthed bottle over the burning candle. When the candle goes out, take up the bottle



(Key) Experiment 27

Explain how each substance is necessary to solve the problem. What use can you suggest for asbestos?

and insert the burning splinter of wood. Then insert the burning splinter in a bottle of fresh air.

B. Try to set fire to the pieces of glass, iron, and asbestos.

C. Warm an end of a splinter of wood. Heat it until it blackens and finally burns.

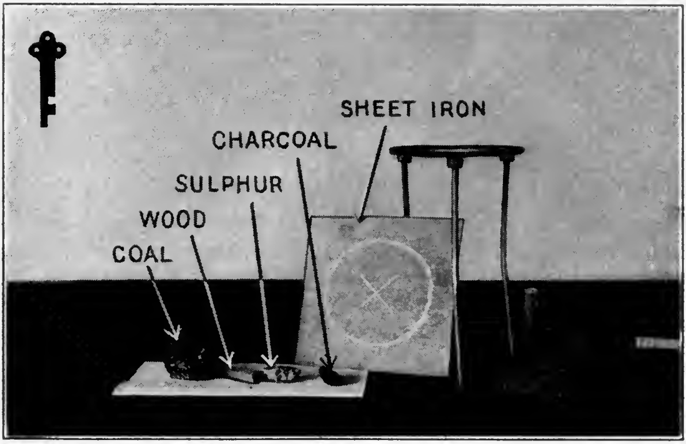
What happens: A. 1. Did the match continue to burn in the bottle which was placed over the burning candle? 2. Did it burn in the bottle of fresh air? 3. What substance did the burning candle remove from the air of the first bottle?

B. 1. Did the glass, iron, or asbestos burn? 2. Are they combustible?

C. Did the splinter start to burn when it was first warmed, or only when it became very hot?

Conclusion: From this experiment, what do you think are the necessary conditions for burning?

Since heat is just as necessary for burning as are the air (with its oxygen) and a combustible substance, the question naturally arises as to whether or not all combustible substances have to be heated to the same temperature to start them burning. They do not, as the following experiment will show.



(KEY) EXPERIMENT 28

Which of the articles shown in the picture are non-combustible? In the experiment, why are the combustible substances placed at equal distances from the center of the sheet iron?

(**Key**) **Experimental Problem 28.** — ***Do different substances start to burn at different temperatures?***

What to use: A piece of sheet iron, six inches square; an iron tripod; a Bunsen burner; small, equal-sized pieces of sulfur, charcoal, wood, coal, and phosphorus (red).

What to do: Near the center of the piece of sheet iron, draw a circle with a two-inch radius. At different points on this circle place the pieces of sulfur, charcoal, wood, coal, and phosphorus. Support the iron firmly in a level position on the tripod and apply heat with the Bunsen flame, exactly under the center mark. Continue heating until the wood chars or burns and the coal begins to smoke.

What happens: The heat spreads evenly through the sheet iron in all directions, so that places at equal distances from the center are heated to about the same temperature at the same time. As you continue heating the iron plate, the pieces on the circle continue to get hotter and hotter. 1. Why? 2. Did all substances start burning at the same time? 3. If not, name the order in which they began to burn. 4. Did they all finally burn? 5. If not, why not? 6. Did the first one to burn start burning at a lower temperature than the others? 7. Explain.

Conclusion: Enter your conclusions in your Science Discovery Book.

107. The Kindling Temperature. — The temperature to which a substance must be heated in order to make it burn is called its *kindling* or *ignition temperature.* While a splinter of wood has the same kindling temperature as a large piece of wood, more heat units are required to start the big piece burning. Gasoline vapor and kerosene will start burning at fairly low temperatures. A form of phosphorus, called yellow phosphorus, will burn at so low a temperature that sometimes even the air is warm enough to ignite (kindle) it. Coal, on the other hand, must be heated to a high temperature to make it burn. A burning match makes a high temperature, but burns out too quickly to ignite a large piece of wood or coal. It will, however, ignite a piece of paper or a splinter of wood, and so may be used to start a fire, if applied to a properly arranged pile of kindling materials.

The speed at which a combustible will burn depends not only on the kind of material but also on the size of the pieces. For example, coal dust burns so quickly that it acts like an explosive substance. Shavings burn faster than a stick of wood. This is because the finer the piece, the easier the oxygen in the air can get to it. Hence it can burn faster.

A Gasoline Fire

What property of gasoline makes it a fire hazard?

General Problem 2. What Are the Products of Combustion?

108. Combustion Products. — Most combustible substances (fuels) are composed of *hydrogen*, *carbon*, *oxygen*, and small amounts of some *minerals*. When a substance burns, these materials unite with oxygen and the new substances are called *products of combustion*.

An experiment will help you to find out that water and carbon dioxide are the products formed when a substance burns.

Experimental Problem 29. — *Are water and carbon dioxide products of burning substances?*

What to use: A Bunsen burner; two 12-ounce wide-mouthed bottles; a porcelain dish; a short candle on a wire; a large

EXPERIMENT 29

Name each article in the picture and tell its use in the experiment. What is the chemist's name for limewater?

beaker; a test tube; a bottle of limewater; and a 10-inch glass tubing.

What to do: A. Hold a cold dish against a gas flame for an instant. 1. Can you see a film form on the dish? This film is water. Turn down the gas to make a small flame. Hold a large beaker upside down over the flame so that the flame is near the center of the space in the beaker. Do not let the flame touch the sides or bottom of the glass. 2. Does a film appear on the glass? 3. What do you think it is? 4. How can you tell?

B. Put a little limewater in one of the 12-ounce wide-mouthed bottles. Cover the bottle and shake it to mix the limewater with the air. Does the limewater turn slightly milky? Set aside for comparison.

C. Light the candle and lower it, by means of the wire, into the second 12-ounce bottle. 1. Does the candle continue to burn? 2. How long? Remove the candle and test the air which remains in the bottle with limewater as you did in part B. 3. Does the limewater turn milky? 4. How does the amount of "milkiness" compare with that formed in the first bottle?

D. Blow through the glass tube into a little limewater in a test tube. Does the limewater turn milky this time? It is carbon dioxide (page 150) that causes the limewater to turn milky. This "milkiness" in limewater is a test for carbon dioxide.

Clean and dry the second bottle and invert it for a minute or two over a small Bunsen flame. Note if a film occurs. Test for carbon dioxide as before.

What happens: Compare the effects of the gases on the limewater. Did the air in which you burned the candle and the gas flame affect the limewater more than the unchanged air in the first bottle?

Conclusion: State clearly how you have proved that both moisture (water) and carbon dioxide are formed by combustion.

NOTE. How does this information prove that burning substances contain the elements *hydrogen* and *carbon?*

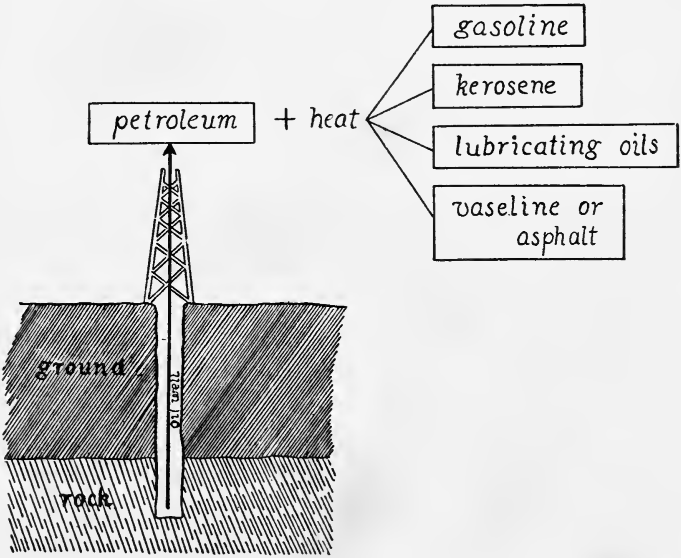
When a substance burns, each of its ingredients unite with a certain amount of oxygen from the air. Thus the hydrogen of the fuel unites with oxygen to form water. (You saw the water mist on the cold dish and in the large beaker.) The carbon of the fuel unites with the oxygen to form carbon dioxide. In such instances, the water and carbon dioxide are called products of combustion. They form as invisible gases and mix with the air. Other elements of combustible substances are usually mineral and also unite with the oxygen to form solid *oxides*.

Oxides from minerals are solid and remain as ashes. You have always known that ashes are products of combustion because they are visible. The other two products of combustion (water and carbon dioxide), though they disappear into the air, are nevertheless just as real products of combustion as the ashes. *The important products of combustion are then water vapor, carbon dioxide, and ashes.*

Heat is formed when combustion occurs. However, heat is energy and is not spoken of as a substance. It is, nevertheless, a most important result of burning.

General Problem 3. What Are Fuels?

109. The Common Kinds. — Fuels fall naturally into two general classes. There are *artificial fuels* and



fuels of *natural origin*. These may be further classified according to whether or not they are *solid*, *liquid*, or *gaseous* fuels. You are quite well acquainted with examples of each type. Wood, peat, and coal are familiar varieties of solid fuels of natural origin. Petroleum, a natural fuel, and its manufactured products such as gasoline and kerosene are liquid forms. Natural gas (occurring only in certain areas of the earth's surface), illuminating gas (an artificially prepared mixture of water gas and coal gas used in most communities where natural gas is not available), and several other kinds of commercial gases are the better known forms of gaseous fuels.

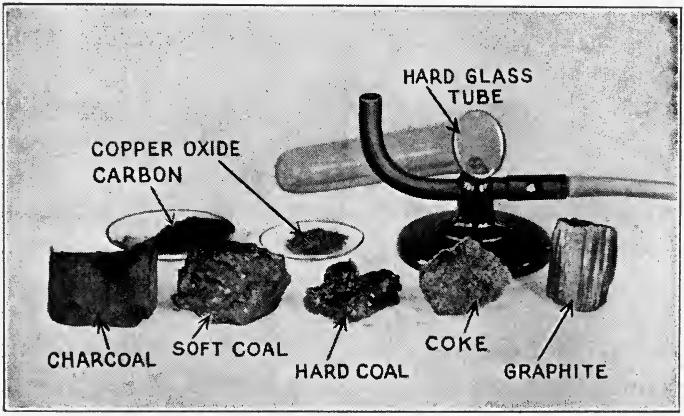
Coke, charcoal, water gas, and coal gas (a by-product of the distillation of coal) are the best known types of artificial fuels and their use is general though, of course, quite limited when compared with the widespread use of coal and wood. Alcohol, too, is finding a place in the list of commercial fuels.

110. What Makes a Fuel. — *Carbon* and *hydrogen* are the chief elements in a good fuel. Both elements produce considerable heat when burned and unite with the oxygen of the air, the carbon to form carbon dioxide and the hydrogen to form water vapor. These are chemical changes and the chemist represents the products by symbols. One part of carbon plus two parts of oxygen equals carbon dioxide (CO_2). Two parts of hydrogen plus one part of oxygen equals water (H_2O). Substances have *physical properties* and *chemical properties*. The physical properties of a substance are color, taste, odor, and the like. Its chemical properties denote what the substance can do, that is, whether it will unite with other substances or cause changes in other substances. The following experiment will show us some of the physical and chemical properties of carbon and hydrogen.

Experimental Problem 30. — *What is carbon like?*

What to use: A hard glass tube; a Bunsen burner; pieces of charcoal, hard coal, soft coal, graphite; some powdered carbon; copper oxide wire; and test tubes.

What to do: Examine the samples of charcoal, hard and soft coal, and graphite. They are all forms of carbon. Note the ways in which they are alike and how they differ, if at all, in odor, taste, color, and form. Try to dissolve particles of each in



Experiment 30

Why is a hard glass tube needed?

water. Try to burn small amounts of each by heating in an iron spoon.

Mix a small amount of the powdered carbon with an equal amount of the copper oxide wire and heat red hot for five minutes in the hard glass tube. Allow to cool and examine the material for copper.

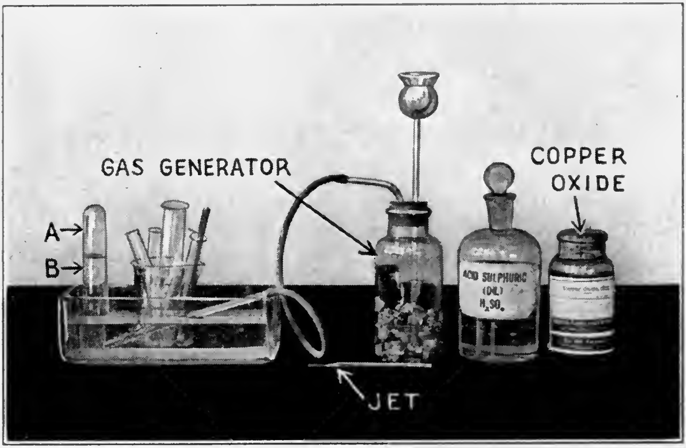
What happens: 1. How are these forms of carbon alike? 2. How do they differ? 3. Did any of the samples dissolve in water? 4. Did they burn? 5. Did heating the carbon with the copper oxide remove the oxygen and leave copper? (Compare with results in Experiment 26, page 195.)

Conclusion: State two or more physical properties and two chemical properties of carbon.

(Teacher's) Experimental Problem 31. — *What is hydrogen like?*

What to use: One 8-ounce wide-mouthed bottle; a dish of water; a thistle tube; a glass exit tube; a 2-hole rubber stopper; a jet exit tube; test tubes; a beaker; zinc; dilute sulfuric acid; and hardwood splinters.

What to do: Make some hydrogen by using a generator like the one illustrated in the picture below. Place pieces of the zinc in the bottle and cover with water. Be sure the water covers the lower end of the thistle tube. Add dilute sulfuric acid slowly through the thistle tube. Watch what happens.



EXPERIMENT 31

What metal should be in the generator to displace hydrogen from the acid? What makes the water **B** stay up in tube **A**?

NOTE. — To hasten the action a few small copper sulfate crystals, or copper oxide wire, may be added.

Caution: Keep flames away from the generator.

Let some of the gas bubble up through a dish of water. Does it appear to dissolve in the water?

Collect some of the gas over water in a test tube, as shown in the picture. Smell of it and look for any color.

Collect a second test tube of the gas and hold a burning taper or splinter at the mouth. Try this again after the action of the acid on the zinc has continued a few minutes. If it burns without popping, there is no air left in the test tube. Look for a flame inside the tube when you ignite the hydrogen.

Attach the jet exit tube to the generator and ignite the hydrogen gas issuing through the jet. ***Caution: Be sure all the air has been driven out of the generator before the gas is ignited, otherwise the gas may explode. To protect against flying glass in case an explosion does occur, wrap a towel around the generator.***

Hold a cold beaker over the hydrogen flame to discover if moisture is deposited.

What happens: 1. What happened when you held the burning taper to the mouth of the bottle containing hydrogen? 2. Did the tube become warm when the hydrogen was ignited? 3. What color and odor did the hydrogen have? 4. Did it burn? 5. What happened when the beaker was held over the hydrogen flame?

Conclusion: State two or more physical properties and two chemical properties of hydrogen.

111. The Heat Value of Fuels. — The method by which fuels are rated according to their heat values is fairly complicated and so we shall postpone our study of it to a later year of our school work. But we should know that fuels do differ and how they differ from each other in their heat-giving powers. Coal is one of the best of the fuels in its heating services; it has more heat per pound than any other fuel except petroleum. Different kinds of coal, such as *anthracite* and *bituminous*, differ between themselves in heat values. Anthracite, for example, gives slightly less heat than bituminous, but it burns with less waste smoke.

Field Research:

Weigh a little broken-up hard coal. Put it in an iron dish and burn it. After it is cool, weigh the ash. Calculate from your

data the per cent of ash in the coal. Do the same with soft coal, coke, and a piece of wood. Compare results. Why is there so little ash in the furnace when coke is burned?

Petroleum has the highest fuel value and is the most compact fuel; that is, a pound of petroleum takes up

COAL MINING

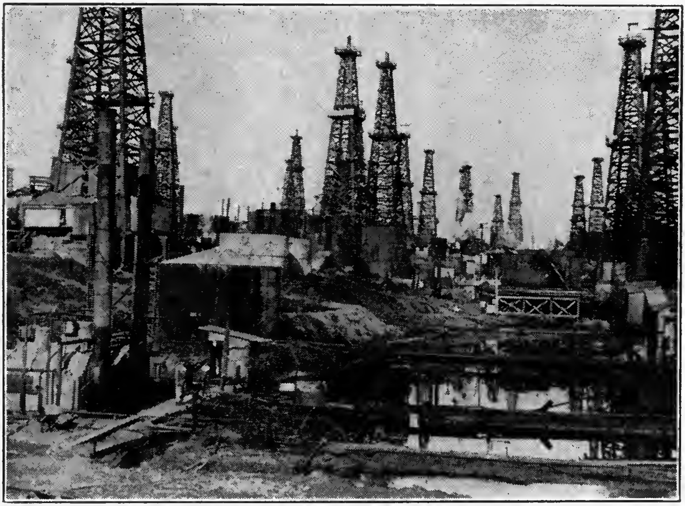
Is there danger of igniting the coal from the miner's lamp?

the least storage space per pound for the amount of heat energy given off when burned.

Wood has a little more than half the heat value per pound that coal has. The several varieties of gas differ in their relative heat values just as do the several other classes of fuels.

There is an abundant supply of these fuels in nature, and, for that reason, until very recent years, man has been wasteful and careless in his use of them. Science, however, has seen the danger of such wastefulness and not only has warned against it but is teaching us how to conserve our fuel resources and how to use our fuels more efficiently.

Although of the commercial fuels gas ranks lowest in heat value, it is such a clean, easily handled fuel that its use is very common. The operation of the burners in a gas stove is so simple that most of us pay little attention to them except to turn them on and off as we



PETROLEUM WELLS

What does the word "petroleum" mean?

need their services. But a correctly adjusted gas burner will do much better work than one which has not had such care. It will also make a marked reduction of the bills which come in from the gas company at the end of the month. Because of this fact, we shall find it worth our while to study the control of the air and gas mixture in a gas burner. As all such burners are constructed on the principle of the Bunsen burner, let us use such a burner for our observations and experiments.

112. The Bunsen Flame. — The ordinary luminous (light-giving) gas flame will not do for cooking because utensils placed over it would quickly be covered with soot (carbon). But if gas is passed through a burner in which it can be mixed with the proper amount of air,

A. Bunsen Burner Flame. Holes Closed

B. Bunsen Burner Flame. Holes Partly Open

C. Bunsen Burner Flame. Holes Entirely Open

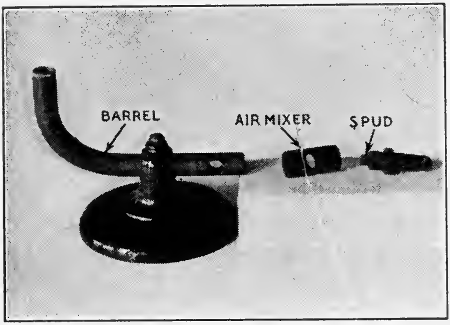
Compare sizes of flames. Note parts of the flame by numbers. Are any parts missing in cuts **A** and **B**? Explain. In which part is the flame temperature highest?

the carbon particles will be entirely consumed, the flame will be blue, very hot, and will not deposit soot. The Bunsen burner was devised to produce such a flame.

The construction of a typical Bunsen burner is shown on the next page. When the holes at the base are open and gas is passing through the tube, air is drawn in through these holes and mixed with the gas. The little sleeve at the base may be rotated to control the amount of air which is allowed to enter the tube. In this way mixture of the air with the gas can be so regulated that not the slightest tinge of yellow may be seen in the flame. Absence of the yellow tinge indicates that all of the carbon products of the combustion are being completely consumed, thus making for an intensely hot flame. The following demonstration will illustrate the principle of and give you practice in operating a typical gas burner.

Experimental Problem 32. — *How does the Bunsen burner operate?*

What to do: A. Examine the picture showing the parts of a Bunsen burner. Learn to name the parts. Try to identify in your laboratory burner the parts shown by the picture.



EXPERIMENT 32

Parts of a Bunsen burner. What is the purpose of each part?

B. Connect the burner with tube to a gas jet. Turn the gas on full and light it at once. Now turn the gas down so you will have a flame two inches high.

Open the holes at the base of the burner. 1. What color is the flame? 2. How many parts or cones can you observe?

Make a diagram in actual size to illustrate the parts of the flame when the holes are open.

C. Now slowly turn the "sleeve" until the holes are closed. 1. What changes appear in the color of the flame? Compare with the flame as in B. 2. Is it the same size?

D. Hold a cold dish in the yellow flame for an instant. 1. Result? Open the holes and try the cold-dish test again. 2. How does the result differ from the test with the yellow flame? 3. Do you have to open the holes completely to obtain a pure blue flame with no yellow tip? 4. If there is any yellow tip to the flame, will soot be deposited on a cold dish?

E. Hold the end of a piece of wire in different parts of the blue flame to find which part is the hottest.

F. Hold a slender piece of wood across the flame just above the burner. Does the wood appear to be burned equally across the flame?

G. Adjust the air going into the holes of the burner so that a perfect blue flame is produced. Now sprinkle a little powdered carbon near the holes. 1. Are particles of carbon drawn into the flame with the air? 2. Can you see the particles of carbon after they mix with the flame? 3. Are they now black or bright?

What happens: 1. State clearly the effect of opening and closing the holes at the base of a burner. 2. Did the yellow flame deposit a black soot (carbon) on the cold dish? 3. Did the blue flame deposit soot? 4. Were the particles of carbon which were drawn into the flame heated to brightness (incandescence)?

Conclusion: 1. Which kind of flame do you think is better for cooking purposes? 2. What makes the bright light when the holes are closed?

Practice regulating the Bunsen burner and gas plate at school. Then when you know how to regulate these gas burners, you should examine the gas flames of your home stove to see if the mixers are properly adjusted.

113. Some Fuel Problems. — When wood is burned, many valuable substances are lost which could be saved if the wood were treated by *distillation.*

When substances are heated in a closed retort (oven) from which air (oxygen) is excluded, easily evaporated substances are driven off. A process of this kind is also called *distillation.* If products of distillation cannot be removed to reproduce the same material, the process is called *destructive distillation.* Making coal gas from coal, and wood alcohol and acetic acid from wood by distillation, are examples of destructive distillation.

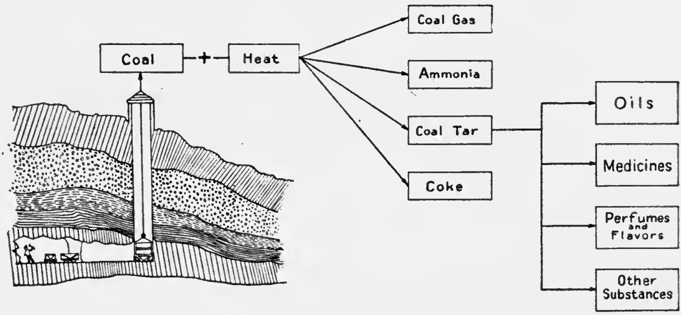
Field Research:

You can make gas from coal at home or school as follows: Get a clay pipe and fill about half of the bowl with fine coal; cover the coal with moist clay (or mud) and dry it.

Now place the bowl of the pipe in a coal fire or over a gas flame; heat slowly and after about two minutes hold a lighted match at the end of the stem. If the bowl of the pipe is hot enough, gas will be coming out of the stem. It is coal gas and will, of course, burn.

Why must the coal be covered with clay?

If we continue to use coal at the present rate and under present inefficient conditions of burning it, the



Coal Products

Explain this diagram.

prediction is made that the supply wili not last many generations. As in the case of wood, when coal is burned, many valuable by-products are lost. Perhaps coal may at some future time be treated at the mines by destructive distillation so that the by-products will be saved and the gas alone will be shipped or piped for use. More efficient methods of burning both coal and gas must be found to help conserve our fuel supply.

Your study of science will help you to conserve fuels and to reduce your heating and cooking bills.

Natural gas, because its occurrence is limited to certain localities, cannot come into general use. Petroleum products — gasoline, kerosene, and the crude or natural petroleum itself — are very valuable fuels and must also be conserved. Safe devices have been

STACKS OF POTENTIAL HEAT

Which has the greater heat value per pound, wood or coal?

perfected for burning these liquid fuels. In the last few years there has been a marked increase in the use of oil-burning furnaces. In many homes oil-burners are installed in furnaces originally intended for the use of coal. Automatic temperature control, both for coal and oil heat, results in saving fuel.

GENERAL PROBLEM 4. ARE FUELS THE ONLY SOURCE OF HEAT?

114. Heat from Falling Water. — Another important source of heat is water power. The energy of water power is converted into electric current and this current supplies heat energy for ever-increasing uses.

When some of you become inventors or fuel manufacturers, you will serve the world well if you can help a little in showing us how to get more heat for less labor and cost and how to prevent waste of fuel supply.

Now that you have discovered the causes that make a fire burn and know some facts about the products of combustion, the kinds of fuels, and how to use them, you will be interested to apply your knowledge to the prevention of fires that result in personal injury and in loss of lives and property.

Key Words

ashes	distillation	ingredients
Bunsen burner	electric current	kindling temperature
by-products	flame	oxides
chemical property	fuel	physical property
combustible	heat	products of combustion
combustion	hydrogen	soot
	ignition temperature	

Key Statements

1. Combustible substances are those that will burn.
2. A combustible substance must be heated to a certain temperature, called its ignition temperature, before it will burn.
3. Different substances have different ignition temperatures.
4. Three things are necessary for burning — oxygen, a combustible substance, and an ignition temperature.
5. Hydrogen and carbon are two important fuel elements.
6. Water and carbon dioxide are given off when fuels containing hydrogen and carbon are burned in air.
7. Ashes are oxides of minerals that formed a part of the original substances before burning took place.
8. Oxidation is the union of oxygen with another substance. In such a union, heat is always produced.

9. The heat of fuels comes mostly from the burning of the hydrogen and carbon of which they are composed.

10. Carbon and hydrogen may, by aid of heat, remove oxygen from some oxides.

Thought Questions

1. Where does the flame go when you blow it out? Do you know what a flame is? Why is it hot?
2. What temperatures are used for cooking? What is the highest temperature of which you know? the lowest?
3. Where is natural gas found?
4. How can you determine if a substance is combustible or non-combustible?
5. What is necessary in order to have a fire?
6. How is burning controlled by Nature?
7. What two gases are given off when wood or gas burns?
8. What do you consider the best fuel in your town? Why?
9. What is meant by conservation of fuels?

Projects for Your Science Discovery Book

1. Find out what materials the head of a common parlor match is made of and why each is used. Make an enlarged labeled drawing of a match and explain how it works.
2. By means of your encyclopedia and research at the library, make a list of fuels and classify them as suggested on page 206. Find out how coal is formed and how gasoline and kerosene are produced from crude oil (petroleum).
3. Go to your local gas office and get permission to visit the gas works. Make a complete record of how gas is made; how it is stored; what hours of the day and what months of the year produce the greatest demands on the gas supply; what *by-products* are obtained and used from the manufacture of the gas.
4. Recall the facts of the water cycle and explain how it is really the energy (heat) of the sun that furnishes the heat from electricity made from water power. Call your explanation an "Energy Cycle."

SURVEY OF TOPIC XII

The long, piercing wail of a siren, the shriek of brakes, and traffic at a standstill, as down the road roars the fire apparatus! Somewhere fire is once more taking its toll of property.

Do you realize that the fire loss in the United States every year is tremendous? That the annual cost is about five dollars a person for every man, woman, and child in the whole country? We pay insurance companies vast sums every year for protection, when prevention would save us seventy-five per cent of our enormous losses. Do all you can to prevent fire waste and see that other people are made to realize their responsibility, also.

Learn all that this chapter has to tell you about fire hazards, fire prevention, and fire fighting. Then spread the knowledge far and wide. Become fire conscious. Practice what you preach. Help to make the demon fire a slave to man, not his master.

TOPIC XII

OUR CONTROL OF FIRE

A little fire is quickly trodden out,
Which, being suffered, rivers cannot quench.
— SHAKESPEARE

Do you know:

1. **What a fire hazard is?**
2. **Of a fire hazard at home? at school? at some theater?**
3. **How to act in case of a fire emergency?**
4. **How to relieve the pain of a burn?**
5. **What treatment should be used to cure a burn?**
6. **What your community fire regulations are?**

GENERAL PROBLEM 1. HOW GREAT ARE FIRE DANGERS AND LOSSES?

115. Fire Hazards. — Soot-filled chimneys, rusty flues, unscreened fireplaces, poor electrical connections, badly placed gas lights or leaky gas connections, wooden ash barrels, rubbish-filled cellars, and many other sources of fire peril are easily to be found, sometimes within your own home. Is your family careful about the way it takes care of matches, both burned and unburned? Do they allow piles of rubbish to accumulate in dark cellar corners and other out-of-the-way places?

Paint oils on rags may produce enough heat by slow oxidation (page 155) to set the rags and oil on fire. A quantity of wet straw or damp newspapers, if shut off from easy access to the air, may likewise take fire by slow oxidation. Such fires are called *spontaneous combustion* fires. In a recent year over $17,000,000 worth of property was lost, owing to fires of this sort. Care on the part of the people concerned has reduced this loss to a little more than $11,000,000. More understanding will result in more care and even less loss.

A FIRE HAZARD

Explain why this represents a fire hazard. It is also a health hazard. Explain.

Cleansing preparations which contain gasoline or naphtha, gasoline and kerosene stoves, gas logs and gas ovens are all useful servants if handled in the right way, but are real fire hazards if carelessly used. Gasoline should never be used for cleansing in the home.

Discuss in class the way in which each of the foregoing materials should be used. Include in your discussion some comments on the careless use of electrical equipment such as electric irons, toasters, heating pads, and the like.

According to a statement issued by the Forest Service, United States Department of Agriculture, forest fires burned over an average of 42,063,777 acres of land in the United States each year during the five-year period 1931–1935, inclusive. The average annual damage caused by fires to timber, reproduction, and forage during this period is estimated at $51,924,579. In addition to the measurable damage caused by these forest fires there were large intangible damages to young

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A Forest Fire

How can you help prevent forest fires?

growth, watershed values, wildlife, scenic and recreational values, which cannot be measured in dollars.

For the National Forests only, the annual average area burned for the five-year period 1931–1935, inclusive, was 352,317 acres, and the measurable damage was $1,320,373. Increasing fire control facilities and effective organization is steadily reducing these fire losses.

Human carelessness has been the chief cause of all forest fires, the number of man-caused fires in 1935 running above 90% of the total number of fires of known cause. Incendiaries were responsible for the greater number of fires, followed in order by smokers, brush burning, campers, lightning, railroads, and lumbering.

In addition to these material losses, fire is responsible for the death of about 10,000 people every year — a horrible fact that condemns every careless user of fire.

117. Fire Exits. — All buildings such as schools, churches, theaters, public halls, stores, and shops

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A Burning Schoolhouse

Is your school fireproof? If not, what can you do to improve the fire drills?

where large numbers of people are frequently gathered together should be provided with safe exits, plainly marked. The building laws of most communities fix the number and character of fire exits for every type of building in which large numbers of people assemble.

Field Research:

Get a copy of the building laws of your town or city and state and study them to find out whether or not your town buildings are properly equipped and protected.

Make a study of the fire exits and fire escapes on any building which you can examine. Tell the number of exits; the number of people who can leave in three minutes, using each exit; the number of fire escapes from the upper floors; and the number of people who in three minutes can pass down each fire escape.

Find out how long it takes you when walking normally to go from the place farthest from an exit to the ground. Would the length of time which it takes you to walk this distance be sufficient to empty the building provided people walked carefully?

In the record of your inspection and study, state whether the exits are of sufficient number and so located that all the people in a full-capacity audience can leave the building in a minimum time of three minutes.

118. Fire Drills. — Do you understand why fire drills are required in schools, factories, and in other public and industrial buildings? In your own school, fire drills train you to form your lines quickly and without confusion and pass to the exits. Many lives and injuries have been saved among school children because the children had become accustomed to fire drills. When the emergency came, they handled themselves like well-trained soldiers.

When fire signals are given, always conduct yourself as if a real fire had been discovered, not as if you were performing a careless drill. You can never be sure that the signal is simply for a drill, and so you should take it for granted that the building is on fire. The drill is useless, if it is not performed in serious fashion. Remember, if you lose your head in time of danger, not only will you place your own life in danger but you may be the cause of injury to others.

119. First Aid for Burns. — If your clothing or that of another gets on fire, you will need all your self-control. Keep your wits about you. Keep the flames from the victim's face by forcing him to the ground or floor.

There is danger in breathing hot air into the lungs. Why?

Do not let him run. Then with a rug, coat, or blanket, smother the flames quickly by rolling the victim inside the rug. Even rolling on the floor will help, if there is no covering at hand. Begin the smothering of the flames at the upper parts of the body and work toward the feet. Keep yourself clear of the flames, of course. If you are the victim and have no assistance, follow the rules already given.

As soon as you have put out the flames send for a doctor. Place the patient in a comfortable position and keep his body warm, with wraps if necessary. Treat for nervous shock by giving strong hot coffee, tea, beef tea, or aromatic spirits of ammonia with water (one half teaspoonful in half a glass of water). While waiting for the doctor you may apply burn remedies such as moist baking soda, vaseline, oils, or trade preparations which may be at hand. Be very careful not to cause any additional injury to the burned parts.

If a doctor is not quickly available, you should *very carefully* remove the clothing from the burned portions. Do not use water to soak off burned clothing, but use some kind of oil such as olive or salad oil. Do not remove clothes if it results in tearing the skin. Wash the burns as thoroughly as their condition permits. Then apply the remedies and cover the burns with bandages soaked in oil to keep out the air. Prevent infection by keeping the injuries clean.

Ordinary burns should be treated with the same care as more severe burns. A paste made from baking soda and water, vaseline, or trade preparations are suitable. If necessary, draw off the liquid from the blister by making a hole with a needle through the skin just at the edge of the blister. Prevent infection by keeping the wound clean; use only material which has been made *sterile* by boiling or being treated with chemicals so that it is free from live germs.

If for any reason you are compelled to enter a burning building or try to escape from one, it is worth while to know how to protect yourself against flame and smoke. In such cases a wet cloth tied over the nose and mouth will permit you to breathe without inhaling much gas fumes and smoke. Since fumes and smoke rise, it is better to crawl along the floor than to walk upright.

If you are caught in a room in a burning building, feel of its door. If it is hot, do not open it. If you do, a blast of hot air will likely rush in and snuff out your life instantly. If the door is cool, you may open it carefully, with your foot against it, being ready to close it quickly if necessary.

If a person is overcome by smoke, get him out of danger and then try to revive him by using aromatic spirits of ammonia applied to a cloth. If the victim does not breathe, try artificial respiration as for drowning or suffocated persons. Use the method of artificial respiration described on page 175. Practice until you become an expert in the use of the method.

General Problem 2. How Can Fire Be Prevented?

120. Fire in the Home. — You have learned that three things are necessary for combustion — (1) oxygen (in air), (2) a combustible substance, and (3) kindling temperature. The prevention of fire in the home is based upon a knowledge of these three factors.

To prevent fire — guard combustibles. Place combustibles where they will not be heated by oxidation, by hot steam pipes, by over-heated stoves or furnaces, or poor electric wiring.

There are building laws in many states specifying the kinds of building material that shall be used in different types of building.

A FIRE SPREADING FROM ROOF TO ROOF

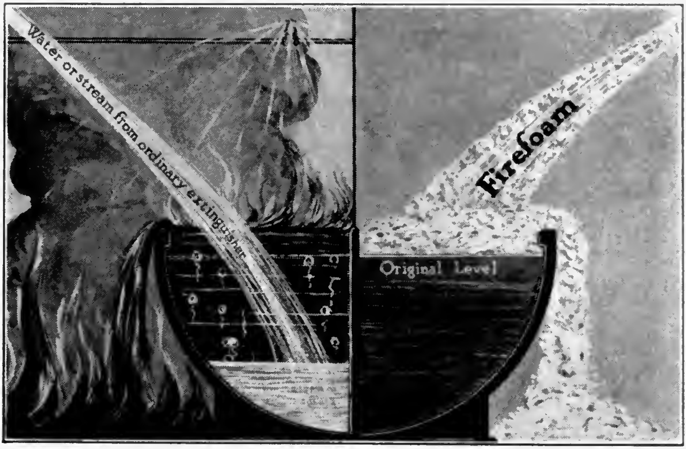
How can spread of fires like this be prevented?

School buildings, theaters, and other public buildings should be constructed of steel, stone, concrete, and other fire-proof substances with as little wood trimming as possible. All buildings should have fire-proof roofs. Shingles are a very great fire hazard because they easily catch fire from flying sparks. So great is the danger from sparks on wooden roofs that many cities have passed ordinances requiring the use of fire-proof roofings.

General Problem 3. How Can Fires Be Put Out?

121. To Put Out a Fire. — To put out a fire you must exclude oxygen or lower the temperature of the burning substances below their ignition temperature, or better still combine both methods.

To prevent the spread of fire, remove combustible materials or protect them by covering them with a blanket of non-combustible material, such as wool.



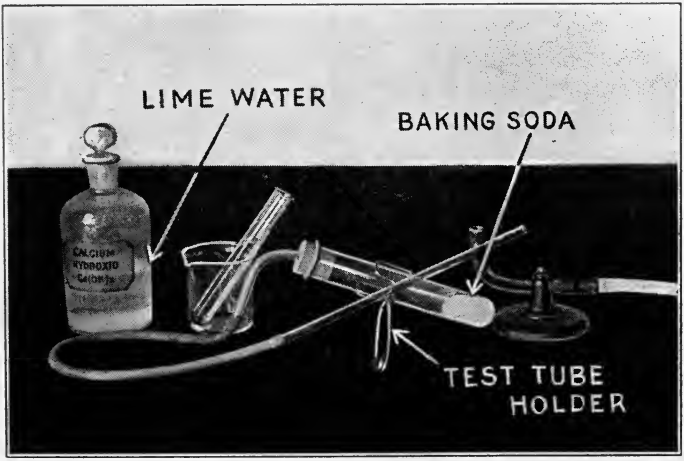
Explain this picture.

Oxygen may be excluded by covering the burning material with water or with a non-combustible gas. To form a non-combustible gas a liquid, *carbon tetrachloride,* is frequently forced in at the base of the flames. The heat evaporates the non-burning liquid to a heavy gas which crowds out the air and so smothers the fire. Water puts out a fire both by cooling the substance on fire and to some extent by excluding oxygen.

When baking soda is heated, a large amount of carbon dioxide is given off. You have learned that carbon dioxide gas will not support combustion and so can readily understand why baking soda makes a good fire extinguisher.

Experimental Problem 33. — *What is the effect of heat on baking soda?*

What to use: A teaspoonful of dry baking soda; two test tubes; a right-angle exit tube; a Bunsen burner; a one-hole rubber stopper; and a bottle of limewater.



Experiment 33

Name each article and tell its use in this experiment.

What to do: Place a teaspoonful of dry baking soda in a dry test tube. Fit the test tube with an exit tube as above. Heat the tube, gently at first, and then vigorously. At the same time place the outer end of the exit tube into a test tube of limewater.

What happens: 1. Was a gas given off? 2. How did it affect the limewater?

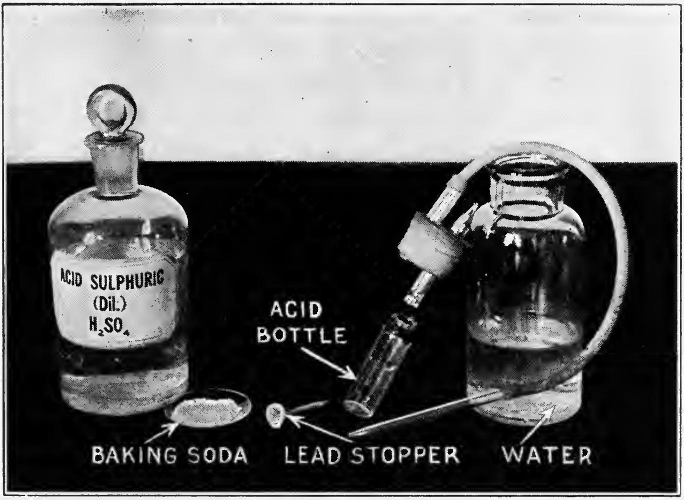
Conclusion: What gas is given off when baking soda is heated?

Carbon dioxide is a heavy non-combustible gas and acts like a blanket to smother a fire. To put out a fire with baking soda, the soda is usually mixed with sand to make it heavier and is thrown at the base of the flames. Of course only small fires can be quickly extinguished by a baking soda and sand extinguisher, or by carbon tetrachloride. Larger fires, except oil or gasoline fires, require the use of water.

School Practice with an Extinguisher
Why must the extinguisher be tipped upside down?

Water may be used to put out burning alcohol, wood alcohol, acetone, or any liquid that will mix with water. Water should not be used to extinguish burning oils or gasoline for the reason that it causes the burning liquid to spread. For oil and gasoline fires, use carbon tetrachloride, baking soda, sand, or special foam-producing substances prepared for the purpose (picture on page 229).

122. Fire Extinguishers. — A study of the various kinds of fire extinguishers is important if we are to use them effectively. The types illustrated in the diagrams on pages 232 and 233 can be demonstrated by models that you can make in the laboratory. Study the diagrams; then make some laboratory models and experiment with them. There are three types of fire



A Laboratory Model Fire Extinguisher

Give the use of each article and substance.

extinguishers, each of which has special values for use in a school, public building, house, camp, or automobile. They are as follows:

Pyrene Extinguisher

Use. — For oils, gasoline, and small fires. Work the handle as you would that of a bicycle pump. Aim at the base of the flame. *Caution: The fumes may be dangerous in poorly ventilated rooms. When the fire is out, ventilate the room.*

Material. — Carbon tetrachloride.

Active Agent. — Carbon tetrachloride gas.

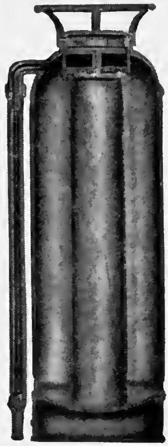
Explanation. — The heavy gas smothers the fire.

Foam Extinguisher

Use. — For gasoline, oil, and other small fires. Take the extinguisher from the wall, turn it upside down to mix the solutions, and direct the stream on to the burning materials.

Materials. — Baking soda solution, a foam material, and aluminum sulfate solution.

Liquid carbon dioxide in a metal bottle is placed in some foam extinguishers. To use, the extinguisher is



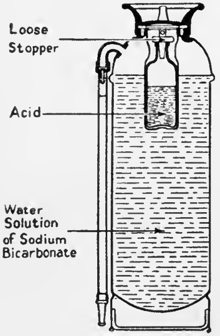
turned upside down and the cap hit against the floor. This punches a hole in the metal bottle, releasing the carbon dioxide as a gas. The pressure of the gas pushes out the foam material.

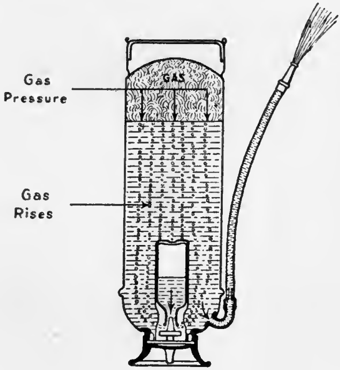
Active Agent. — A heavy foam.

Explanation. — The foam excludes oxygen from the burning material. The cross-section cut above pictures the operation of this extinguisher.

Water Extinguisher

Use. — For small fires, not for oils or gasoline. Point the nozzle at the base of the fire. Then turn the extinguisher upside down and hold it by the handle on its under side. The soda solution will spurt out of the nozzle. Play the stream where it will do the most





good, as you have only a limited amount of the solution available.

Materials. — Water solution of baking soda and a bottle of sulfuric acid.

The bottle of sulfuric acid has a loose heavy stopper of lead.

Active Agent. — Water.

Explanation. — When the extinguisher is turned upside down, the lead stopper of the acid bottle falls out and the acid mixes with the baking soda solution.

The action of the acid on the baking soda (sodium bicarbonate) liberates great quantities of carbon dioxide gas which exerts a pressure that pushes the water solution out through the nozzle of the tube. The water smothers the flames and cools the burning substance.

123. Emergency Materials for Extinguishing a Fire. — Sand will put out a small fire, and burning oils and gasoline, because it smothers the flames. A rug or blanket may also be used effectively to smother small fires. Sometimes it is possible to beat out a fire by use of some article such as a broom, a shovel, or a tree

Courtesy Boy Scouts of America

A Boy Scout Fire Brigade

What have these boys to use for fire fighting and what are they doing?

branch. Water is usually one of the most easily secured weapons against fires, but we must remember that it is a hindrance instead of a help in case of grease and oil fires.

Key Words

carbon dioxide	fire loss	hazard
fire drill	fire prevention	spontaneous combustion
fire exit	first aid	sterile
fire extinguisher	forest fire	

Some Fire Prevention Rules

Matches

1. Buy a good grade. Avoid the kinds that throw off the burned head, or that glow after being blown out.

2. Never throw one away carelessly. Be sure it is out. Then place it where it can do no harm. If outdoors, break it in two, stick the head in the ground or step on it.

3. Do not carry matches unless necessary. Never carry them loose in a pocket.

4. Keep them out of reach of little children who are too young to know their danger.

5. Close the box before you strike a match on it. Strike away from you, not toward you.

Candles

1. Use them only in holders that will neither burn nor tip over.

2. Keep lighted candles away from everything that will burn, especially from curtains and draperies.

3. Never use them on Christmas trees.

Kerosene lamps

1. Use only lamps that will not tip over.

2. Never fill a lamp except in daylight.

3. Do not place one too near curtains or other inflammable materials.

Gas

1. Protect gas flames with globes.

2. Never use old or leaky tubing; flexible metal tubing is better.

3. Never look for a leak with a lighted match. Trace it by your sense of smell and use a flashlight, if necessary.

Stoves

1. Protect walls and woodwork behind stoves by asbestos board, sheet iron, or tin shields. Leave an air space between metal and wood surfaces.

2. Protect the floor under a stove by sheet metal, particularly near the door to the ashpit.

An Observation Station

On Guard against Forest Fires

Our government employs fire-rangers to keep a constant look-out for signs of forest fires. At the first glimpse of curling smoke rising in the mountain air, the news is telephoned to the nearest fire-fighting unit.

What is your responsibility in this enormous task?

3. Never let a stove get red hot.

4. Be sure that stove pipes are sound and that both pipes and chimney are clean.

5. Do not pile boxes or other wooden or paper containers near stoves.

6. Never pour water on burning fat. Smother it with sand, earth, salt, or metal cover.

7. Do not use stove polish on a hot stove. Do not buy inflammable stove polishes.

Furnaces

1. Never overheat.
2. Never put ashes in wooden boxes or barrels.
3. Never use kerosene or gasoline to start a fire.

Electricity

1. Never leave an electric device, especially an electric flat-iron, without making sure that the current is turned off.

2. Do not use electric light bulbs for warming beds or drying clothes.

3. Be sure that the electrical wiring in any building in which you are interested follows the rules of the National Board of Fire Underwriters.

4. Be careful in your use of electric warming pads.

5. Know where the main switch for the house is and how to replace fuses.

Acetylene

1. Keep calcium carbide only in a tightly covered metal box.

2. Do not use any acetylene device unless it is approved by the National Board of Fire Underwriters' Laboratory.

3. Refill generators and lamp in daylight only.

4. Acetylene devices are very dangerous if carelessly used.

General rules

1. Put out a fire before it gains headway.

2. Locate your nearest fire alarm box and learn how to operate it. When you have rung the alarm, stay near the box until the firemen come, so that you can direct them to the fire.

3. Learn from your telephone directory how to give a fire alarm by telephone.

4. Closed doors and windows help to prevent a fire from spreading.

5. Keep your wits and help others to keep theirs. A cool head will stop a hot fire.

Forests

The following rules (U. S. Department of Agriculture, Circular 211) are for the protection of our forests:

1. Be sure that your match is out. Break it in two before you throw it away.

2. Do not allow anyone to throw pipe ashes and cigar or cigarette stumps into brush, leaves, or pine needles.

3. Build your camp-fire small and in the open, — not against a tree or log or near brush. Clear away any surrounding trash.

4. Never leave a camp-fire, even for a short time, without quenching it with water or earth.

5. Never build bonfires in windy weather or where there is the slightest danger of their escaping from control. Do not make them larger than you need.

6. If you find a forest fire, try to put it out. If it is too large for you to handle, get word to the nearest United States Forest Ranger or State Fire Warden at once.

Key Statements

1. Most fires are the result of carelessness and are therefore preventable.

2. The cost of preventable fires is increasing each year.

3. Most fire hazards about the house or other buildings are the results of neglect.

4. Spontaneous combustion is the result of the slow accumulation of heat from substances which are easily oxidized.

5. Gasoline should not be used for cleansing in the home. Use non-inflammable substances.

6. Suitable fire exits should be required on all buildings where large numbers of people assemble.

7. When the fire signal sounds, you are to conduct yourself as if a real fire existed.

8. If a person's clothing catches fire, smother the flames and

prevent them from reaching the victim's face. Treat for shock. Call a doctor.

9. Smoke and fumes rise. To pass through a room filled with smoke, crawl along the floor. Cover the nose and mouth, if possible, with a wet cloth.

10. Treat ordinary burns to keep out the air and to relieve the pain. Use baking soda paste, vaseline, linseed oil, and lime-water, or trade preparations. Do not break the blisters.

Thought Questions

What would you do in case:

1. You smelled smoke in your house?
2. You saw someone throw a burning cigarette stub into a rubbish pile?
3. You found some oily rags thrown carelessly into a corner of a building?
4. You were the first to see a house on fire?
5. A fire started in a room and the doors were open?

Projects for Your Science Discovery Book

1. List all the fire hazards you know of, whether they occur in the home, in some public building, or out in the open. Opposite each entry discuss the best way of controlling such a hazard.
2. Write a brief discussion of forest fires, the damage they do, and the best way of controlling and preventing them.
3. Copy the building regulations of your town. Do they provide properly for fire prevention?
4. Collect a page of newspaper clippings relating to fires.

Sequoia National Park

The lordly redwoods, aged monarchs of the western forests, were old when the pyramids were being built. Their cinnamon-red bark is a foot thick; their leaves are soft green and featherlike; their tiny seeds are hidden in small, oval cones.

"The big tree is Nature's masterpiece. As far as man is concerned, it is the same yesterday, today, and forever — emblem of permanence."

— John Muir

UNIT V. TREES

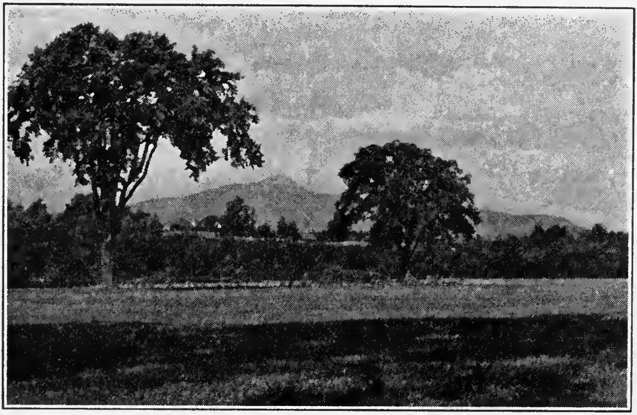
LOOKING AHEAD INTO UNIT V

"THE oldest living thing." Does that not carry your imagination back to Columbus' time and on back to the time when Christ was born in Bethlehem? But that was only a little more than nineteen centuries ago, while some of the great trees on our western coast were even then twenty to thirty centuries old.

It is estimated that the General Sherman Tree in Sequoia National Park in central California is now between forty and fifty centuries old and is the largest known living thing. It stands 273.9 feet high and is 37.3 feet in diameter at the base. In other words, it is as large around as a good many of our houses. The diameter of the largest branch is 7.3 feet. The total weight of the tree is estimated at 6167 tons.

To learn about trees is to understand and appreciate such masterpieces of nature.

SURVEY OF TOPIC XIII



What pleasant things trees remind us of: picnics, swings, pine needles; restful shade; nesting birds; whistles; hickory nuts and pecans; maple sugar! And what luscious fruits they bear: apples, cherries, peaches, pears! We admire their beauty, we make use of their lumber, we are made comfortable by their shade, we eat their fruits. Truly, a tree is our friend.

The rainbow colors of the evening sky are no more lovely than the colors that Nature gives the trees — the soft greens of young birches in spring; the flaming red and yellow and orange of the maples in autumn; the dark green of the evergreens in winter. It takes so long to make a tree, and it is so beautiful wherever it stands, that we should be careful not to hurt one needlessly.

Trees work for us in many ways. This chapter will tell you about them and their importance to our environment; your experiments and observations will prove their worth; you will learn how to help your community protect its trees.

TOPIC XIII

THE KING OF PLANTS

He that planteth a tree is a servant of God.
He provideth a kindness for many generations,
And faces that he hath not seen shall bless him.
— HENRY VAN DYKE

Do you know:

1. **Why some trees are called evergreen trees?**
2. **What kind of trees produce sugar sap?**
3. **Whether it injures a tree to break off a branch?**
4. **Whether your town has any societies for the protection of trees?**
5. **Whether there are more birds and other small animal life in the woods than in the open?**
6. **Why in summer it is cooler in the woods than in the open?**
7. **Why forest conservation is necessary?**

GENERAL PROBLEM 1. HOW DO TREES HELP US?

124. Timbered Treasures. — The timberlands of our country are one of the most important sources of our national wealth. Not only are many of our houses made from wood but practically all of our furniture was once a living part of some forest. Ships, railroad ties, telephone poles, pencils, paper, and dozens of other like articles are silent witnesses to the widespread and even reckless use of our timber. Only in recent years have our people realized the enormous wastefulness which has marked the destruction of some of our finest forests. Trees which Nature spent years in producing, men have cut down in a moment, without regard for future needs. Perhaps, if we take a little time to consider in detail the varied and valuable uses of trees, we shall be better fitted and more eager to do our part in the program of forest conservation.

A Forest-bordered Stream

How do the trees help to maintain this stream?

125. Flood-Checks and Windbreaks. — Probably the first use man made of trees was to seek their protection from storms and wild animals. Of course there is not nearly so much need for such protection in these days, but even now, particularly on our western plains, farmers cultivate wood lots not only for their wood products but also to serve as windbreaks against winter winds.

Forest floors usually consist of a thick layer of leaf mold mingled with the soil and brush litter. The roots

Wooded Slopes in a National Forest

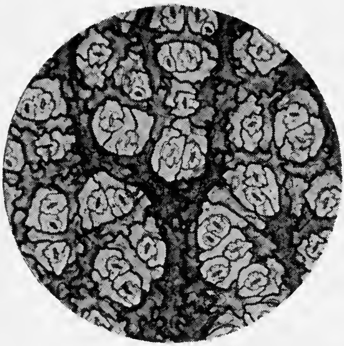
How do National Forests help in conservation?

Treeless Slopes

Compare the two pictures on this page and explain the differences.

of the trees spread out through this soil in a vast web-like network which keeps the soil in place when heavy rains occur. The soil is also protected from the full force of driving rains by the shelter of the overhanging boughs and the massed tree trunks. Because of them the water falls more gently and has a chance to soak into the spongy soil instead of being driven along the surface by succeeding torrents. The very sponginess of the soil makes it hold the water longer, so that there is a gradual flow to the stream and river beds. Then, too, in winter and spring the forest roof of tree tops somewhat shields the fallen snows from the sun, thus permitting a gradual melting of the snow.

1. How do the foregoing statements show that forests help to prevent floods? 2. Why is it a good thing for a watershed (page 55) to be forest covered? 3. What would happen to the soil of the forest floor if the trees of the forest were cut down?

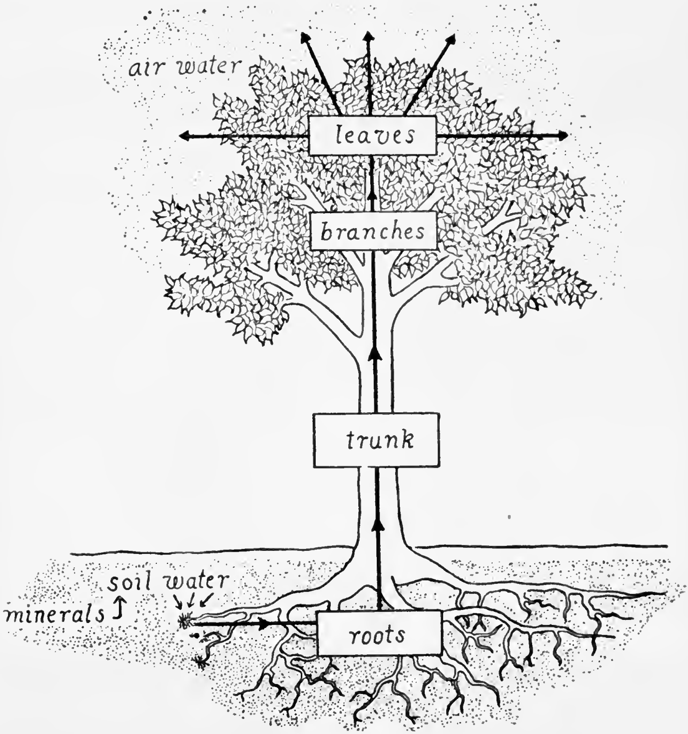

Magnified 50 times

THE UNDERSIDE OF A LEAF

The oval openings are stomata through which water escapes.

126. Trees as Air-Coolers. — Trees, like any other plant, take large quantities of water into their systems by means of the thousands of *root hairs* which grow along the surface of their rootlets. They do this in order to get the soil minerals which are drawn in with the water. After the minerals have been separated from the water in the process of making food, the tree must get rid of most of the water.

It does this by a process called *transpiration*, in which the water passes into the air through small pores in the leaf surface, mostly from the underside of the leaves.



TRANSPIRATION

Explain each part of the diagram. How is this process related to the water cycle?

Here the water is evaporated, absorbing heat from the air as it passes off in the form of water vapor. This process, combined with the shade which the leaves provide, makes the air of a forest moist and cool.

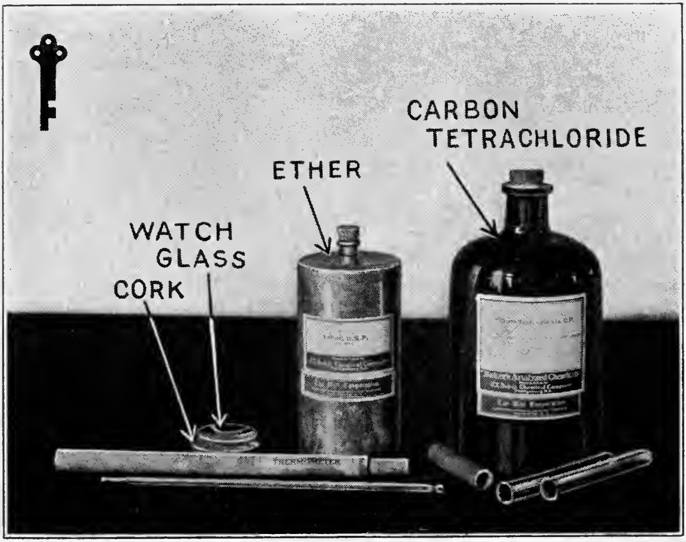
Explain the cool moisture of a greenhouse.

(Key) **Experimental Problem 34.** — ***Do liquids absorb heat when they evaporate?***

What to use: A flat cork; a small watch glass; ether; carbon tetrachloride; and a thermometer.

What to do:

Caution: Ether is inflammable. Do not have any flames about while using it.



(KEY) EXPERIMENT 34

Why are ether and carbon tetrachloride used instead of such liquids as oil and water?

Place a little carbon tetrachloride on the hand and fan it. Repeat, using a few drops of ether.

Note the temperature indicated by the thermometer and then wet the thermometer bulb with carbon tetrachloride and fan it.

Place a few drops of water on the surface of the cork and carefully place the watch glass on the water. Nearly fill the watch glass with ether and fan briskly until the ether disappears. Then notice if anything has happened to the water between the glass and the cork.

What happens: 1. Did the liquids evaporate? 2. Did the evaporating liquids make the hand feel cold? 3. What did the evaporating liquids do to the mercury in the thermometer? 4. What happened to the water on the cork?

Conclusion: 1. What is one effect of evaporating liquids? 2. What effect did fanning have on the rate of evaporation?

Applications: Explain why your body feels colder standing in the wind than when sheltered.

FOOD PRODUCERS

Can you tell the kind of food these trees furnish?

127. Trees as Food Producers. — If you live in some parts of our country, you know where the old hickory nut tree stands, and have gathered its offering in the fall after a heavy frost. Or if you live in the city, you are familiar with the many varieties of delicious nuts which trees have sent to your storekeeper's counter. And the little old man with his oven and pans of hot roasted chestnuts is a welcome tradesman on the streets of our northern and eastern cities. From these examples it is easy to see that food in the form of nuts is an important contribution of trees to our diet.

Still more important than the nut trees are the fruit trees, — apple, pear, plum, persimmon, peach, orange, lemon, cocoanut, banana, and many other tasty and health-giving fruits which in this day of refrigerator cars can be had at places far distant from the place where they are grown. Wherever we live our attention is constantly called to the usefulness of trees as food producers.

128. A Source of Beauty. — For a long time after the tree pioneers had about vanished from parts of

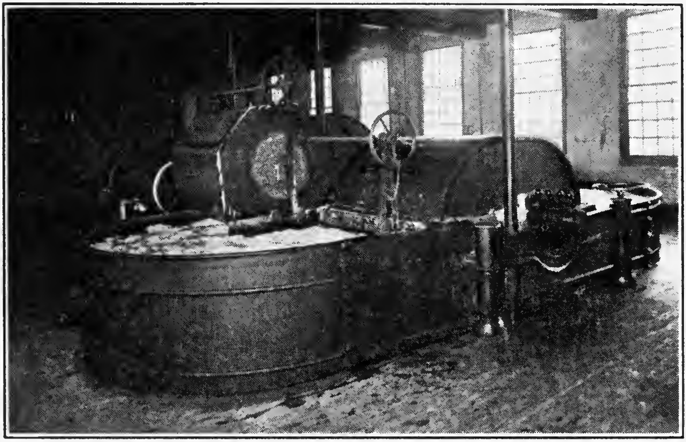
Beautifying with Trees and Shrubs

Try to find rhododendrons and hemlocks. The tree beyond the walk, at the left, is a magnolia.

our land, people did not pay much attention to the purely beautiful things of life. Ugly tenements and huge smokestacks, dirty streets and grimy factories were regarded as necessary evils, if a community were to be prosperous. All this has changed. To-day we know that spacious lawns and stately trees contribute immensely to the value of a community. Great parks, requiring tremendous sums for their up-keep, are marks of a community's prosperity, showing that it has a care for the health and happiness of its citizens. Even the Nation itself has learned the lesson and has set aside huge areas to serve as its playgrounds. And the most important factors in the development of these centers of beauty are trees and water. What a barren world this would be, if we were to be deprived of the beauty and usefulness of trees.

129. Other Uses. — Soft woods such as poplar and birch are cut into short lengths and ground into a pulp to make the paper used in newspapers, cheap books, wrapping paper, and other similar inexpensive paper products. Paper of the better quality is made from the wood pulp after it has been treated chemically. This process takes out part of the wood and leaves nearly pure *cellulose*, a substance composed of carbon, hydrogen, and oxygen. Cotton is nearly pure cellulose.

Some kinds of pine are used for making turpentine. The trees are tapped somewhat as maple trees are tapped for sugar sap. The juice or sap of the pine runs out into containers. When it is distilled (page 192), it becomes the turpentine used in paint. Sometimes turpentine is obtained by distillation from small pine pieces which are the waste material in lumbering. The pieces are cut up and placed in a retort (page 215) that is closed and heated. The turpentine passes off as a gas which, when cooled, condenses in the liquid form with which we are familiar.



PAPER MAKING

One way in which great quantities of wood pulp are used. The paper in this book contains wood fibers.

Hard woods are distilled to produce wood alcohol which is valuable for fuel and for making shellacs and varnishes.

Natural rubber is a gum formed by allowing the sap of the rubber tree to thicken. This, after a chemical treatment, is used for many of our rubber products.

GENERAL PROBLEM 2. WHAT ARE THE PARTS AND FUNCTION OF A TYPICAL TREE?

130. Three Main Parts. — Like most of the well-known plants which grow above the surface of the earth, trees have three main parts, *roots*, *trunk* (stem), and *crown* (branches and leaves). Each part has its work to do, and if one part fails, all must die.

The roots are most important to the welfare of the tree. Not only do they serve to hold it in place by their grasp on the soil, but, as we read on page 246, the fine short fibers called root-hairs enable the roots to absorb great quantities of water with its store of dissolved minerals. These raw materials and carbon

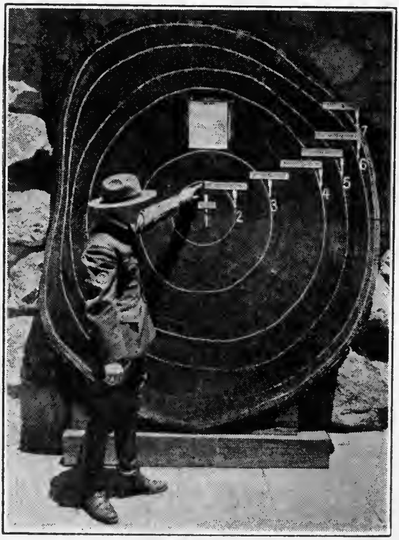
THE ROOT SYSTEM OF A DOUGLAS FIR

Look for evidence that the root system serves the tree as told in sections 126 and 130. Why did it fail in any of these uses?

dioxide taken in by the leaves are needed by the tree to manufacture its food.

The trunk of a tree serves to hold the crown aloft in the sunlight. The trunk and its branches, and also the roots, contain passageways for water and minerals to go up to the leaves where most of the food is manufactured. There are also passageways by which the food is distributed to all parts of the tree to enable it to grow, and still others for storage of food.

The trunk with its branches is made up of an outside protective layer called *bark*. Next to the bark is the *cortex*, where some food is stored. The *sap*, which is mostly sugar dissolved in water, travels down through the thin-walled cells just inside the cortex.



Courtesy Yosemite Park & Curry Company

RINGS OF GROWTH

This tree started to grow about 923 A.D. The chalk lines mark rings which date historical events: (1) 923 A.D.; (2) 1066, Battle of Hastings; (3) 1215, Magna Carta; (4) 1492, Discovery of America; (5) 1620, Landing of the Pilgrims; (6) 1776, Declaration of Independence; (7) 1860, Civil War.

The growing region, called the *cambium*, comes next, and each year it adds new layers of cells which unite with cells above and below to form hollow tubes through which water and the dissolved minerals pass up from the roots. Each year the new growing region forms a ring. By counting these rings, as they appear in a cross-section of the trunk, the age of the tree can be told.

The part of the tree inside the growing region is composed of compressed woody cells which, united into a compact mass, give strength and rigidity to the stem and form what we know as wood. At the center of the stem is found the *pith*.

If you will observe carefully a twig or branch of a living tree, you will see it is divided into sections separated by joints. A new joint forms and a new section grows each year. After the first year a section does not increase in length but it does build a new layer of wood just beneath the bark each successive year. You can observe this for yourself by cutting cross-sections of a branch through two adjacent sections and counting the layers or rings. The newer section will, for example, have three layers of bark while the adjacent one, which is a year older, will have four.

Field Research:

Cut through a maple branch to find from what part of the trunk of a maple tree the sap comes. Does the sap move up the trunk and branches toward the leaves or is the reverse true?

Courtesy U. S. Forest Service

TREE TRUNKS RAISE THEIR CROWNS HIGH INTO THE SUNLIGHT

How do trees cool the air?

The crown of a tree also plays an important part in the life and growth of the tree, since in the leaves occur the manufacturing and digestive processes whereby the plant is supplied with the right sort of food. Because sunlight is necessary for the leaf to carry on its manufacturing, trees grow tall or broad, as the case may be, to get their leaves into the sunshine. The leaves also are the principal breathing organs of the tree. The crown is important also because its twigs carry the buds that may give rise to new generations of trees.

General Problem 3. How Do Trees Continue Their Kind?

131. How Trees Produce Other Trees. — A tree cannot live for itself alone. Every spring you have observed that the smaller branches, the twigs, of a tree contain buds. Some of these buds open up to form leaves while others near at hand produce flowers. One part of the flowers, the *pistil*, receives *pollen* from other flowers, by which it is fertilized. After fertilization and ripening, part of the pistil, the *ovary*, becomes a fruit or seed pod from which the seeds are scattered by birds, winds, and rains to fall into soil where they will produce new trees, if the conditions are favorable. These new trees will develop roots, stems, and leaves and in their turn produce more seeds, — another of Nature's cycles.

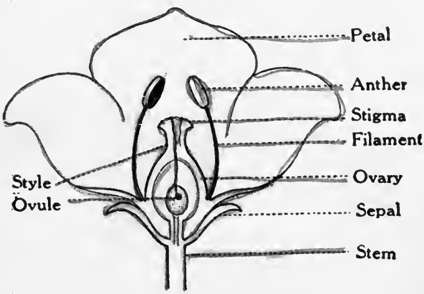
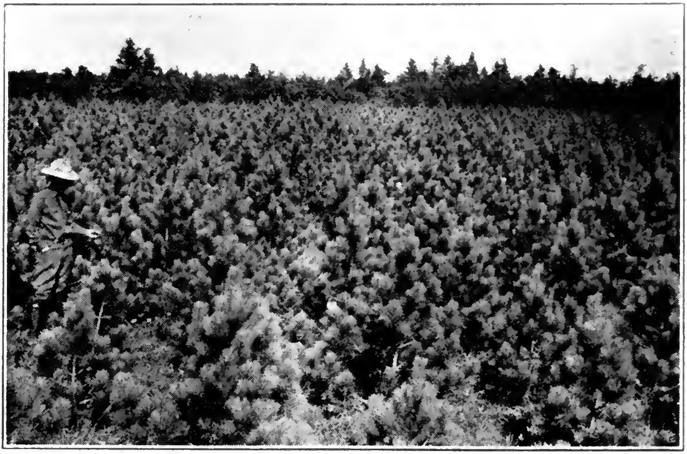


Diagram of a Flower
Which part becomes the fruit or seed pod?

Courtesy U. S. Forest Service

A TREE NURSERY

Thousands of young pines ready for transplanting.



Courtesy U. S. Forest Service

A STAND OF YOUNG PINE

Trees are often reproduced by sprouts which grow from roots, stumps, or fallen branches. Some trees are started by rooting a young stem in water or moist soil and then resetting it. If you are especially interested in tree culture, perhaps you can find out how to graft a tree and demonstrate the method to your class.

132. How to Know a Tree. — Different kinds of trees have different forms of bark which help identify them. The branching arrangement and the shape of the leaves are also a means of identifying a tree.

In your observations of trees, you should note the details of the leaves, — the shape, size, veins, structure, length of stem, the joint on the twig, the arrangement of the leaves on the twig, and the manner of branching. Make a practice of observing these characteristics accur-

THE HORSE-CHESTNUT TREE

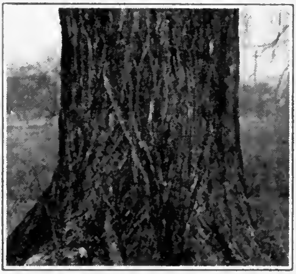
Top. Leaf and flower buds opening.
Center. Flower-stalk and leaves.
Bottom. The tree in full bloom. Note its shape and the position of the flowers.

ately. Then you will be able to recognize trees as you recognize friends. Try to become familiar with as many common trees as possible. Make them your friends. They will teach you much.

General Problem 4. Why Plant Trees?

133. Arbor Day and National Forest Protection Week. — In nearly every state of the Union a day is now set aside each spring as Arbor Day. *Arbor* is a Latin word which has been taken into English. It means "tree." On Arbor Day many thousands of people everywhere in the United States devote some time to the protection and planting of trees.

The first Arbor Day was April 10, 1872, and honor for the plan belongs to the Nebraska Board of Agriculture of that time. Now we recognize not only Arbor Day but



American Elms

Top. Detail of its bark. Compare with the bark of the hickory nut tree, page 261.
Center. In winter.
Bottom. In summer.

also a National Forest Protection Week, proclaimed by our President.

The national observance of such occasions has resulted in a widespread knowledge of trees and of their value to our health, comfort, and needs. Because of this greater respect for trees, laws have been enacted to protect them and to govern the planting of new ones.

EVERGREENS IN WINTER

Why are they called evergreens?

134. Community Tree Regulations. — Often the trees on the streets of a community are under the care and supervision of a committee of tree wardens. More frequently a park board is charged with the care of trees in streets and parks. The tree wardens and park commissioners determine what trees are to be planted and when they are to be pruned and sprayed.

135. What Trees to Plant. — We are all interested in beautifying our yards, our school grounds, and our community parks. Let us consider the advantages of selecting certain kinds of trees which will be both beautiful and useful. If you are planning to make your yard attractive, you will take into account the amount of space which can be given over to trees, making proper allowance for the growth and spread of the branches. You will carefully study tree catalogues to find out whether your soil is suitable for the kinds of trees you are considering. Perhaps you will want graceful elms, or giant oaks (if you have a great deal of space), or

THE SHAGBARK HICKORY TREE

DETAIL OF ITS BARK

Compare the shape of this tree with that of the elm, the horse-chestnut, and evergreen trees. Why is the tree called "Shagbark"?

sturdy little white pines (for more limited areas). There are men who make it their business to advise you how to beautify grounds. It is worth while to consult them because of their scientific knowledge of trees.

If you select fruit trees for your yard, you must be willing to give them the attention which they require. They will need careful pruning, and must be sprayed regularly to prevent insects from harming the fruit.

Do you know that trees suitable for country streets and homes are sometimes not suited to cities which have excessive amounts of smoke and soot? The soot tends to seal the pores or openings in the leaves, and thus make it difficult for the trees to breathe. Trees frequently die of suffocation under these conditions. Certain trees like the Carolina poplar have a varnish-like substance covering the leaves from which the dust and soot are easily washed by rains. Except in a continued drought, dust and soot do not prevent these trees from breathing.

Nut trees grow slowly and do not produce nuts for some years after they have been planted. Most nut trees cause so much litter during the fall that they are objectionable on home lawns and parks. Commercially, however, in some sections of the country, nut tree orchards or groves have become profitable business enterprises.

Field Research:

Observe and be able to describe the branching, budding, and leaf arrangement of a special tree. How do you know the tree in winter?

In making a selection of trees for your yard, you can plant trees and shrubs which furnish food for birds. Many of the trees and shrubs which birds like are also ornamental. By careful selection you can, therefore, both beautify your yard and attract birds to your home. The following trees and shrubs are attractive to birds: flowering dogwood, juniper (red cedar), dwarf sumach, white mulberry, blue cornel (shrub), black alder, Japanese barberry (hedge), rosa rugosa, high bush cranberry, and birch honeysuckle.

Usually you will make your selection of shrubs and of fruit and ornamental trees at a nursery where the shrubs and trees are first grown from seeds or cuttings. When the young trees are from two to five years old, dependent on the kind of tree, you can safely take them from the nursery for their second transplanting in your own yard.

136. How to Transplant Trees. — Trees may be transplanted either in the spring or in the fall. In the spring they should be transplanted before the buds start to swell. In the fall they should be set out after the fruiting period is passed or after the leaves have dropped.

Courtesy Caterpillar Tractor Company

TRANSPORTING A LARGE TREE FOR TRANSPLANTING

Estimate the height of the tree.

To transplant a tree successfully requires especial care in handling the soil and the roots. A hole should be dug somewhat larger and deeper than the roots of the tree will occupy; a little loose soil should then be put back into the hole and a sufficient amount of water stirred into the soil to make a thick mud paste. The roots should then be carefully pruned, leaving only a sufficient amount of the main roots to serve as a support to the tree while it is growing. The rootlets and root hairs should be carefully protected from injury.

The branches should be pruned so that there will not be too great a leaf area to demand more water and food than the roots will supply during the first growing season. Pruning also helps to shape a tree or shrub.

If the roots have been wrapped at the nursery in a ball of earth, the ball of earth and the roots together should be worked up and down in the mud paste. It is most important that so far as possible all the smaller root and root hairs be worked into the moist earth so as to get rid of the air about the roots. In other words, the soil and water should be worked into close contact with the roots. Additional soil should then be put into the hole and packed hard. Care should be taken to see that the trunk of the tree is buried not more than an inch or two deeper than it was before the tree was transplanted. If the tree is set in too deep, it is likely to die.

Sometimes a tree may be transplanted when the earth is frozen. A mass of frozen earth is removed with the roots and transported as a whole to the new planting place. In this manner valuable large trees are frequently transplanted.

After a tree has been transplanted it should be watered thoroughly every few days, but not lightly every day since the latter practice is likely to cause the soil to sour (become acid). The soil about the tree should be cultivated to prevent loss of moisture and to kill the grass and weeds which rob the tree of the soil's nourishment.

Before you start your planting in a city or town, you should learn the city regulations which control the setting out of trees and shrubs. Furthermore, you should make sure that all plants for transplanting have been properly inspected and approved as free from contagious plant diseases.

Trees and shrubs for transplanting should, as a rule, be obtained only from well-established nurseries. Otherwise you may obtain diseased plants, especially if you take them from some near-by "woods." Some tree diseases are communicable to other trees and so

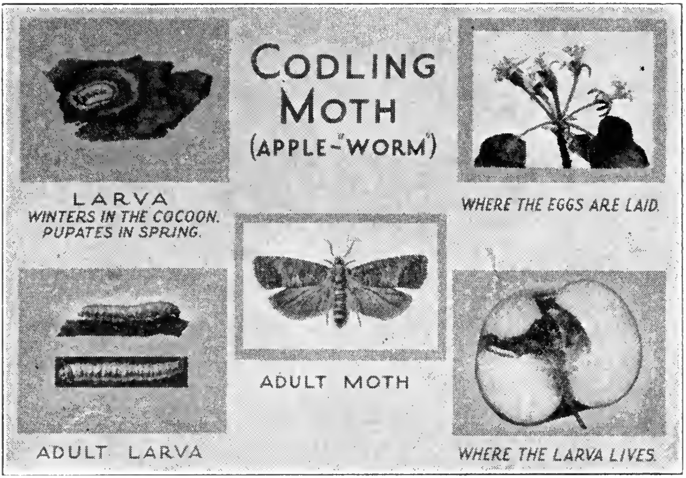
A Park Planting Arrangement

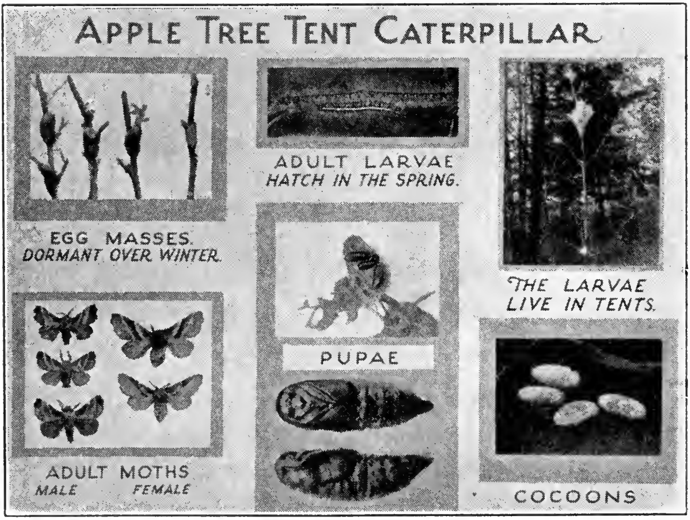
What has been done to the soil about the trunks? Why? How many kinds of trees can you detect in the picture? Those with white blossoms are called Shad trees.

must be controlled by fumigation, disinfection, and quarantine just as human diseases are controlled. Tree surgery has become a real science.

General Problem 5. How Are Trees Protected?

137. Tree Enemies. — Having assured yourself that you have secured and planted healthy shrubs and

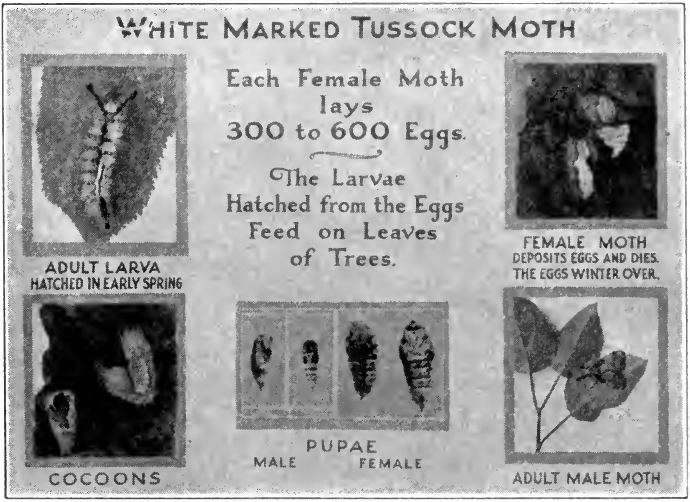




Learn how fruit trees and fruit are protected from these pests.

trees, you will want to know the various types of enemies which threaten them in order that you may fight such foes more effectively.

One of the enemies is the soot of large cities. The only remedy against the damages of soot is to force manufacturing concerns and private establishments to



Which stage may be profitably collected by hand? Which stage is most harmful?

operate their furnaces so that a minimum amount of smoke and soot escapes through the smokestack.

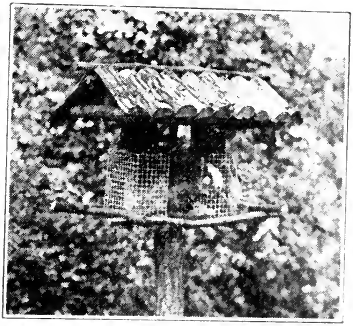
The greatest enemies are the hordes of insects which wage ruthless and unending war against trees. The *codling moth* makes our apples wormy. The *white-marked tussock moth* destroys our maples, elms, and other shade trees. Various *scabs* form on fruit trees which not only injure the fruit but eventually kill the tree. The apple tree *tent caterpillars* and *gypsy-moths* are leaf-eaters, causing the death of many of our trees. The *San José scale* is caused by a sap-sucking insect.

138. Ways to Combat Insect Enemies. — There are three effective ways of protecting our trees against these various insect enemies. The best way is to *enlist the help of insect-eating birds.* For example, it is said that one pair of bluebirds practically unaided will protect an apple orchard of moderate size from the work of the codling moth. Orioles consume enormous numbers of tent caterpillars. Encourage all insect-eating birds to make their homes in your community.

A Flicker Protecting a Tree

When decayed trees and stumps are cut away, the birds have difficulty in finding nesting places. You can attract the birds to your trees by putting up bird houses or nesting boxes. Feeding stations in winter and even in summer help to keep the birds in a neighborhood. One of the simplest and yet most important things to be done is to keep available a supply of water for the birds that they may drink and bathe. In winter, the water should be warmed before it is put into the bird bath. This will keep it from freezing too quickly to be of service.

Have you observed the various types of bird baths erected in private yards and public parks? Why not put up one in your yard?

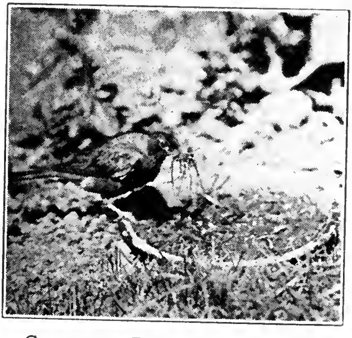


A Bird Feeding Station

A Humming Bird Feeds Her Babies

A Bluebird at Nest Box

A Bluebird at Bath



Gathering Building Materials

A dish of mud and grass will help the robin at nest-building time.

A Golden-Wing Warbler

The mother bird feeds her babies. Birds are not afraid of their friends

Another method of protecting trees from some of their insect pests is *an actual hand gathering of the masses of eggs.* In this way you can protect the trees in your own yard. However, the larvæ hatched from eggs which are not gathered from neighborhood trees will attack all trees within their reach. Consequently, it is necessary to organize forces to combat the common

108,000 Egg Masses

A million egg masses of the white marked tussock moth were collected by school pupils in four weeks!

foe. You have learned that "in union there is strength."

In a city of 300,000 people the school children engaged in a campaign against the white-marked tussock moth. In a four-week period in the fall 6000 pupils who were engaged in the contest gathered more than 1,000,000 egg masses by hand. The fact that each of these egg masses contained from 300 to 600 eggs and that the larvæ would have hatched the following spring had the eggs been left on the trees will give you some idea of the enormous saving which results from this organized hand gathering of insect egg masses. Study the picture on page 270. It shows the egg masses collected by the pupils of one junior high school in this contest. More than 108,000 egg masses are in the pile.

A third method of combating insect pests of trees is by *spraying* with poison. This must be done at

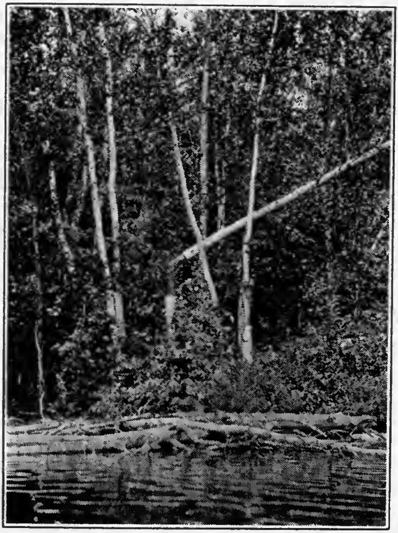
Courtesy Caterpillar Tractor Company

A Modern Spray Rig

How is this method more effective for the control of insects than hand pulling of egg masses?

appropriate times, because while some sprays kill larvæ, others destroy only the eggs. It is almost impossible to prevent the adult moth or insect from laying its eggs. We must therefore know the proper time to spray for eggs and larvæ that we may destroy them before they change to the insect stage. Diseases such as scale are also controlled by spraying.

139. How People Harm Trees. — While the insects and plant diseases cause the greatest amount of injury and destruction, there are many ways in which man himself causes damage. For example, a slender white birch with its beautiful bark offers an almost irresistible urge to young and old to pull the bark from the tree. Have you ever pulled bark from a white birch to make souvenirs of various kinds? Do you know that the bark of a tree protects it just as your skin protects you? Taking the bark from the birch tree lets the trunk dry out and thus hinders the passage of the food from the roots to the branches. The removal of the bark weakens the tree so that it is easily broken down by the wind. Furthermore, a bad-looking scar is left which destroys the beauty of the tree. Will you do your part to protect the birches?



BROKEN BIRCH

Explain why one birch broke in the wind and others did not.

Sometimes people carelessly cut into the bark of trees with a knife, hatchet, or ax. These injuries may not kill the trees, but they make tender spots for disease germs to enter. Most people who injure trees do so either because they are thoughtless or ignorant of the harm which they cause. You cannot afford to be thoughtless and you cannot plead ignorance now that you have read this paragraph.

140. How Long Will Forests Last? — Can you predict how long our forests will last at the rate we are now using them? Do you know that America uses more wood than any other nation of the world? Nearly

Courtesy Caterpillar Tractor Company

PULP WOOD FOR PAPER

Why are soft woods preferable for paper making?

100% of our farm buildings, and more than half of our city buildings are made of wood.

According to reports of our Forestry Department 25 to 28 billion board feet of lumber are used annually for building purposes. Railroads use over 100 million wooden ties. In our stoves and boilers we burn a hundred million cords of wood. Each year we consume great quantities of wood in the production of paper and manufactured articles. For making paper we use several million cords a year. It is said that one Sunday edition of a New York newspaper requires wood from 15 acres of forest and that the daily editions in three months require wood equal to that in a forest as large as Central Park of New York City (over 600 acres).

Courtesy U. S. Forest Service

REFORESTATION

What enemy of forests has made this necessary?

Not only are our forests being cut off rapidly but over 33,000 forest fires every year burn over more than 7,000,000 acres. (What is the acreage of your state?)

All together nearly 25 billion cubic feet (one cubic foot equals about 8 board feet) of wood are used or wasted annually. This means that we are using wood about three times as fast as we are growing it. What is the answer? Both for the sake of self-protection and because of our love of trees, let us be on the alert to protect them.

141. The Farm Wood Lot. — How many trees make a forest? Probably no two answers would agree but at least it is certain that all the farm wood lots of the country taken together would make a vast forest.

The farm wood lot is too often left to care for itself. It is merely a convenient place to cut a little fire wood each winter or a place to cut fence posts and a little lumber. By scientific care this wood lot can become a profit-producing piece of land. Many owners of unprofitable wood lots would do well to seek the advice of a state forester. All dead or diseased trees should be taken out. Misshapen trees should be replaced by thrifty new trees. Mature trees should be cut into logs. Dead brush, which increases the fire hazard, should be disposed of.

142. How to Preserve Our Forests. — It is easy to see that we can all do our share to prevent forest fires. We can keep ourselves informed about insect pests and tree diseases, and help to spread scientific advice regarding their control. We can take part in all community plans to plant and conserve trees. We can help to organize clubs to protect birds.

The first State Forest Preserve was established in 1885 in the Adirondack Mountains of New York State. This state now owns about 2,300,000 acres of forests. The state constitution provides that this great acreage shall be held perpetually as forest lands where the cutting of timber shall always be prohibited.

The New York State Conservation Commission has developed six forest tree nurseries where about 147 million young trees are growing. They are sold at cost to land owners in the state to aid reforestation.

In 1891 President Harrison created the first National Forest Reserve. Now the United States has millions of acres of forest reserves which are being guarded

Courtesy National Park Service

GIANTS OF SEQUOIA NATIONAL PARK

Should these living things from the past be sacrificed to fire?

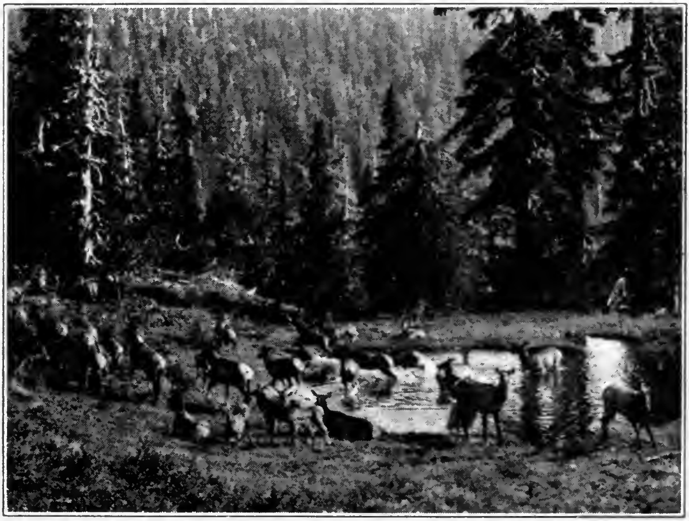
against fire and disease and from which mature trees only are cut, thus insuring a continual production of timber.

The United States has twenty-two National Parks and a number of National Monuments (land areas). They are located so as to preserve and open to the public some of the wonder places of our country.

While each National Park is selected for its striking and interesting features, all are wild bird, wild animal.

and fish sanctuaries, and each is a forest sanctuary as well.

The Parks range from the height of Mt. McKinley in Alaska, 17,000 feet altitude, to Death Valley, which is many feet below sea level.



Courtesy Northern Pacific Railway

PROTECTING FORESTS

Why is this better than charred stumps?

Your class may care to write to the Director of National Park Service, Department of the Interior, Washington, D. C., for descriptive bulletins. They are free.

KEY WORDS

Arbor Day	flood-checks	sap
bark	food-producers	seed
branch	leaves	transpiration
buds	lumber	tree
crown	reproduction	trunk
egg mass	root hair	

Key Statements

1. The value of a tree is determined by its size, form, foliage, hardness, length of life, and usefulness.

2. Moisture escapes from a leaf as a vapor. The process of expansion into the gaseous state absorbs heat from the air. Accordingly, trees in leaf cool the air about them.

JUST BE THE BEST

If you can't be a pine on the top of the hill,
Be a shrub in the valley — but be
The best little shrub by the side of the rill;
Be a bush if you can't be a tree.
If you can't be a bush, be a bit of the grass —
Some highway some happier make.
If you can't be a muskie, then just be a bass —
But the liveliest bass in the lake.

We can't all be captains, we've got to be crew;
There's something for all of us here.
There's big work to do and there's lesser to do,
And the task we must do is the near.
If you can't be a highway, then just be a trail.
If you can't be the sun, be a star.
It isn't by size that you win or fail —
Be the best of whatever you are.

— *American Lumberman.*

3. Trees help to prevent floods by taking excess moisture from the soil and by adding humus so the soil can hold more water.

4. Trees are sources of food, lumber, paper, and many chemical products of great value.

5. A tree has three parts — roots, stem, and crown.

6. The crown is the manufacturing center of the tree and produces the flower and seeds necessary for reproduction.

7. Trees, as well as other plants, are reproduced not only from seeds but also by sprouts, grafting, and other methods.

8. Trees can usually be identified by their branching arrangement, shape, and characteristics of leaves, flowers, seeds, fruits, and bark.

9. Many insects are injurious to trees. We must combat them by protecting and encouraging the birds, by spraying, and by hand-picking the insect egg masses.

10. Trees are subject to diseases, many of which are communicable to other trees. Diseases are controlled by fumigation, disinfection, and by quarantine in much the same way that human diseases are controlled.

11. Trees should be transplanted either before the buds start to swell, or after the fruiting season is passed and the leaves have dropped.

12. In order to conserve forests, we must prevent forest fires, control insect pests and diseases, and aid the community by planting trees and encouraging birds.

13. The national observance of Arbor Day has resulted in widespread interest in forest conservation.

Thought Questions

1. Can you describe an experiment that illustrates how trees keep the air cooler?

2. Why does fanning make one feel cooler?

3. Why must trees have sunshine?

4. Do trees have mouths such as we do? If not, how do they take their food and drink?

5. If a tree eats, do you think it must have a stomach or digestive system? Does the tree need to " digest " its food as you do yours or is the food already soluble? How do you know this is true?

6. Which do you think is the most important part of a tree? Why?

7. How is sap obtained from a maple tree, and how is sugar made from the sap?

8. What is the name of your favorite tree? Explain exactly how you distinguish it from other trees.

Projects for Your Science Discovery Book

1. Collect as many different kinds of tree seeds as you can find and either mount each seed or draw a picture of it. Write a story about one of the seeds, telling where you think it came from and how it got to the place where you found it. Also tell what conditions of soil and moisture are most favorable to its good growth. If possible, find a picture of the kind of tree into which each seed would grow, if given the chance. Mount these pictures with the corresponding seed.

2. Draw, life size, the leaves of three or more kinds of trees which you know.

3. Write a story telling how you have helped to fulfill the purposes of our National Arbor Day and Forest Protection Week.

4. Write a paragraph telling about the State Forests in your own state.

5. Write the " autobiography " of a tree.

UNIT VI. HEALTH

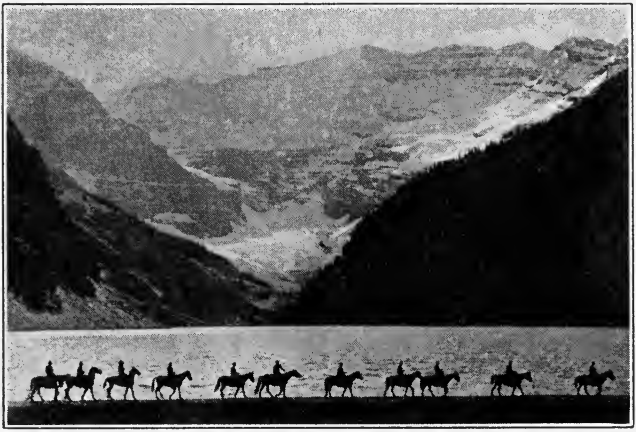
LOOKING AHEAD INTO UNIT VI

For a time we leave the study of the principal natural factors that make up our environment — Water, Soil, Air, and Fire. We have learned about the King of Plants, the Tree. It remains now for us to study our own selves. Where do we fit into this scheme of Nature? How are we constructed? What is our relation to our environment? How can we maintain an efficient body? How can we make ourselves a healthful part of the environment Nature has provided?

As human beings, we differ from all the things we have been studying in one important particular. We can think and reason. We can, pretty much by our own will, control our development. We can learn from life around us; and we can use or not use what we learn, as we choose.

Nature, as we have seen, operates in a very orderly way. There are certain laws which are unchangeable and which must be obeyed. It is our responsibility, as *thinking* human beings, so to guide our lives and habits as to maintain healthy bodies and healthy minds and thus contribute the best we have as our share to *Our Environment.*

SURVEY OF TOPIC XIV



Diet (lamb chops and pineapple)! Exercise (the radio at seven-thirty every morning)! Vitamins (oranges and spinach)! How familiar these subjects have become in American life to-day! What does it all signify? Everywhere we turn, in every magazine or paper, we see advertisements that tell us what to eat and why, and how to keep our bodies fit.

What is this body of ours that it needs a careful choice of foods, and plenty of fresh air and exercise? Why is there so much emphasis on these needs in our present-day living?

We have already learned how plant life needs air, sun, water, and certain minerals for its proper growth. Human beings are like plants in this respect; they, too, need clear air, sun, water, and minerals. Let us then find out why we need these things, how we are going to get them, and what we are going to do with them after we obtain them.

TOPIC XIV

THE HUMAN MACHINE

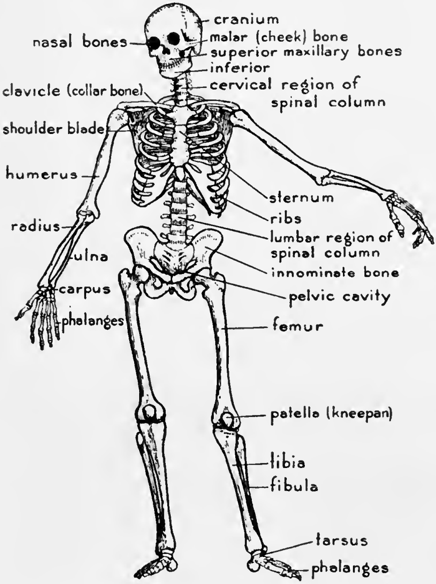
Good health and good sense are two of life's greatest blessings.
— Publius Syrus

Do you know:

1. **Why you have movable joints?**
2. **What mineral your bones and teeth need?**
3. **What makes you grow?**
4. **How exercise may help or injure you?**
5. **How your body-machine uses food?**
6. **Why you should have a well-balanced diet?**

General Problem 1. How Is the Framework of the Body Constructed and Repaired?

143. Construction Materials. — Bones make the framework for our bodies. Their use is three-fold: (1) To serve as levers by means of which our muscles may produce motion; (2) to give form, shape, and size to the body; and (3) to form cavities to protect delicate parts of the body such as the brain, heart, and lungs. Each bone has its proper shape and size to fit it for its own particular use in the body. There are the long, hollow bones of the arm and leg; the flat bones of the skull; and many little bones, such as the bones of the ear called the hammer, anvil, and stirrup. Each bone, however, is made of the same substances, and its composition is an important factor in its usefulness. All bones have something else in common besides their composition; they can increase in size and shape, and they can keep themselves in repair.



A Diagram of a Skeleton

In what ways are the bones of the arm and hand similar to those of the leg and foot?

Why do you think bones have to increase in size? What might happen to a bone which would necessitate repairing it?

Scientists tell us that bones are composed of mineral matter and organic matter. You have already learned that organic matter will burn (page 113), forming a gas that escapes into the air, and that minerals will burn and form an ash (page 205).

What did you discover about the effect of acids on minerals?

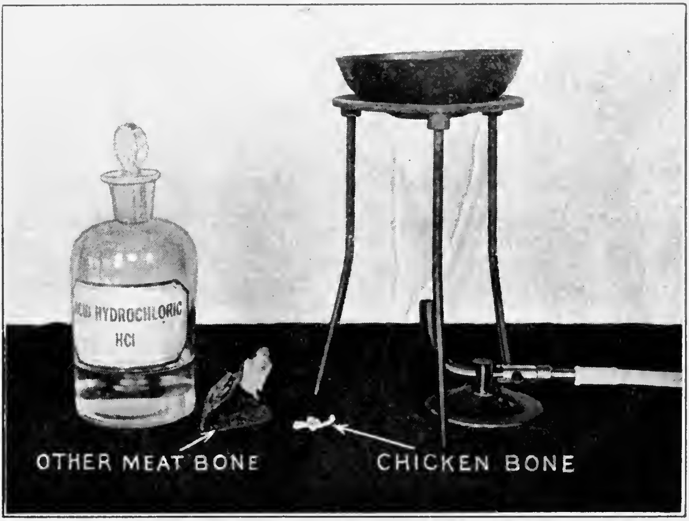
Let us see what acid and heat will do to bones.

Experimental Problem 35. — *Are bones composed of mineral matter and organic matter?*

What to use: Two chicken leg bones, vinegar or dilute hydrochloric acid, bottle, iron dish, support, and Bunsen burner.

What to do: A. Place one bone in the bottle and cover with vinegar (which contains an acid) or dilute hydrochloric acid. Let stand a day or so, or until it becomes soft and flexible.

B. Take the other bone and break it with a hammer. Place a few pieces of the bone in the iron dish and heat as hot as possible with the Bunsen burner until they become gray and very brittle. Perhaps some pupil will try burning the bones in the stove at home.



EXPERIMENT 35

Name each piece of apparatus. How do you suppose the little chicken bone was tied in a knot?

What happens: Record accurately what happens, and what you think causes the effects in each case.

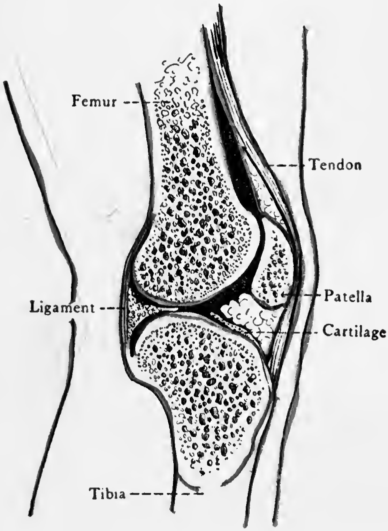
Conclusion: What two kinds of material do bones contain?

Applications: Bones left from beef and other kinds of meat are often burned and the mineral matter which is left used in fertilizers for gardens and farms (page 118).

The mineral matter in bones, about two thirds of the bone by weight, is principally calcium phosphate and calcium carbonate.

In the study of chemistry, elements (simple substances, page 119) are expressed by letters which form symbols. "Ca" stands for calcium, "P" for phosphorus, "O" for oxygen. Thus calcium phosphate is written, $Ca_3(PO_4)_2$. The little subscript numbers express the proportionate amounts of each substance. Can you explain what the little numbers in the above symbol mean? (See Section 110.) What other chemistry symbols do you know?

Many animals other than man have bony skeletons, either internal or external (shells), of calcium compounds. You will remember that some limestones and chalk are really deposits of the lime skeletons or shells of animals (page 68).



THE KNEE JOINT
What is the purpose of the kneecap?

144. Joints.—You all know that the skeletons in your bodies are not entirely rigid; that in many places where the bones are joined there are joints which make it possible to bend that part of the body. Some joints, like that of the elbow, knee, and the finger joints, are designed to bend in only one direction; a stop arrangement prevents them from bending backward. Other joints, like those of the wrist, ankle, and backbone, can move backward and forward and can twist in a circular motion.

Examine these joints in your own body and note how marvelously they operate. Then study the illustrations to find out how they are constructed. Notice especially the knee cap and its use.

Movable joints are to give the body free motion, and man has a greater variety of kinds of motion than any other animal.

Fixed joints are found in the skull. In babies these joints are really *cartilage* (a gristle-like material). As the years pass, these joints become rigid because of the lime that is deposited there. During the process of growth and expansion of the skull, ridges and "bumps" sometimes form. Thus one person's skull differs from another's in shape and outline. It is these "bumps" that some so-called scientists claim to use in reading a person's character by means of the science of phrenology. So far as is known scientifically, no such relation exists. Do not be deceived by anyone who claims to read your character or your future by this means.

X-RAY PICTURE OF A DISLOCATED FINGER JOINT

What two motions are necessary to reset this?

145. Maintenance and Repair.—The bones of living animals are very much alive. For that reason they must have suitable food for growth. The body will do its part, if it is provided with suitable food. Since we have discovered that bones contain so much calcium, then we may draw the conclusion that food which contains calcium will be good for the bones. That is why growing children should have plenty of milk. Milk contains calcium, and if a growing child will drink at least one quart of milk a day, he will receive the necessary amount of calcium for proper bone development.

Good posture is also important while you are young, for young bones are easily misshaped and stunted.

LACK OF CALCIUM FOODS PLENTY OF CALCIUM

What are the most notable effects of lack of calcium shown by the picture?

Fortunately these defects often can be corrected, but prevention is better and much easier than correction, which is sometimes a long, tedious process.

A BROKEN HUMERUS

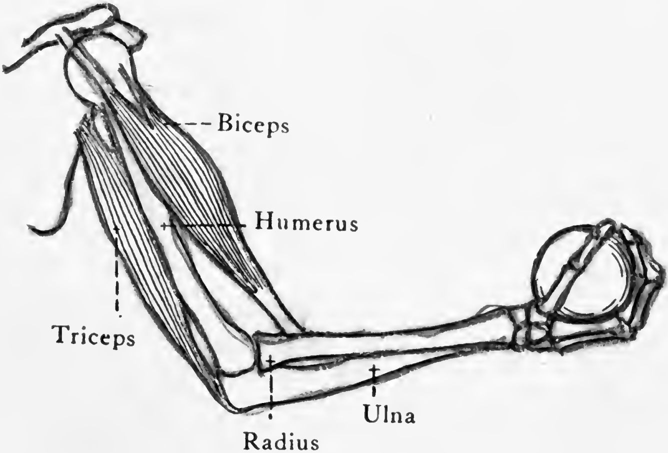
What bone in the leg corresponds to this bone in the arm?

Our responsibility lies in providing in our diet the necessary food materials for the growth and repair of the bones, and maintaining correct postures and proper exercise without strain. This responsibility will be discussed in much fuller detail later on.

There is, however, one more point which we must consider before leaving the subject of bone construction. We have talked about bone repair, and we have hinted at what might necessitate such repair. Bones do sometimes break, and bones which lack proper amounts of calcium are apt to break more easily than well-nourished bones. A broken bone or a dislocated joint requires the immediate attention of a physician. As first aid you should make the injured person as comfortable as possible. If necessary, fasten the limb to a board; or otherwise act so as to prevent the movement of the injured part. Do not wrench, twist, or pull the injured member in any way.

General Problem 2. What Are Good Muscles?

146. Functions of Muscles. — Fastened to the bony skeleton by threads of tissue called *tendons* are the



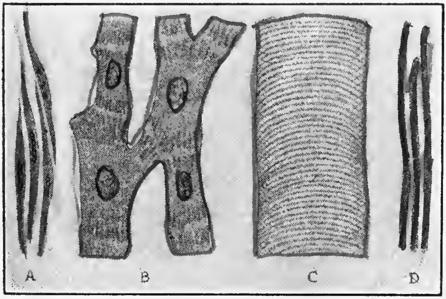
Arm Muscles and Bones

How are the muscles attached to the bones?

muscles by which the bones are moved. Movement results from muscle contraction (shortening). The bones of the skeleton are not only moved but held in position by muscles. Each bone maintains its characteristic position because of two opposed muscles, each pulling gently in a direction opposite to its mate.

Feel your upper arm. Find the hard bone in the center. Feel the bunches of muscle surrounding the bone. Move the arm and feel the muscle move.

These skeleton muscles are not the only muscles in the body, however. There are other muscles which cause movements of the blood vessels, the stomach, the heart, the lungs. Food is mixed or churned in the stomach by the muscular action of that organ; the heart keeps up its rhythmic beating because of the regular contraction of its muscles; we breathe because of the action of the muscles of the chest.



Voluntary and Involuntary Muscles

What kind of muscle can be trained? **A,** four smooth muscle cells from the wall of the stomach; **B,** muscle cells from the heart; **C,** a small portion of a skeletal muscle cell; **D,** large portions of three skeletal muscles, very much less magnified, to show their form.

147. Kinds of Muscles. — This muscular system of ours, then, is composed of two parts: the *skeletal*, consisting generally of the voluntary muscles, and the *visceral*, consisting of the involuntary muscles. The voluntary muscles are the ones which respond to our will. For example, you can start to walk or you can stop walking to suit yourself; you can raise your arm, or not, as you like; you can chew as fast or as slowly as you wish. The involuntary muscles, on the other hand, carry on their work without our thinking about them or doing anything. You never think about your heart beating, unless it beats particularly hard because of exertion or fright. You seldom think about breathing, unless you purposely take a long breath or a deep one. Your heart goes on beating and you go on breathing in spite of yourself.

It is to be expected that muscles so different in activities would be different in structure. Such is the case. The microscope reveals a difference in appearance; voluntary muscles have stripes running across the tiny fibers of which they are composed, and so are called *striated*. The bundles of fibers are enclosed in a thin, elastic membrane.

MUSCLE BUILDING

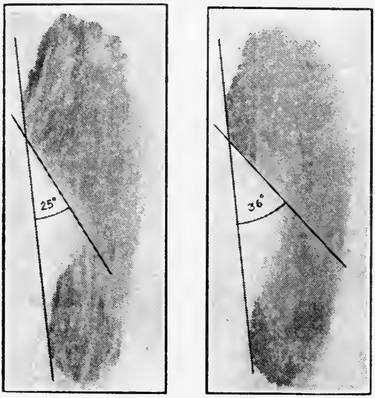
What precautions should be taken in exercises like this?

The involuntary muscles do not have these stripes and so are called *unstriated* or *smooth* muscles. They are made up of spindle-shaped cells.

Just as the bones are held together by organic matter, so the muscle bundles are composed of individual muscles, each surrounded by a tough coat of connective tissue, bound together into groups or bunches, each ending in its tendon. The nerves stimulate the muscles, the muscles contract and exert a pull on the tendon, and movement of the part of the body to which the muscle is attached results.

148. Muscle Development. — Good muscle development depends upon the right amounts and kinds of foods, upon the proper amounts and kinds of exercise, and upon rest.

Muscles which are used regularly become firm and strong. Skill in the use of muscles may be, and should be, improved by practice. But too great a strain on muscles should be avoided. The muscles that hold the body erect can be trained so that they will automatically hold the body erect when standing or sitting. On the other hand, poor posture will result in muscles not properly trained, which in turn results in not only a poor appearance but also in weakened health. Thus, round shoulders may prevent proper breathing habits, and improper standing and walking may injure foot posture. (Study the problem on page 347.)

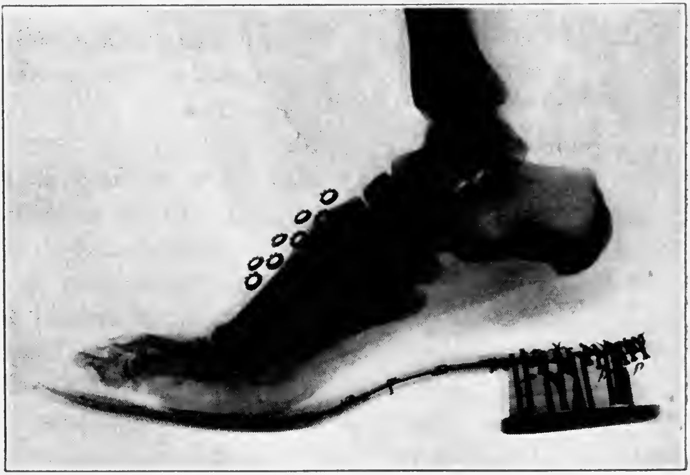


Foot Prints
Which print indicates the better arch?

149. Handicaps to Proper Muscular Action. — Poor muscular action is caused by violations of the rules of good muscular development. Straining the muscle by overexertion; lack of rest; lack of proper food supplies; the use of alcohol and other narcotics or other drugs; all these interfere in some way with the normal nourishment of the muscle and the result is muscles that are flabby, weak, or lacking in skill in motion.

The use of alcohol and tobacco seriously affects the

X-Ray Picture of a Foot in an Improper Shoe
Note the high heel and the bent toes bearing most of the weight of the body

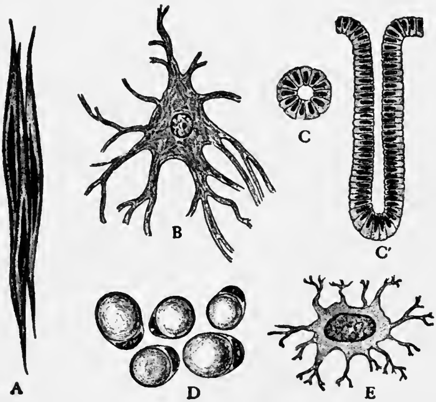


X-Ray Picture of a Foot in a Proper Shoe
Note the low heel which bears a large part of the weight of the body.

speed with which muscular action responds to the will; that is why athletic coaches will not permit the members of a team to smoke, and why alcohol users are more likely to have automobile accidents than those who do not use it.

General Problem 3. What Makes and Maintains an Efficient Body?

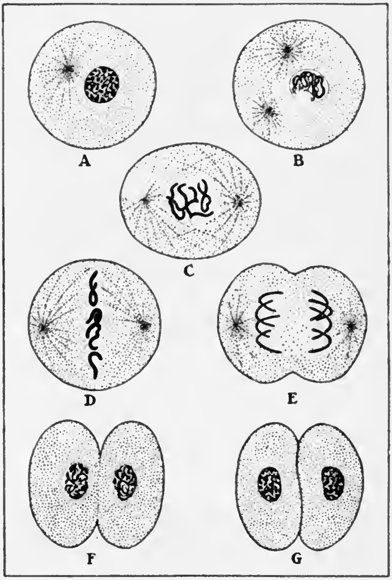
150. The Living Cell. — Our bodies are constantly busy manufacturing the cells of which all living things consist (page 120). Each cell has a central portion called the *nucleus* and many cells have a covering called the *cell wall.* The substance of the cell is called *protoplasm.* These cells are not all the same size nor shape. The cells in the muscles are long and narrow, because their work is to exert a pull by shortening themselves. The cells in the skin, or in the lining of the mouth, are thin and flat and overlap like shingles.



Different Kinds of Cells

Does each cell contain a nucleus? **A,** three muscle cells, magnified 300 times; **B,** a brain cell, magnified 400 times; **C,** a cross section of a stomach gland magnified 200 times, and **C′,** a lengthwise section of the same gland: **D,** fat cells, magnified 400 times; **E,** a bone cell, magnified 1000 times.

A cell can reproduce itself by dividing into two cells, each cell taking half of the original nucleus and the other matter which compose the original cell. Each of these divisions then divides, and the process continues. Thus you can see how your bones and your muscles grow as the cells of which they are composed keep dividing and dividing. When a cell dies, it is replaced by a new one, and the dead cell is oxidized or burned up.



Cell Division

When a cell divides, does each part retain a portion of the nucleus?

151. Tissue. — We learned on page 120 that cells are built up into various kinds of tissue. This tissue is built up to form the various *organs* or working parts and other parts of the body. Thus we speak of liver tissue, bone tissue, fat tissue, or brain tissue. In bones, in tendons, and in the tough tissue that holds the bones together the quantity of matter between cells is large. This intercellular matter makes the tissue in which it occurs, very strong. Such tissue is called *connective tissue*. It supports and binds together parts of the body. The strong intercellular material is the chief part of this tissue, and its cells serve to produce and repair it. On the other hand, in the brain, or in the muscles, the cells are the important part of the tissue and only a little of the fibrous intercellular structure is needed.

152. Tissue Building. — Tissues are made up of living cells, dead cells, and liquids which contain mostly water. Chemically these body tissues are composed of twelve important elements: (1) oxygen, (2) carbon, (3) hydrogen, (4) nitrogen, (5) calcium, (6) phosphorus, (7) potassium, (8) sulfur, (9) sodium, (10) chlorine, (11) magnesium, (12) iron. Other elements are present in very small quantities, of which copper, iodine, and manganese are especially important. In order that body tissues should be supplied with these chemical elements, it is necessary to provide foods containing them.

Oxygen, carbon, and hydrogen are the most important body materials and so food containing these is most important. Starches $(C_6H_{10}O_5)_n$ and sugars $(C_{12}H_{22}O_{11})_n$ are made of these three elements. Fats also contain large amounts of hydrogen, oxygen, and carbon. You have learned that when hydrogen and carbon are burned, or oxidized, large amounts of heat are liberated; so these foods — starches, sugars, and fats — which are oxidized in the body as they are assimilated create heat for the body and are therefore called energy foods (page 173).

Experimental Problem 36. — *How can starches and sugars be tested chemically?*

What to use: Test tubes, Bunsen burner, starch, potato, bread, and other starchy foods. Glucose, molasses, honey, corn syrup, and sweet foods. (Granulated sugar is a kind of sugar which cannot be tested in the same way that the other sugars are.) Iodine solution to test for starch, and Fehling's or Benedict's solution to test for sugar. These solutions may be made by following the directions in the Appendix, page 25.

What to do: A. Make a dilute starch solution by boiling a little starch in water. Allow it to get cold. Pour a teaspoonful of the starch solution in each of two test tubes, and in a third test tube place the same amount of water. To each tube add a few drops of iodine solution.

B. Boil each food to be tested a few minutes in water, cool, and test with iodine.

C. Make a dilute solution of glucose. Place a quarter of a teaspoonful of the solution in each of two test tubes, and an equal amount of water in a third test tube. Add to each tube an equal amount of Fehling's or Benedict's solution, and heat to boiling.

EXPERIMENT 36

Name each piece of apparatus. Why is plain water tested for starch and sugar in the experiment?

D. Boil each food to be tested in water for a few minutes. Pour off a little of the water solution, cool, and test for glucose.

What happens: 1. What color formed when starch was tested with iodine? 2. Did water alone give the color when tested with iodine? 3. What color, if any, formed in the case of each food tested? 4. What color formed when the glucose solution was heated with Fehling's or Benedict's solution? 5. Did the water give this color? 6. What color, if any, did each food give when tested?

Conclusion: 1. How can you test for starches and simple sugars? 2. Why did you test plain water in A and C?

Application: Which foods did you discover to contain each food substance (nutrient)?

Nitrogen has an interesting use in the body. Muscle tissue especially is made of compounds containing nitrogen as an important element. To build new tissues, as in growth, or to repair worn-out muscle tissue, foods containing nitrogen are required. Starches, sugars, and fats contain no nitrogen, hence will not serve this purpose.

Lean meat, which is muscle tissue, white of egg, and parts of peas, beans, and other vegetables contain the food substance called protein (page 174). All proteins contain nitrogen. Hence, to build and repair body tissues, foods containing the nitrogen compound protein must be eaten. Not all proteins are of equal value to the body. The protein in meats, milk and milk products, and eggs are good quality; while string beans, peas, and navy beans contain proteins of poor quality.

Experimental Problem 37. — *How can proteins be tested chemically?*

What to use: Hard-boiled white of egg, lean meat, beans, and other foods, concentrated nitric acid (use carefully), ammonia water (ammonium hydroxide), Bunsen burner, test tubes.

What to do: Place a good-sized piece of the hard white of an egg in a test tube. Add enough nitric acid to cover it. Heat carefully. Note color changes, if any. Pour off the acid into a waste jar, and add a little ammonia water and heat. Note further change of color, if any. Make the same test on various foods.

What happens: The color changes produced with the egg white are characteristic of proteins. Describe the color changes with white of egg.

Conclusion: How can you test for proteins?

Applications: Which foods did you discover to contain proteins?

Calcium, as we have already discovered, page 287, is needed for growing and repairing bone tissue and for the hard parts of the teeth, especially the enamel. Milk and milk products are excellent sources of calcium. Turnips, string beans, cabbage, and a few other vegetables are fair sources of calcium. Cauliflower is especially rich in calcium.

EXPERIMENT 37

Why is the protein test applied to plain water as well as to foods?

Next in importance is phosphorus. The pure chemical is yellow, very combustible (page 202), and very poisonous; but united with other substances it is very necessary to the body. Meats, milk and milk products, and cereals contain good quantities of compounds with phosphorus. Brain and nerve tissue especially require phosphorus, and hence foods containing phosphorus compounds are very necessary. Calcium and phosphorus combine to perform another important function; they act together to maintain a proper balance between the acid and alkaline condition of the body.

Iron, with traces of copper, is necessary in the manufacture of the red substance (hæmoglobin) carried in the blood. This substance is the carrier of oxygen from the lungs to the various parts of the body, exchanging its oxygen for carbon dioxide, which it takes back to the lungs, where the gas is given off and more

Foods Rich in Phosphorus

What structures in the body especially need phosphorus?

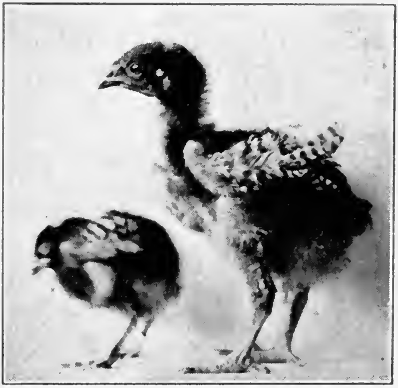
oxygen taken in. Liver and other lean meats are important sources of iron. Among the leafy vegetables that contain iron, spinach stands at the top. Eggs and potatoes are also good foods for iron.

Some minerals may be tested for in the ash formed when a food is burned until all the organic matter is burned off. If the ash contains a fair proportion of calcium, the ash may be boiled with water and the cooled solution tested with red litmus paper. If the paper turns blue, calcium was probably present in the food.

The remaining elements of the twelve named on page 296 all have their special part to play in body building and care. They may also be found in foods and tissue by laboratory tests, but we have considered the ones most important to our study and will leave these others, — sulfur, sodium, and so on, — for more advanced classes.

153. The Need for Vitamins. — For a long time certain diseases affected sailors and other people forced to go without fresh fruits and vegetables. It is now known that the lack of certain vitamins, substances whose chemical composition is still uncertain, causes faulty growth and disease.

Six vitamins, called A, B (B_1), C, D, E, and G (B_2), have been identified and experimented with. These vitamins are necessary to promote many of the processes of the body, and if, for any reason, a particular vitamin is absent from the diet for a sufficient length of time, some body process suffers and the body becomes affected with certain symptoms which doctors are now able to recognize. If you include in your diet milk, eggs, fresh fruits, and green-leaf vegetables, in addition to meat, potato, and bread, you will provide enough of all vitamins. (See table, page 36, Appendix.)



THE EFFECT OF SUNLIGHT ON GROWTH

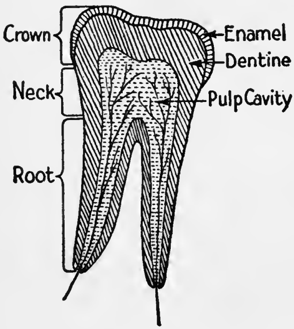
The larger chicken grew faster because of exposure to sunlight. The small chicken was kept out of the sunlight. Do you think sunlight might have a similar effect on the growth of children?

Vitamin D is especially important as an aid to the work of calcium and phosphorus. Oysters, eggs, and cod-liver oil are good sources of this vitamin, especially the latter.

Vitamin D is sometimes called the Sunshine Vitamin because exposure of the body to sunshine results in the formation of this vitamin in the body. This is why everyone should be out in the sunshine as much as possible.

In the Temperate Zone the sunshine of the short winter days is not very rich in ultra-violet light which produces Vitamin D, hence more care must be taken to secure Vitamin D through foods. The smoky atmosphere of cities reduces the amount of ultra-violet light also.

Vitamin D can also be produced in the body by exposure to ultra-violet light from special lamps. Have you ever seen such a lamp used? Ultra-violet light is invisible, so one should not be misled by using lamps giving a violet-colored light. Only approved lamps should be used.



TOOTH STRUCTURE

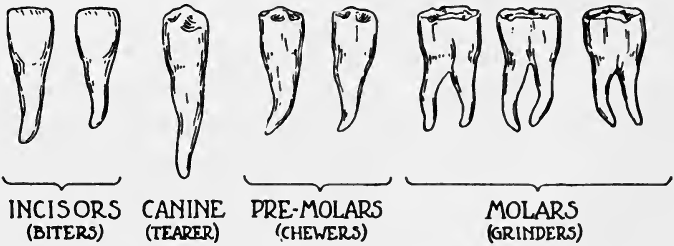
Why is it easy to crack the enamel on a tooth?

Certain foods when acted upon (irradiated) by powerful ultra-violet light rays have the Vitamin D increased in amount.

154. Teeth. — Food, after it is taken into the mouth, must be cut and ground to a proper fineness by our teeth. It is extremely important that the teeth do their work efficiently. They must be correctly placed in the mouth and they must be healthy, for if they are misshapen or diseased, proper chewing of the food is likely to be neglected. The structure, kinds, and arrangement of the teeth are shown in the illustration. Study this carefully. How many of these can you locate in your mouth?

Calcium forms an important part of the mineral substance of teeth; we have already learned that we must eat plenty of food that contains calcium if we are to have good teeth. How are we going to care for and protect our teeth in other ways?

Everyone has two sets of teeth. The first, or temporary set, appear during the first two years of a baby's



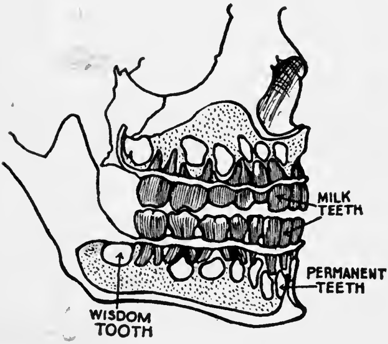
KINDS OF TEETH

Why do teeth vary in shape and size? Why do some have two roots?

life, although the ages vary with different children. There are twenty teeth in all in this set, ten in each jaw.

This first set of teeth are very important and should be carefully cared for, even if they are but temporary. They are needed to keep the jaws in proper shape, and to make room for the permanent teeth which follow them. The normal loss of these first teeth is gradual, beginning when a child is about six years old. By the time he is twelve the first teeth have all been replaced and he has several entirely new ones. The six-year molars (so-called) are permanent teeth which are not preceded by temporary ones, and should be very carefully taken care of. At the age of twenty (sometimes as late as twenty-five) a person has developed the third set of molars, the wisdom teeth, and has then completed the set of thirty-two.

As the new permanent teeth form below the temporary teeth they gradually push out the temporary teeth, whose roots have been absorbed. If for any reason the permanent teeth cannot come in at the right place, or do not have room in the jaw, defects may occur. It is important to have a child's teeth examined frequently by a dentist, and to have him take X-ray pictures to find out if the permanent teeth are forming properly and in the correct place.



TEMPORARY AND PERMANENT TEETH

Why is it important to keep the temporary teeth as long as possible?

The spaces between the teeth may become clogged with food. In the warm temperature of the mouth such food will decay quickly and may give disagreeable odors to your breath. Frequent and thorough cleaning of the teeth is important. And be sure that you use only safe tooth pastes and powders. Go to your dentist for removal of tartar and for regular inspection, so that small cavities may be discovered before any harm is done.

Not only are good teeth absolutely necessary to good health, but good teeth help your personal appearance. Proper foods, proper personal care, and regular dental attention are the best aids to a good set of teeth.

155. Converting Foods into Body Tissue. — Most of the foods which contain the necessary elements needed by the body must be changed in form in order to be used in the body process. The method by which foods, raw and cooked, are prepared in the body for assimilation (changing the food into living matter) is called *digestion*. The products of this digestive process are absorbed by special structures (*villi*) into the blood, or *lymph*, and distributed to the parts of the body where they are needed. There the assimilation takes place.

Digestion is principally a series of processes by which food materials are made soluble in water, or broken up (emulsified) in the case of fats, so that they will mix with water.

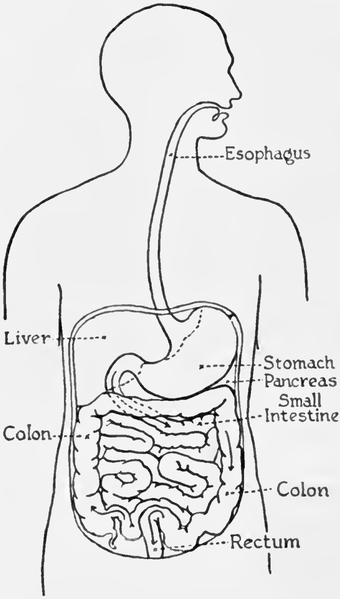


DIAGRAM OF THE DIGESTIVE ORGANS

What causes the food material to be passed from one organ to another?

Starches and most sugars are changed into simple sugars either by action of the saliva in the mouth or by other digestive juices in the digestive system. Proteins, which even when cooked are insoluble in water, must be acted upon by *ferments* (enzymes) in the stomach and small intestines in order to change them into a soluble form. Fats are acted on by fluids in the small intestine which cause them to split into simple soluble substances; or they may be emulsified (broken into very tiny particles) so they will mix with water and so be absorbed.

Foods should be chewed thoroughly before swallowing, to insure rapid and complete digestion.

The small intestine is the main organ of absorption.

It is about twenty feet long and one inch in diameter. Here the digested food is absorbed into the blood or the lymph, through the villi (very tiny hair-like projections which multiply the surface of the intestines many times). From the blood, the food is carried to the *liver*, where it may be stored, or acted on and sent back into the blood. Fatty food is absorbed by the *lacteals* (minute tubes) and finally is given over to the blood for transportation to the various cells in the body. It leaves the blood in the form of lymph and surrounds each individual cell. The cell absorbs what food it needs for growth and gives back to the lymph liquid whatever it does not need.

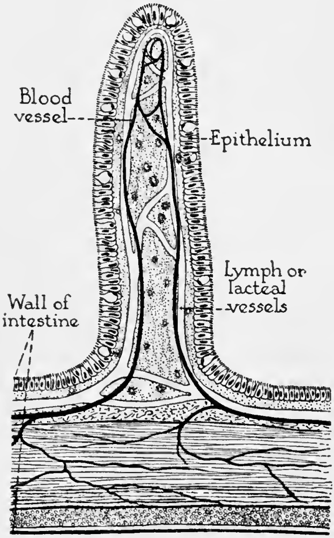


Diagram of a Villus

How must food be changed in order to be absorbed by the villi?

156. Oxidation and Energy. — We know that ordinary combustion, where flames occur, produces heat and the waste products, water and carbon dioxide. In this case, the combustible substance is usually dry. In the body, however, the materials (food) that are to be burned (oxidized) are wet. Oxidation in the body takes place in the individual cell and produces heat and generally water and carbon dioxide, as in the case of a fuel burning outside the body. Of course, no flame is produced. But neither is a flame produced when decay (a form of oxidation) takes place outside the body.

The oxygen for the oxidation is supplied by breathing and is brought to the cell by the red blood corpuscles. The carbon dioxide that is formed is taken by the red blood corpuscles back to the lungs and exchanged for more oxygen. (See section 90, page 173, and the diagram on that page.)

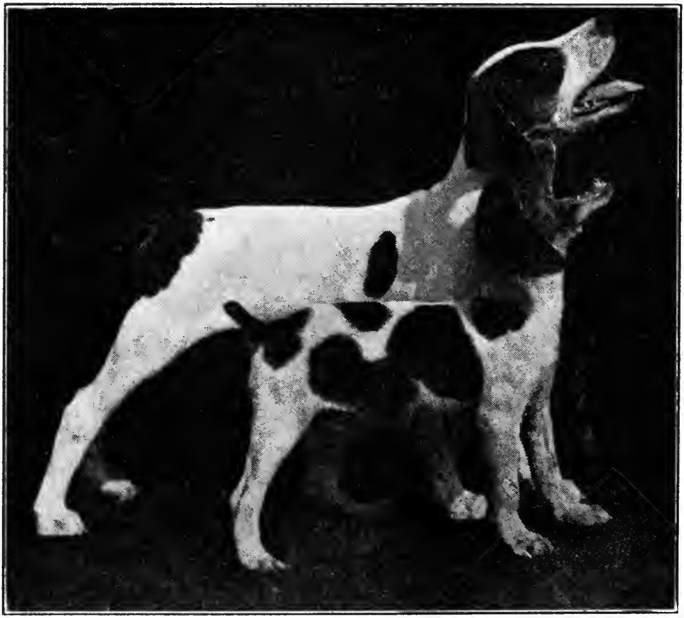
157. Handicaps to the Maintenance of an Efficient Body. — You have already learned that a persistent lack of any food element or any kind of vitamin will result in decreased body efficiency. Too much of some food elements will result in ill effects, also. A person must have a well-balanced diet, if health and growth are to result. Underweight may result from too much of one thing as well as from too little of another.

It is well to study balanced menus in books on foods to find out suitable combinations. Here is a good general rule for growing children : One quart of milk a day, fresh or canned fruits, cooked and raw vegetables, a reasonable amount of meat and eggs, bread (preferably whole-wheat bread), cereals (because of the minerals and vitamins they contain), and six glasses of water daily.

Alcohol and tobacco are serious handicaps at all ages, and especially so during growth.

Alcohol even in moderate amounts is known to interfere with digestion by causing too great a flow of digestive juices, by hardening proteins in the stomach, thereby increasing the difficulty of digestion, and by taking moisture from the delicate linings of the digestive organs, especially the stomach. This results in irritations and inflammations of these tissues and prevents their normal work.

You have learned that alcohol and tobacco both interfere with proper muscular response. Since good digestion depends upon good muscular action of the walls of the digestive organs, anything which affects these muscular actions will result in poor digestion.



EFFECTS OF MILK ON GROWTH

The smaller dog went without milk. What effects do you think lack of sufficient milk in your diet might have?

GENERAL PROBLEM 4. HOW ARE FOODS AND WASTE MATERIALS TRANSPORTED IN THE BODY?

158. The Circulatory System. — The blood, as you have learned, is the form which nutrients (food elements) take after digestion. It flows from the heart to the tissues of the body as pure blood and returns carrying waste products which are to be expelled from the body. This continued flow is called circulation.

The heart is a double, self-acting pump, consisting of four chambers. The top *left* chamber receives blood with its new supply of oxygen from the lungs, and forces it into the lower chamber through valves that work in one direction only. The walls and muscles of this lower chamber contract and force the blood out through a great *artery*, called the *aorta*. Other arteries branch off and divide and subdivide into smaller and smaller tubes, finally ending in the *capillaries*. The capillaries supply every part of the body with food and oxygen-laden blood. So you see why food, when taken into the blood, is carried to all parts of the body.

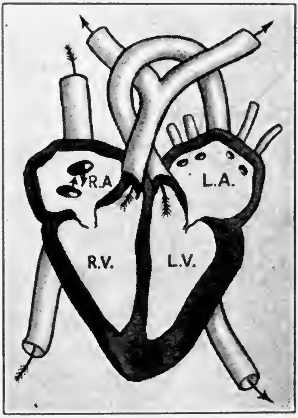


Diagram of the Heart

The arrows show the direction of the flow of the blood. The initial letters of the names of the four chambers of the heart are shown. Can you find out the full names?

After the blood has given up its useful materials and taken on waste materials, it returns to the heart by means of capillaries leading into *veins* like tributaries to a river. Finally, through two great veins the blood reaches the top *right* chamber of the heart. Here it is forced down into the chamber below, and thence to the lungs, where the carbon dioxide is exchanged for oxygen. Then the cycle starts all over again.

Each organ has its own special blood supply, and if anything interferes with it, trouble results.

The heart and arteries are built with complicated involuntary muscles (page 290) which are responsible for keeping the blood in constant flow. Contraction of the side-wall muscles of the arteries help to push the blood along. Valves in the larger veins prevent the blood from flowing in the wrong direction, as do the valves in the heart.

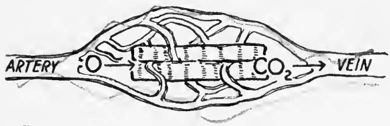


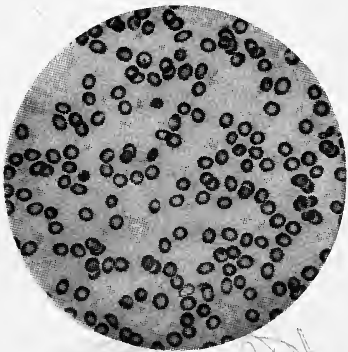
DIAGRAM OF THE BLOOD SUPPLY TO A MUSCLE

What gas is supplied to the muscle and what gas is removed by the blood?

159. Blood and Lymph. — Blood is a liquid containing huge numbers of red corpuscles and white corpuscles.

Do you remember when you broke the bone open for Experiment 35 that there was a cavity in it filled with some substance? We call that substance *marrow*, and it is here that the red corpuscles are probably manufactured by the million.

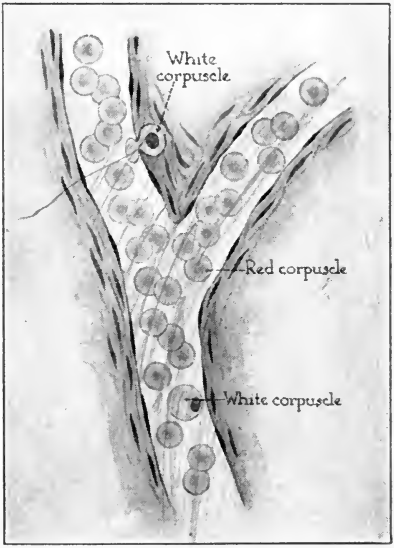
The liquid is colorless, made of about 80% water, and is called *plasma*. The color of the blood is due to the red corpuscles. These red corpuscles (see picture) are shaped like circular discs. They are so small that a single drop of blood contains several million. They contain a red substance called *hæmoglobin* which carries the oxygen. When a person has too few red corpuscles, there is also a lack of hæmoglobin, hence body cells may not get enough oxygen.



Magnified 250 times

RED BLOOD CELLS

White corpuscles are living cells with one or more nuclei. They vary in size, have no cell wall and so change their shape constantly. White corpuscles can destroy certain foreign materials in the blood, including some germs. Hence they are very important aids to health. In healthy blood, there are six or seven hundred red cells to every white cell.



RED AND WHITE CORPUSCLES IN A CAPILLARY

What is one function of each? Notice how many more red cells there are than white cells. One white cell is passing through the capillary wall.

Lymph is a colorless fluid that surrounds and bathes the cells in the body. It is manufactured in glands situated in different parts of the body and is filtered (separated out) from the blood through the capillary walls. We may think of the blood being inside circulating tubes and lymph being outside. There are little tubes that distribute lymph, but it is not pumped around as is the blood.

160. First Aid to Cuts and Bruises. — A cut or scratch or bruise that breaks the skin may seem just a trifle, something not to bother about. However, greatest care should be taken that no disease germ finds a lodging place there. The most insignificant cut or pin prick may result in blood poisoning if it is not thoroughly cleaned and sterilized.

Bleeding from small blood vessels usually can be stopped by applying moderate pressure to the wound by a clean pad or bandage. The bleeding stops because the blood itself forms a tough clot over the opening of the wound and seals it up.

CAMPERS BEING TAUGHT FIRST AID
What is the boy on the right doing?

In more serious accidents large arteries or veins are sometimes severed. An artery will spurt blood as the heart beats; the blood from a vein will flow smoothly. These kinds of bleeding are dangerous because much blood is lost rapidly. Until a doctor can be reached, the flow of blood should be stopped by pressure of the thumb on the vein or artery, close to the wound; between the wound and the heart, if it is an artery but with the cut between the heart and the pressure if it is a vein.

Can you explain why the pressure comes in different places for a cut vein or a cut artery?

161. Handicaps to Development and Maintenance of the Circulatory System. — The muscles of the heart, like other muscles in the body, can be overworked or strained, resulting in a weakness that may last many years. For that reason directed exercise is valuable for boys and girls; too strenuous play should be avoided.

The use of drugs that affect the heart is especially harmful. Alcohol has a depressing or paralyzing action on the heart and blood-vessel muscles. Alcohol also injures the white blood corpuscles, thus making the body less able to fight germ diseases.

Tobacco used by growing children prevents the proper growth of the heart. Perhaps some of you have heard the term "tobacco heart" and can explain what it means. Both alcohol and the nicotine of tobacco are habit-forming drugs. Avoid them!

General Problem 5. How Are Waste Products Related to Body Health?

162. Waste Products. — We now come to those waste products which we have mentioned before as a result of certain processes taking place in the body. These must be discharged from the body to preserve health. This discharge, or *excretion* as it is frequently called, is accomplished in several ways and through several organs, according to the kind of waste being thrown off.

When the oxidation of food takes place in the cells, carbon dioxide and water are the products obtained. The water is used, but the carbon dioxide is not needed, except in small amounts. Hence it is gotten rid of by means of the lungs in the breathing process.

When digested food leaves the small intestine and is absorbed by the blood, certain indigestible (not soluble) portions are passed on into the large intestine. The plant substance cellulose (page 251), occurring in many vegetables, is an example. If these substances are left too long in the intestine, they decay and form poisons. These poisons in turn cause headaches and general weakness, making a person more liable to illness. By muscular action of the walls of the large intestine, this undigested matter is expelled from the body. Such action should come at regular intervals, if good health is to be maintained.

The use of protein in the body results in the formation of *uric acid*, which dissolves some mineral salts to form *urea*. This material, salt, and other minerals dissolved in water are passed out through the kidneys. Drinking six glasses of water a day helps to wash out these waste products.

Perspiration on the surface of the skin is more than water seeping out through the tiny pores. It contains salts of various kinds. The water evaporates, leaving the waste materials upon the skin. Daily bathing is necessary to remove this material because it accumulates all the time, even though you cannot see it.

163. Handicaps to Excretion. — Lack of sufficient water each twenty-four hours will quickly upset proper excretion. Likewise, overeating of constipating foods and the unwise use of medicines will cause breakdowns of the excretory organs. Lack of sufficient rough, indigestible material with the food may lead to constipation, since such roughage is needed in the large intestine to stimulate the flow of juices to lubricate the waste material. When food intake and elimination are kept in proper balance, a healthy body will very likely be maintained.

This, in a simple way, is the story of digestion. The complete story of digestion, absorption, and assimilation is very complicated and interesting, but the important thing for you to know now is — give these processes a chance to build and maintain a healthy body for you by providing proper food, and observing proper eating and eliminating habits. Proper exercise and rest and plenty of drinking water are important necessities to good digestion and elimination.

Key Words

artery
assimilation
cell
cellulose
circulation
digestion
fats
involuntary
kidneys
liver
lymph
molars
muscle
nucleus
proteins
protoplasm
red corpuscles
skeleton
stomach
sugars
tissue
vein
vitamins
voluntary
white corpuscles

Key Statements

1. The frame of the body is provided with joints to permit motion.
2. Bones are composed of mineral matter and animal matter and are constructed of cells.
3. A healthy bone grows and repairs itself if necessary food is provided.
4. "Bumps" on the head do not indicate character or abilities.
5. Calcium and phosphorus compounds are needed for bone and teeth growth and repair.
6. Young bones are easily misshaped by poor posture.

7. There are voluntary muscles controlled by the will, and involuntary muscles that are not controlled by the will.

8. The function of muscles is to cause movements of organs of the body or of the body itself.

9. Muscles are made of living cells.

10. Good or bad posture becomes a habit.

11. Narcotics in alcohol and tobacco have a paralyzing effect on muscle action.

12. Energy from foods is needed to operate and maintain a healthy body.

13. Muscles grow and repair themselves if proper food and energy is provided.

14. Digestion is a series of processes needed to make food materials soluble so they can be absorbed.

15. Starches, sugars, and fats are energy-producing foods.

16. Proteins are tissue-building foods.

17. Digested food is absorbed mostly from the small intestine.

18. Oxidation of food material takes place in each body cell and produces heat.

19. Good teeth are essential to good health.

20. Vitamins are necessary to promote certain body functions.

21. Alcohol interferes with normal digestion.

22. Healthy blood contains the proper number of red and white corpuscles.

23. Lymph transfers food substances from the blood to the cells.

24. The use of tobacco by growing young people prevents normal heart development.

25. Normal elimination of waste products is necessary to a healthy body.

26. Proper food, plenty of water, exercise, and rest promote proper elimination.

Thought Questions

1. Why does the shoulder joint admit of more motion than the elbow joint?

2. Why can you show mineral matter in bones by burning?

3. What may be the cause of bow legs?

4. How can you be sure of good posture as you grow older?

5. Why does man have a greater variety of kinds of motion than any other animal?

6. Why must foods be digested?

7. Why should growing young people avoid smoking? use of alcoholic beverages?

8. Why is it important to promote proper elimination of waste products?

Projects for Your Science Discovery Book

1. Check yourself on posture by comparing your own posture with someone else's. Record each case against yourself for one day. At the end of the day, summarize in a simple statement a plan for improvement.

2. Describe and make drawings of a leg bone of lamb which has been sawed lengthwise and crosswise through the middle. (Your market man will sell you one for a small price and saw it for you.)

3. Study your own skeleton by counting your ribs, noting how they move; counting and noting the movement of the bones in your hand, arm, leg, and foot. Study also the diagram in your textbook on page 284. If possible, examine a prepared skeleton of man, and of some other animal such as a cat, crow, snake. Explain how they are alike and how they are different.

4. Make a study of muscle attachment and show by simple drawings how a muscle is attached to cause motion, and how it is attached to exert force.

5. Keep a height and weight record for a few weeks.

6. Make a list of the different foods that contain calcium.

7. Examine under a miscroscope, if possible, various kinds of cells: onion skin cells, muscle cells, leaf cells, yeast cells, root tips, green slime from the pond. Make drawings of the cells you examine.

8. Make a study of scientific data and authoritative books on the effects of alcohol and tobacco on the human body. Then formulate your own opinion and record it with the facts.

SURVEY OF TOPIC XV

Man has at last succeeded in doing what he has visioned for many years — he has produced a mechanical man, fashioned from raw products of the earth and able to perform efficiently certain tasks of drudgery in the world of work. *Televox*, as he is called, can see, hear, feel, smell, and talk. But he cannot think; he cannot decide anything for himself. He depends entirely on outside control. He has to be guided by someone or something outside himself.

Man is superior to such an automaton, because he has the spirit of life and a brain capable of controlling his actions. It is therefore important for us to try to understand something about the way our brain operates, and about its complicated system of controls, so that we may constantly improve our habits of living and our habits of thinking. It is also important that we learn to know those things which have a harmful effect upon our control system and guard against them.

Life is an adventure and a game. It has its rules like any other game. Let's follow the rules, let's play the game, with the very best that is in us.

TOPIC XV

CONTROL CENTERS OF THE HUMAN MACHINE

For 'tis the mind that makes the body rich.
— SHAKESPEARE

Do you know:

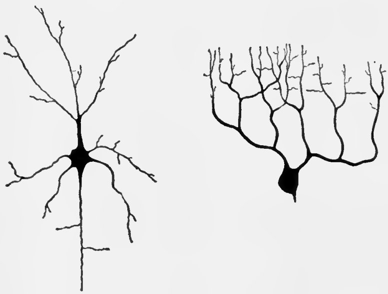
1. **Why you need a control system?**
2. **How your brain functions?**
3. **How you learn through your senses?**
4. **How you can form good habits?**
5. **Why drugs and narcotics are harmful?**

GENERAL PROBLEM 1. WHAT KEEPS THE HUMAN MACHINE OPERATING SMOOTHLY?

164. The Control Center of the Body. — Running all through the human body is a system of long and short fibers somewhat like the many wires running to a telephone exchange. These fibers, called *nerves*, perform much the same service as the telephone wires, that is, they carry messages. For example, when you cut your finger, a rapid exchange of messages takes place in the *nervous system* and you jerk your finger away from the sharp edge as quickly as you can.

The message to save your finger is only one of many, many ways in which the nervous system serves you. Every movement of a muscle, every response of the five senses (seeing, hearing, tasting, smelling, and feeling) is controlled by some action in the nervous system. It is the control center of all you feel and do and so you ought to know some of the important facts about it.

165. Parts of the Nervous System. — The nervous system acts in two ways: (1) as a result of thought in the *brain*, and (2) by automatic response of certain cells in the *spinal cord* to messages which do not require action of the brain. The first kind of action controls all voluntary movements, such as picking up a pencil or reading a book; the second regulates such automatic movements as breathing or blinking the eyes.

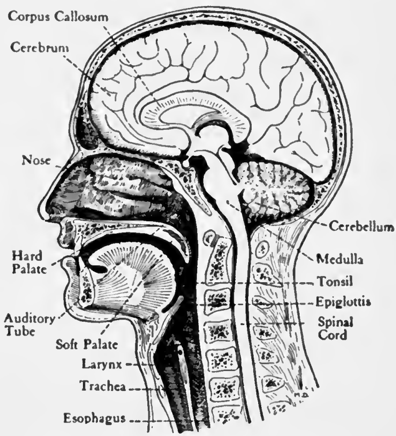


NERVE CELLS
What are the branches for?

166. Nerve Cells. — Like all other parts of the body, the tissue of the nervous system consists of cells. They differ from other cells in that they are much larger and have several branches, one of which is usually considerably longer than the others. These branches are the fibers of which we have already spoken and together with their cell they form a structure called a *neuron*. The neuron is the simple unit of the nervous system. The branches of one neuron intertwine with those of others and all join in a regular network of lines by which the messages are carried back and forth over the system.

167. The Spinal Cord. — The spinal cord is inclosed in the spinal column, where it is protected from injury and jarring. Thirty-one pairs of spinal nerves lead from the spinal column to all parts of the body. The outside of the cord consists of white nerve fibers which carry the messages up and down. The inside portion consists of gray nerve cells which pick up the messages which require instant action of a muscle, without reference to the brain.

The upper end of the spinal cord, just inside the head, is enlarged and is called the *medulla oblongata*. It is the part of the brain which controls the automatic processes of circulation, breathing, and motions of the digestive organs which we have already studied. The movements that take place in these processes are involuntary movements. The medulla oblongata also controls other involuntary movements such as winking the eyelids, sneezing, or coughing.



CROSS SECTION OF THE HEAD

What is the main function of the cerebrum, the cerebellum, and the medulla?

168. The Brain. — The brain has two large divisions, the *cerebrum* and the *cerebellum*. The cerebrum is the larger division, and is itself divided into two parts, right and left halves. The outer layer has deep irregular folds, called *convolutions*, and is composed of gray nerve cells. Inside the cerebrum are white nerve fibers for the pick up and transfer of messages. All our emotions (anger, joy, fear, hate), all our sensations (sight, hearing, touch, smell, and taste) are dependent upon the operation of the cerebrum, as well as all our ideas, our will power, and our memory.

The coöperation between the cerebrum and the cerebellum makes our muscles work together, so that we walk or run without falling. The three parts of the brain working together, as you can see, control our actions, our motives, and our emotions. If we do our share, this control system keeps our bodies healthy and normal.

169. Automatic Control. — Each of us responds to the sights and sounds and feelings of his environment according to the way his brain or other parts of his nervous system work. The sensations that come to it arrange themselves in definite patterns which are reproduced in the tissues of the brain. Once a pattern has become fixed, we say that a *habit* has been formed. Thus, once you have learned to write, you no longer have to think about the mechanical part of writing. It becomes automatic, leaving your brain to the more important work of giving attention to what you wish to write.

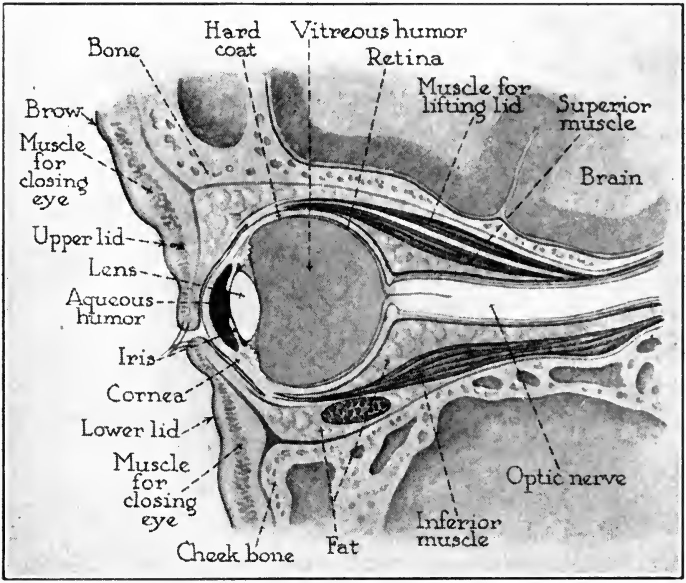
Write your name as usual. Then try to write it backwards. Why cannot you do this as readily as the normal way?

Such automatic or mechanical actions are called *reflex actions*. Reflex action winks your eyes at a threatened blow; it withdraws your finger from a hot article.

What other reflex actions can you mention?

General Problem 2. How Do We Learn?

170. Habits and Reasoning. — Some forms of behavior are natural, some have to be learned. By seeing, hearing, feeling, tasting, and smelling we learn about things. Then we think about what we learn, we compare this with that and we come to some sort of conclusion. This process of forming correct mental conclusions is called reasoning. Lower animals learn by



STRUCTURE OF THE EYE

Which part is sensitive to light? Which part focuses the rays of light? Give a use for each of five other parts.

their senses and develop certain reflex actions, but it is doubtful if they reason about what they learn as you do.

Field Research:

Try to work out a plan by which you could learn some facts about an apple or a jackknife, without using any of your senses.

171. Seeing. — Our eyes are constantly in use receiving messages to be carried by the optic nerve to the brain. They work under all kinds of conditions; in sunlight and artificial light, in murkiness and in shadows. Sometimes they grow tired and fail us. Sometimes they are deceived. It is our duty to lighten the strain on our eyes in every way possible. They will then be our very good servants.

The *lens* in the eye reproduces on the *retina* an exact duplicate of the objects that are reflecting light into it. Without this lens there would be no image formed. There might be color, but no colored pictures. Just as a camera takes a picture, so your eye receives the image of the object which you are looking at. The lens carries the image back to the retina, where it is transferred to the brain. The same image always causes the same sensation, and so you learn to know and recognize it. The following experiment will show how this takes place.

Experimental Problem 38. — *How does a lens form an image?*

What to use: A lens (reading glass or other magnifier), piece of white paper.

What to do: A. Hold the lens between the paper and an electric light or a bright window. Move the lens to and from the paper to produce a sharp image of the object on the paper.

B. If you have more than one magnifier, try each one on the same object and at the same distance away, and note if the distances from paper to lens, the *focal distance,* are the same with each lens when the image is sharp.

C. Measure the focal distances when a near object is focused and when a far object is focused. Note also if the size of the image changes.

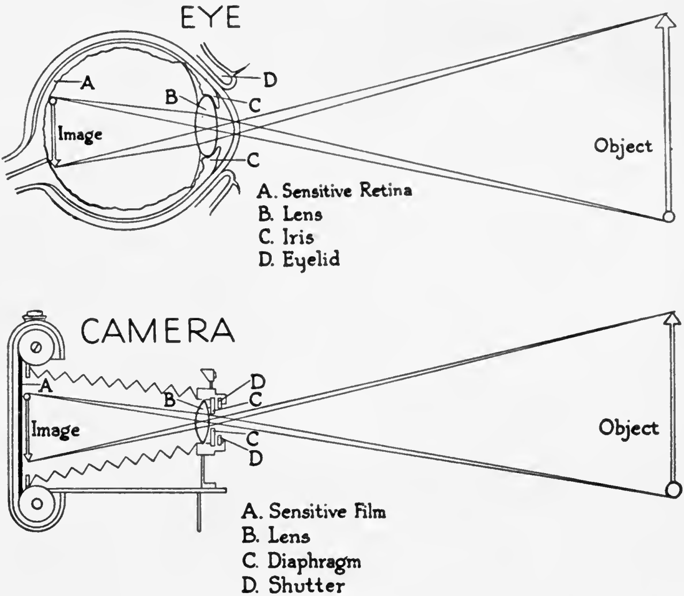
What happens: 1. Did you succeed in making a sharp image? 2. Was the image right side up or reversed? 3. If you used two different lenses, what did you discover about the focal distances? 4. When focusing objects at different distances, what did you discover about the focal distances? about the size of the image?

Use labeled diagrams to show what happens.

Conclusions: Tell what you have learned about a lens.

Applications: The lens in the camera acts in the same way as your magnifier to produce an image on the film. The film is affected by the light and then can be developed to bring out the image.

A remarkable thing about the lens in your eye is that little muscles cause it to change its curvature as needed,

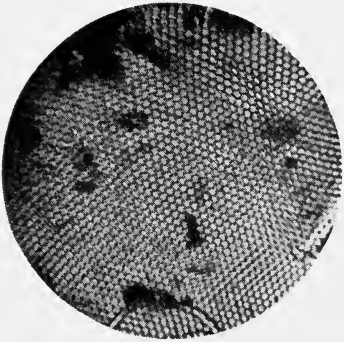


Diagrams Comparing the Structure of the Eye and a Camera

What parts have these in common? How does the eye differ from the camera?

so that while the letters on this page form distinct images for you, if you turn your head and look out of a window at a distant object, the lens will adjust itself and you will still have a sharp image. If your eye were a camera, you would have to change the distance from lens to film to have a sharp image in both cases. If your eye is normal, the little muscles around the eye change the shape of the lens because the distance from the lens to the retina is fixed.

Either one or both eyes of a person may be imperfect in structure. Thus, the retina may be too near the lens or too far away, resulting in blurred images and eye strain. Other eye defects are due to incorrectly shaped eye balls or to weak muscles. It is advisable to have your eyes tested every year or so by a dependable optician. If they are imperfect in any way, glasses should be worn to correct the condition. If properly fitted, glasses will help your vision and possibly prevent an eye trouble from getting worse.



Magnified 300 times

PART OF COMPOUND EYE OF A FLY

Does each little part look like a lens?

If you tire your eyes by working under poor light; if you are careless in cleansing the eyes; if you rub them with dirty fingers, trouble is bound to follow. Your eyes are precious. Give them your best attention.

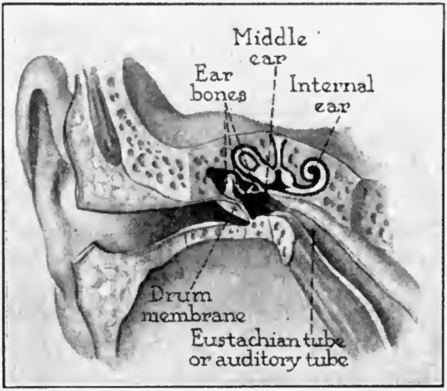
Field Research:

Test your eyes, one at a time, to find if they are alike, or whether you can see better with one or the other. Try with distant and near objects. Compare your vision with another's vision. It is better to cover one eye than to shut it when testing the other one.

172. Hearing. — Do you remember when we were talking about bones, back on page 283, we mentioned the hammer, anvil, and stirrup, the small bones of the ear? Let us try and find out how these small bones work and so help us to hear.

Sound is the result of vibrating matter. The string on a violin gives out a tone when it is caused to vibrate by rubbing the bow across it, or when it is plucked with the finger. A tin pan gives out sound when it is hit because the blow causes it to vibrate. Air will give out sound when it is set vibrating in a horn or a whistle.

Give some more examples of sounds and tell what vibration causes them.



STRUCTURE OF THE EAR

Which part of the ear contains air? Which part contains a liquid?

Any substance that will vibrate can receive and pass on a vibration and hence can do the same with sound. Thus air carries sound; water does it even better than air; and metals even better than water.

When vibrating air (air waves) strikes your *ear drum* (see the above diagram), the ear drum is set vibrating like the *membrane*, the thin cover, of any drum. That vibration in turn sets the little ear bones, the hammer, anvil, and stirrup, vibrating; and this vibration is carried to a liquid in the inner ear. These liquid waves affect the nerve endings, the nerves send a message to the brain, and you know you have heard a sound. Sounds that are heard over and over again become familiar. That is why you learn to recognize sounds, just as you learned to recognize things you see.

Field Research:

Test your hearing by listening to whispers, whistles, the tick of a watch. Test one ear at a time.

Start a tuning fork vibrating by striking it against a piece of wood or the palm of your hand. Have someone hold the handle end against the bone in back of your ear. When you can no longer hear it that way, signal, and have the fork part (the prongs) held in front of that ear. You should hear it again.

Hold the handle of a vibrating tuning fork against one of your upper front teeth. Can you hear it? Stop one ear with your finger. In which ear does the sound now seem louder?

If you are not sure the tuning fork is vibrating, dip the tips of the prongs just below the surface of water in a glass. Does the water spatter? Hold the vibrating ends so as to just touch a piece of paper. Does the paper vibrate?

Hearing may be imperfect due to several different causes. A blow on the ear, certain diseases of childhood, adenoid growths in the throat, or constant colds may affect the hearing. Children should be seriously cautioned about putting any sharp instruments in the ear. If wax is allowed to gather in the ear, it will often cause temporary deafness. If it cannot easily be removed by a soft cloth, the child should be sent to a physician for treatment. Children should have their ears tested occasionally to find out if they need attention.

173. Tasting, Smelling, Feeling. — These three special senses are needed, in addition to sight and hearing, to give us complete knowledge of our environment.

Taste and smell help us to get pleasure from food, and help, to some extent, in protecting us against poor or unsanitary food.

There seem to be at least four distinct tastes: sweet, sour, salt, and bitter. Combinations of these tastes make food palatable.

Why do you suppose food has so little taste when your nose is stopped up with a head cold?

As in the case of sight and hearing, special nerve endings are sensitive to special tastes and odors, and messages to correspond are sent to the brain. Thus we become aware of taste and odor.

Nerve endings all over the body are sensitive to touch. That is why we so easily learn to identify a smooth or rough, a slippery or a sticky surface.

What are some examples of special training of the senses: taste, smell, and skin sensations (cold, warm, touch, pain)?

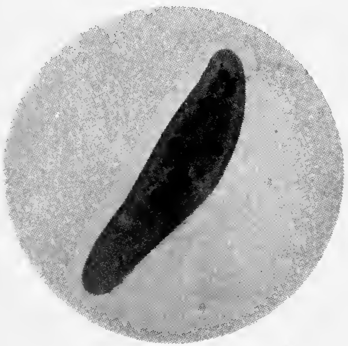
Keep your sense organs in proper working order. If you have imperfect organs, try to correct them. Do not handicap your learning by faulty senses.

General Problem 3. How Can We Improve Our Habits and Methods of Thinking?

174. Habits of Doing. — You have learned that when you practice some act, you are awkward at first because you must think just what to do. You perform the act voluntarily. With training, that is, repetition, the reflex nerve centers carry on the act without further attention on your part. For example, good posture is a habit formed by consciously maintaining good posture until such time as your reflex centers are able to take it in charge. Therefore, it is important that you are reminded frequently if your posture is incorrect. Bad posture habits are just as easy to acquire as good ones, perhaps easier.

What is your favorite habit? Does it benefit you or handicap you?

Habits may be the kind that promote the doing of a desirable act, or they may serve to prevent doing an undesirable act. Both are important. For example, one can form a habit of answering back angrily or withholding an impulsive answer. " Think before you leap " is a good rule to follow as a habit. It not only will prevent hasty answers, but will help you to control your actions for the good in many other ways.



Magnified 300 times

A One-Celled Animal — The Paramecium

What processes does your body carry on that this animal does not? What habits do you have that this animal lacks?

175. Habits of Thinking. — All " doing habits " are the result of thinking and so we ought to form thinking habits that are clear and direct in contrast to the unsystematic or careless thinking of some people. Good thinking habits result in accurate comparisons, proper organization of facts observed, and the ability to recognize cause and effect.

When you have formed correct habits of thinking, you will not believe in superstition, but will demand sufficient evidence or data before you give an opinion about a problem. Reasoning is a habit of thinking which may be developed, just as a good posture habit or the habit of politeness can be developed.

In studying science you have been training your mind to think scientifically as a habit. This means you have been trying to solve problems. To solve problems you now know you need to secure many related facts. You obtain facts by means of reading and discussions, by working out experiments, and by making accurate observations both indoors and outdoors. Your five senses enable you to get facts about things.

Magnified 1000 times

WOOL FIBER

Using the scientific method of thinking, decide if a human hair and wool fiber are alike as to origin.

Having secured your facts, you organize them, discarding those that may be unrelated to your problem. Your organization will help you to make simple, direct statements (Key Statements) telling what you have learned from each set of facts. By studying the simple statements, you decide for the moment upon a conclusion.

Your temporary conclusion must be tested and so you proceed to apply it. You explain new but related problems, such as the Projects at the end of each topic or the Special Problems at the back of your book. Better yet, you apply your conclusion to problems of your own discovery.

This process of thinking from facts to the solution of a problem is the scientific method and one which you no doubt have learned to know well during this course. With practice, the method has, we hope, become a habit with you, one that will be invaluable to you.

Select the habits you want to develop by the scientific method. If you prove to yourself that a certain habit is to your disadvantage, use your will power and discard it. Be content only with habits that are to your advantage.

General Problem 4. Are Narcotics and Other Drugs Harmful?

176. Alcohol and Tobacco. — Your investigation of the effects on the body of alcohol, tobacco, and various other common drugs calls for you to apply the method of science before making your conclusion.

In your study of body needs, you discovered that certain foods, minerals, and vitamins are required. You did not discover any way in which narcotics are needed.

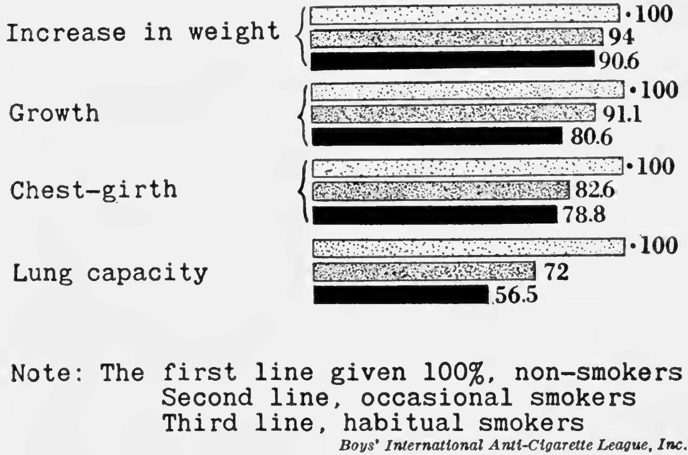
It is true that alcoholic medicines have been prescribed for certain ailments. However, modern scientific methods of treating disease do not include treatment with alcoholic beverages.

You should review the effects of alcohol and tobacco as they have been discussed in previous pages. Just now we are concerned with their effects on the brain and nervous system.

If alcohol is not injurious to people, why are skilled workers, athletes, and the like required to abstain from its use? There is much evidence from actual experiences with players of football and baseball, runners, swimmers, sharpshooters, and other athletes, that proves the bad effects of alcohol or tobacco. Their use results in loss of body strength, loss of endurance, and loss of skill. Accuracy and reliability are decreased.

Why do present-day conditions of transportation, factory and industrial problems demand clearer brains and steadier nerves than a generation or two ago?

Alcohol has a depressing effect on the brain and nerve cells which brings a lack of self-control. Impatience



TOBACCO AND GROWTH

According to Dr. W. Seaver of Yale University, this chart shows how three different groups of schoolboys developed physically during three and a half years.

often results and sometimes acts of violence that would not have been committed if the person had not used alcohol.

Alcohol and tobacco and other narcotics are habit forming and should be avoided on that account.

It has been stated [1] that when alcohol is in the blood to the extent of five-hundredths of one per cent, the

[1] *Science News Letter*, December 17, 1932.

average person becomes a danger to himself and others.

Dr. Benedict, in his article, "Inflexible Science,"[1] says to the modern automobile driver, "'*Moderate Drinker, keep off.*' For at least four hours after a dose of alcohol, formerly considered 'permissible,' you as a motor vehicle operator may well be considered a menace to society."

Narcotics paralyze the nerves and so interfere with every voluntary and involuntary action of the body. They likewise decrease a person's ability to think properly and to form good judgments.

177. Drugs and Remedies. — In the hurried life of to-day, nervous strain, improper eating habits, and excesses result in headaches, constipation, and a general run-down condition. Children, especially, should consult a doctor at once in such cases and older people generally ought to be more careful in the use of drugs to bring relief for such ailments.

Laxatives, headache remedies, cures for fat people and for lean people, flood the market. One must demand real evidence before believing the glowing statements of some advertisements. Be cautious. Prevention rather than dependence upon relief is a good slogan. Remedies are safe only when prescribed by your own doctor.

Unnatural face and lip colors and other so-called cosmetics are probably harmless in many cases, but some are known to be harmful. It is better to put natural color into the skin by proper food, exercise, and rest than to use "make-up."

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[1] *Science News Letter*, December 17, 1932.

Sometimes cures for tuberculosis and cancer are advertised. All are said to be frauds. Your doctor is your safest adviser, not advertisements.

HEALTH MEANS HAPPINESS

Name all the aids to good health that this picture suggests.

Your body is wonderously beautiful, and marvelously made and ordered. You have a brain subject to your will. You can make or mar your life, depending on whether you make the most of your body and mind, or whether you mar them. Determine now that you will learn all you can about the proper care of your mind and body and that you will do all in your power to make good health and good sense, habits of your daily living.

KEY WORDS

anvil	habit	reasoning
brain	hammer	reflex
cerebellum	hearing	retina
cerebrum	lens	seeing
convolutions	medulla oblongata	sensation
emotions	narcotics	sense organs
eye	nerves	spinal cord
fibers	nervous system	stirrup
focal distance	neuron	vibrate

Key Statements

1. All parts of the nervous system are made of cells.
2. The medulla oblongata controls circulation, breathing, and digestion.
3. The cerebrum is the seat of emotions, sensations, memory, and will power.
4. The cerebellum causes the muscles of the body to work harmoniously.
5. Muscular actions are either voluntary or involuntary.
6. Certain muscular actions at first voluntary are by training made automatic by means of reflex action.
7. By directing immediate action in emergencies, reflex action nerves protect the body from injuries.
8. Information about the world of things is gained for the brain by the five senses.
9. Following the advice of competent physicians from early childhood about eyes and ears may prevent or relieve defects in these sense organs.
10. You are constantly developing either good or bad habits. You have the power to develop good habits if you wish.
11. Alcohol is a narcotic danger that is especially harmful to nerve cells, causing a sort of paralysis. It is a habit-forming drug.
12. Tobacco contains a narcotic poison, called nicotine. Its action on young people may result in stunted growth, debility, and decreased mental development. Nicotine is a habit-forming drug.

Thought Questions

1. What is the unit of structure of all living things?
2. What are some differences between voluntary and involuntary muscles?
3. Which part of your brain enables you to answer this question?
4. Explain how it is that you may wink before you think?
5. Do habits or actions come first?
6. How can a voluntary act become a habit?

7. What is meant by the statement: Alcohol and nicotine are habit-forming drugs?

8. What particular mental habit do you think is desirable? Describe it.

Projects for Your Science Discovery Book

1. Make a labeled diagram to show what happens when a person unexpectedly touches a hot iron.

2. Make a list of ten motions that are voluntary but which take place without your attention.

3. List five mental habits you think are desirable and five mental habits you think should be avoided.

SPECIAL PROBLEMS

TOPIC I. *Water and Its Ways*

Page 9

1. Trace the course of some spring with which you are familiar. See if you can discover the source of its water. Try to find out something about the character of the soil which will explain why the flow of water takes the form of a spring. An encyclopedia will give you a good start on this problem.

2. Try to find a plant or animal that has a special means of protecting itself against its enemies. Tell your classmates about it.

3. Make a balanced aquarium.

4. Make collections of harmful and helpful insects. Tell how each one is helpful or harmful.

TOPIC II. *Water as a Worker*

Page 25

1. Tell a simple story about the power system at Niagara Falls or some other falls with which you are acquainted.

2. Tell from your own observation, or reading, a number of ways in which floods are destructive.

3. Report on any action that Congress has taken to prevent floods in the United States.

4. If you can get to a stream, collect samples of the water to examine at home. Is it clear? Is there much

sediment (*sediment* is the material deposited by water)? Where do you think the sediment came from? Let the sediment settle and then evaporate some of the clear water in a clean dish. Did it contain anything?

5. If you can get to a river, try to find out where the water is flowing fastest by throwing in pieces of wood and observing how long it takes them to go a certain distance. What do you find? Does the water flow faster on the inner or outer edge of a curve? Where does the stream seem to be cutting or wearing away the bank the most? Is it filling in anywhere to make a sand-bar?

6. In your own yard or in some convenient place build a little pond or lake so you can make an opening and let the water run out and down a little hill. Add more water to the lake and try to find out how the little stream finds its way along. Why does it not flow straight?

7. The quotation at the head of this topic was taken from a poem called *The Song of the Chattahoochee*, by Sidney Lanier. Let some pupil find out where the Chattahoochee River flows and tell the class about it. Perhaps his English teacher will help him locate the poem so that he may read it and briefly explain it to the class.

8. Make a study of the fish to be found in your neighborhood. Have you caught any of them? If so, tell how you caught them. Are they good to eat?

9. Find out if any sewage is allowed to get into a stream in your locality. Do you think it is a good idea to put sewage into streams? Do you think the fish and plants like it? Try to find your answers by

reading, by asking other people, and by your own observations.

10. Investigate the causes that led to the location of your town, your state capital, and one of the following cities: St. Louis, St. Paul, Minneapolis, Detroit, New York, Boston, Chicago, Atlanta, Kansas City, New Orleans, Norfolk, Jacksonville, Denver, Salt Lake City, San Francisco, Los Angeles, or Seattle. Report to the class.

11. Explain how some railroad in your vicinity is laid out so as to take advantage of the land formations, such as valleys, water-gaps, divides, and river courses.

Topic III. *Land and Water*

Page 43

1. Find out the names of the planets. List them in the order of their distance from the sun.

2. Look up references in your library to find out about a recent earthquake. Did it occur near the ocean?

3. Make a study of volcanoes of recent times and report on them.

4. If you are especially good in English diction, plan to read or recite to the class the poem from which the quotation for this topic was taken.

Topic IV. *Rocks*

Page 63

1. Make a collection of as many of the scale minerals as you can find.

2. Test different shells and coral with acid to discover if they are made of lime.

3. Find out what localities provide good building limestone.

4. Make an investigation of the building stones used in your community. In your report tell where they come from, how they are quarried and shipped, what their cost is, what particular use is made of them in building, and why they are preferred.

5. Try to separate a mixed assortment of stones into piles with only one kind to a pile. Prove that your classifications are correct.

6. Make a report on some of the rocks to be found in your community. Include a statement as to whether or not they are igneous or sedimentary.

7. Start a collection of rocks and minerals.

Topic V. *Soil Formation*

Page 89

1. Just after a heavy shower, collect a quart fruit jar full of the discolored water running in a street gutter. Set the jar aside for some hours, then report fully on your observations.

2. Explain why a slow-moving stream, such as the Missouri River, is always muddy.

3. Report on some public building that shows evidence of weathering. What has caused it?

Topic VI. *Kinds of Soil*

Page 105

1. Determine the per cent of water a given soil may contain.

2. Will soil with fine particles hold more or less air than soil with coarser particles? Devise an experiment to prove your answer.

3. Examine any kind of soil with a hand lens to find if it contains sand. How can you tell? Describe other substances or particles which you may find. Is the sand fine or coarse compared to the other particles?

4. Dig a hole in some soil, deep enough to discover the difference between "topsoil" and "subsoil." Which is better for plant growth? Why?

5. Report on one of the important irrigation projects now being undertaken in this country.

Topic VII. *Life in the Soil*

Page 127

1. Find out by actual experiments which kinds of soils in your yard, garden, or farm are best for plant growth. Report to the class.

2. Find out whether certain kinds of soil are particularly adapted to certain kinds of plants.

3. Study by observation the life of a woodchuck (or a mole or an earthworm) to find out what it does to help plant growth. Report to the class.

4. Find out if a certain kind of tree is better adapted to one kind of soil than it is to another. For example, will a peach tree thrive better in sandy or clay soil?

5. If you can catch a meadow mole, bring it to the laboratory and put it in a box of earth for observation. Remember to feed him as long as you keep him prisoner.

6. Study your own garden to find what pests are destroying your flowers, fruits, or vegetables. When you find such an insect, try to identify it, observe what it eats, and learn the best methods of destroying it. Learn how to protect your plants from such pests.

TOPIC VIII. *The Use of Air*

Page 139

1. Try to devise some method for estimating wind velocity by observing its variations and effects over a period of several days.

2. Find some household utensil which is rusting, clean off the rust as thoroughly as possible, and put the proper sort of covering on to prevent further rusting.

3. Find out why silverware will tarnish although silver does not oxidize?

4. To demonstrate the force of air pressure on the sides of a tin can, get a clean, gallon-tin varnish can. Put in a half cup of water. Set the can on the stove and heat the water to boiling. Boil for five minutes, then remove from the stove and *at once* insert a cork or rubber stopper to make the opening air tight. Now watch what happens. How can you explain what happens? The boiling water in the can supplies steam, which drives out much of the air in the can, leaving it filled with hot steam. As the can cools, the steam inside cools and condenses, therefore taking up very much less room. Now you go on with the story.

TOPIC IX. *Air and Health*

Page 163

1. Keep a daily record for a month of the humidity of your schoolroom.

2. Make a hygrometer of your own. Compare its readings with those of the school hygrometer. Then use it to keep a record of the humidity in your living room at home.

3. Study the ventilation problems of your home and report to the class as to whether or not the same ventilation is needed for all parts of the house.

4. Find out how to adjust windows to ventilate a room properly.

5. Make a report to the class on one of the new air-conditioning devices.

TOPIC X. *Fire — Friend and Foe*

Page 187

1. Try to start a fire without matches.

2. Lay the material and start a campfire, using only one match.

3. Make a list of the uses of fire.

4. Find out what temperatures are best for cooking certain foods which you yourself name.

5. Determine the melting point of lard, chocolate, paraffin, and ice.

6. Go to your library and prepare a class report on the history of the match.

TOPIC XI. *Combustion and Fuels*

Page 199

1. Make a list of combustible materials which are used in building a home and which could be replaced with non-combustible materials. (A discussion of the new-type houses of steel and glass might be interesting here.)

2. Report on the manufacture of coal gas.

3. Build a fire in a stove or furnace and take full charge of it for two days. Explain how you changed the dampers to make the fire burn faster or slower.

4. Study the construction and operation of an oil-burning heating unit. Make a report to the class, using pictures, if possible.

Topic XII. *Our Control of Fire*

Page 221

1. Obtain a wide, shallow pan and fill it with sand to be used for building small wood fires in the laboratory. With the help of your instructor, build a small fire, using splinters and small pieces of wood about four inches long, and try the effect of a mixture of baking soda and sand on it.

2. Using a wide-mouthed 12-ounce bottle, construct an acid-soda extinguisher and use it to put out a small fire as above. You will need one 12-ounce wide-mouthed bottle, one 1-dram vial, one lead stopper for vial (whittled from a chunk of lead), one 2-hole rubber stopper, one glass exit tube, one glass nozzle (opening $\frac{1}{8}''$), some $\frac{1}{4}''$ rubber tubing, and a small quantity of copper wire.

3. Make a report on the per capita fire loss for your town or city, and what portion of this was due to preventable fires. Tell what might have been done to prevent them.

4. Write an opinion regarding the cause and prevention of several fires reported in newspaper clippings.

Topic XIII. *The King of Plants*

Page 243

1. Describe to the class the process of making paper.

2. Report on the process of "vulcanizing" rubber. Who discovered the process, and what did he use?

3. Go to the library and see if you can find out whether or not the leaves of a sugar-maple tree have anything to do with the making of the sugar.

4. Elect two or three of your classmates to go to park officials or the community tree committee, and ask what they are doing for the community's trees, and what they expect you and every citizen to do. Make a report on what they find out.

5. Look up the ordinances of your city about smoke. If they are not being observed, start a campaign to eliminate smoke from your town.

6. Report on how many acres of Forest Reserve your State has and what is being done to preserve the forests.

7. Find what bird likes to build its nest in each of several kinds of trees.

8. Find what tree blossoms first in the spring and whether the leaves or flowers come out first.

9. Find by observation how certain trees are protected by birds.

10. Get up a contest for collection of insect egg masses.

11. Form a club for the Study and Protection of Trees.

12. Get up a program for Arbor Day and for Bird Day.

13. Find out what your State Conservation Commission is doing to help maintain and protect your forests.

14. Learn to identify ten hardwood trees and five evergreen trees.

15. Learn to identify five birds that are insect eaters and five insects that are harmful to trees.

16. Find out what kinds of trees are common to your locality.

Topic XIV. *The Human Machine*

Page 283

1. Try putting an egg in a bottle. Soak the egg in vinegar or dilute acid until the mineral matter is dissolved. The shell will then be soft and flexible like the bone (page 285). If you are careful, you can put it through the neck of a bottle, if the neck is not too narrow. If you succeed, put in some limewater and note if the shell becomes hard again.

2. Have you good feet and do you take proper care of them? Make footprints of each foot (see Appendix for directions). Compare your prints with those in the picture, page 292. If your prints show faulty foot posture, do something about it. Ask your Health Education teacher for corrective exercises, or see your physician. Look also for the cause of your trouble. It may be that your shoes do not fit, or that they are badly constructed, with too high, or too low heels.

3. With the help of your chemistry teacher, collect, bottle, and label as many of the 12 or 14 elements found in the body as you can.

4. Test various face powders for starch.

5. Warm some starch mixed with saliva for about five minutes; then, test the starch before and after treatment for grape sugar.

6. Make three lists of the foods you ate yesterday. In one list place those foods that are body builders (contain liberal amounts of proteins); in the next place the energy-giving foods (those that contain starches, sugars, and fats, but little, if any, protein); and in the third list place those foods that contain the mineral elements, calcium, phosphorus, and iron.

7. Check the foods you ate yesterday for the vitamins they contained (use the table of vitamins and foodstuffs in the Appendix of your textbook) and make a report of your findings.

8. How do the teeth of a dog, cat, cow, and rabbit differ from your own? What relation does the kind of food they eat bear to the arrangement of their teeth?

Topic XV. *Control Centers*

Page 319

1. Give a report on Helen Keller and tell especially how she has trained certain senses to help because of handicaps in other senses.

2. List all the occupations you can think of which require people with special sense training.

3. List several of your personal habits, such as manner of eating, interrupting another who is talking, laughing boisterously, manner of using the feet in walking, and decide if each habit is a good or a bad one. If bad, make plans to correct it.

4. Using any science problem in the text, show how you used the scientific method in solving it.

5. Choose the problem: "Is alcohol harmful to young people?" or "Is tobacco smoking injurious to young people?" and by whatever means you have at hand, and to the best of your ability, make a scientific solution of the problem you choose.

APPENDIX

SCIENCE DISCOVERY CALENDAR

" . . . to enjoy the things the world has agreed are beautiful, to be interested in the knowledge mankind has found valuable, to comprehend the principles the race has accepted as true, — this is culture."

— A. LAWRENCE LOWELL

How useful are your eyes and ears? Is there beauty you do not see? Do you hear Nature's music? Seeing and hearing are two most important senses for you to develop and to train if you want to know and enjoy what the world regards as good and beautiful.

To be the first to discover the " spring beauty " in the woods, or to hear the first robin on the lawn, gives everyone a thrill; to hear and to know the note of the wood thrush; to understand the ways of the stream and of the wild creatures of the woods and fields add to the joy of living. So this Science Discovery Calendar is made to help you discover these good things.

Experience in the woods and fields and gardens tells you when and where to look to make discoveries. What you learn by yourself in this way will also help you to understand and solve the problems you meet in your study of science. When you go afield for study, always take your notebook with you, for records made at the time of the discovery will be more accurate, and therefore more valuable, than if made from memory.

SCIENCE DISCOVERY CALENDAR

SEPTEMBER

First Week

Determine from a calendar the time of rising and setting of the sun.

Observational study of the planets:

Venus Jupiter Saturn	What time do they rise? set? Do they appear in the evening sky after dark or in the morning sky shortly before the sun rises?

Make drawings of one or more constellations.

Donate to the laboratory the following plants which may otherwise be thrown out at home: *geraniums, begonias, coleus, snapdragons,* old *ferns.* They can be used for planting experiments.

Now is the time to make collections of grasshoppers for future study; also caterpillars for terrarium.

The monarch butterfly breeding can begin now.

Tussock moths: destroy egg masses.

Ovenbirds and chimney swifts will nearly all go south by the 15th.[1]

Wind: direction and velocity observations.

Write the weather bureau to place your school on the mailing list for the daily weather maps.

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[1] All dates are approximate for northern and eastern United States. You should make allowance for your locality.

Second Week

Devote some time to discussion of summer observations and experiences.

Boys and girls may collect crabs (crayfish), frogs, and toads, and keep them alive in an aquarium for later study. (Caution: *Know and observe the conservation laws of your state.*)

Collect insect cocoons and keep for observation.

Observe and discuss seeds and seed dispersal. Make collections for later study.

Observe weeds, especially those that cause nasal infection (goldenrod, ragweed, etc.). Learn how to get rid of them.

Sow rye in the garden for green fertilizer.

Begin plans for Fire Prevention Day.

Indigo buntings are migrating southward. Try to observe them.

Continue wind observations and recording. Have you discovered any prevailing wind direction?

Plan a bulb sale for your school. Wholesale florists will coöperate with you. Give directions for potting and care with each sale.

Third Week

Observe spiders. Are they insects? How do they make webs? What is a web for? Why doesn't the spider get stuck on his own web? How many kinds of spiders do you find? What good are spiders?

Start a campaign for the extermination of rats and mice, as a means of prevention of waste and disease. (*National Geographic Magazine*, July, 1917; Department of Agriculture bulletins)

Equal lengths of day and night occur September 21. Explain. Continue to make accurate wind and temperature observations and records.

Observe the habits of the earthworm. You may keep some in a box with a glass front to observe how they live. Feed them cabbage or lettuce and water them.

Harvest onions and squash. Sow onions for wintering. Learn and practice the proper method of root plantings. The geraniums should be planted in jars and cut back; ferns should be separated at the root and replanted.

Learn how to start ageratum, geraniums, coleus, sultana, and snapdragons by stem cuttings. Potting soil for these plants should be a mixture of half soil and half sand.

Planting leaf cuttings is interesting. A begonia leaf is placed on the sand and two or three toothpicks stuck through it into the sand. Roots should appear at these points. The leaf is then divided accordingly and each part repotted for growth. Try the experiment for yourself.

Lettuce seeds may be planted for study.

Wood peewees are leaving this week.

See note about Fire Prevention Week under October.

Fourth Week

Observe the earthworms.

Observe the weather factors and make weather forecasts.

Each month of the year your parks have some special display. This month is the month of colors. The Viburnums with colored foliage and berries are worth seeing. The plums are a special attraction and a likely place for birds.

Can you find any of these?

The Rose of Sharon	Clethra — Sweet Pepper
Evodia	Cornelian Cherry
Japanese Sophora	Cotoneaster — Fire Thorn
Clerendendrums	Sobaria

The following bulletins may be obtained free from the Department of Agriculture, Washington, D. C. Write for them.

No. 44, *Important Insecticides*
No. 359, *Canning Vegetables in the Home*
No. 637, *The Grasshopper Problem and Alfalfa Culture*
No. 660, *Weeds — How to Control Them*

House wrens are migrating. Golden-crowned kinglets have arrived. From where?

Plant seeds of calendulas, stocks, and snapdragons for spring flowering in the home or greenhouse.

OCTOBER

First Week

Sun rises at —— A.M. and sets at —— P.M.

A blackboard graph showing the time of sunrise and sunset from day to day will prove interesting.

Keeping a record of the length of the shadow of a post or pole at a certain time each day will provide data that you can use.

Is Saturn an "evening star"? (Consult an almanac.) What is an "evening star"? "morning star"?

Jupiter is an "evening star" until what date?

Venus is an "evening star" until what date?

Mars is a "morning star" until what date?

Locate and make a drawing of the "Big Dipper" and show its position at different hours.

Continue wind and temperature observations. Have your weather maps started to come?

Store the cabbage, beets, and carrots raised in your garden. Conduct the bulb sale.

Fire Prevention Week is next week. Plan a special project. Write the National Board of Fire Underwriters, New York City, for bulletins. Also write to your State Conservation Commission.

Observe color changes in leaves — maple, beech, etc. Explain. Do all trees drop their leaves?

Observe the fall migration of birds. How fast do birds fly? Find out what birds stay with you all winter. Juncos are coming from the north.

Second Week

Fire Prevention projects.

Seeding habits of plants should be studied.

Fall bird migration is now on (second and third weeks).

Swat the fly.

Make exhibits of objectionable weeds.

Continue wind and temperature observations and records.

Make a record of the date of the first killing frost.

Continue observation of planets. Saturn becomes a "morning star."

Locate the constellation Cassiopea. What is its position with respect to Ursa Major at a given hour?

Third Week

Observe the Milky Way. What is it?

Locate and observe the constellation Pegasus.

Find out how to locate the celestial prime meridian by means of the North Star, Cassiopea, and Pegasus.

Winter birds are here. Put out suet and grain for them.

Fourth Week

Feeding stations and window boxes should now be ready for birds.

Bulbs should be potted and set aside for the rest period. Hyacinth and narcissus bulbs should be obtained and potted for forcing. Place them out of doors or where they will be kept cold.

If hydrangea plants can be obtained, root planting may be made.

Green wood cuttings should be started from roses, forsythia, and hydrangeas.

Partridge berries may be obtained from the woods and put into glass jars with moss for winter decoration.

The parks are rich with fall colors. Your attention is called to the following:

Tupelo	Iron Wood
Oxydendrum	Mountain Maple
Red Maple	Acer Genata

Rats. — They are a real menace. See *How to Get Rid of Rats.* (Farmers Bulletin No. 1302, United States Department of Agriculture)

Bulletins

United States Department of Agriculture
- No. 77, *The Liming of Soils*
- No. 104, *Notes on Frost*
- No. 345, *Some Common Disinfectants*
- No. 679, *House Flies*

United States Department of the Interior
Technical Paper No. 127, *Hazards in Handling Gasoline*
United States Geological Survey
No. 418, *The Fire Tax and Waste of Structural Materials in the United States*
Board of Underwriters bulletins

NOVEMBER

First Week

Sun rises at —— A.M. and sets at —— P.M.

Observe time of moon's rising and setting for a few nights. Explain variation.

Orion is high in the southeast.

Wintergreen and partridge berries are waiting for Mr. Bobwhite.

Put out food for birds.

Gather winter vegetables from the garden. Store root crops.

Second Week

Shrikes have come from the north.

Pegasus is a prominent constellation in the southwestern sky.

When is the moon nearest the earth? When is the highest tide?

Be on the lookout evenings for "shooting stars." What are they?

Third Week

Is Mars a morning star?

It is not too late for outdoor bulb planting, if the ground is not frozen.

Observe the forms of clouds.

Learn to read a barometer.

Fourth Week

This is a good time to think of the robin, his whereabouts and activities.

Examine the sugar maple for branching and budding.

This project is recommended — A Study of Fertilizers, namely, sodium nitrate, acid phosphates, bone meal, and manure.

Pansy seeds should be started.

Seedling growths from September and October plantings should be transplanted.

Cuttings should be transplanted.

Diphtheria Antitoxin

From September Rochester Health Bulletin

What is diphtheria antitoxin? Diphtheria antitoxin is an artificial antitoxin produced for convenience in the body of the horse, because the horse is a big, clean animal. It is used to help patients to recover when they get diphtheria. It is only of value when used *very early* in the disease. It is of no use when used late in the disease.

The Schick test shows which children are susceptible, that is, which can take diphtheria. The test consists of one drop of a very dilute solution of diphtheria toxin put *into* the skin on the right forearm (a convenient place). The Schick test will show whether or not the child or adult has sufficient natural antitoxin of its own making in his body to protect him against diphtheria.

Diphtheria Vaccine

What is toxin-antitoxin vaccine? It is a mixture prepared from diphtheria bacilli and antitoxin. It is given in three doses injected into the arm about a week apart. The purpose of this vaccine is to stimulate the body to produce its own natural antitoxin. When the body has not enough natural antitoxin to protect it, diphtheria vaccine, or what is known as toxin-antitoxin mixture, given in this way will in more than 90 per cent of the cases protect the child or adult against diphtheria, and it will *always protect* the child against death from diphtheria.

DECEMBER

First Week

Sun rises at —— A.M. and sets at —— P.M.
Observe the morning and evening stars.
Observe the Big Dipper and the Pole Star.
Determine true north.
Find out how to tell time by the stars.
Keep the bird free-lunch counter well supplied.

Second Week

Take trips to commercial greenhouses.
Make more stem cuttings.
Identify four kinds of clouds. Do they indicate anything about the weather?

Third Week

The shortest day of the year is December 21. Explain.

Try to find a blue jay.

The nuthatches are hunting their food in the bark of trees. Do they work up or down the trunk and branches?

What wind direction occurs with cold spells?

Fourth Week

Make a Christmas Day bird census.

Easter lily bulbs should be started for forcing.

All potted narcissus bulbs should be brought into the conservatory to prevent freezing and a portion of the hyacinths should be brought in.

"Bedding Plants," namely, ageratum and geraniums, should be started.

Record the wind direction and velocity, the air temperature at 8 A.M. or 8 P.M., and the barometer reading on December 25.

When you get the weather map for December 25, make comparisons of your city with other cities.

JANUARY

First Week

Note from newspaper, almanac, or observations, the times of rising and setting of the sun one day each week.

Venus rises about what time? Is it visible just before daylight in the east? Is Venus a morning star?

Saturn rises at what time? Is it visible just before daylight? Is Saturn a morning star?

Jupiter sets about what time? Where is it visible after dark? Is Jupiter an evening star now?

Locate the constellation Ursa Major (Big Dipper) and the Polestar. Make a drawing of each and enter the time of your observation.

For several days observe the clouds at sunset. What form are they? Do you believe that a red sunset indicates a fair to-morrow?

Be sure to put out some food for the birds. (Farmers Bulletin 621, *How to Attract Birds in Northeastern United States*)

Sow onion and lettuce seeds under glass.

Second Week

Learn something about each of the three planets mentioned last week. What is the difference between a planet and a star?

Observe the position of Jupiter in relation to the nearby stars and make as accurate a drawing as possible of their positions. Preserve the paper in your Science Discovery Book. Always record the time and date of your observation.

Identify the constellation Cassiopea. What is its position with reference to Ursa Major and the Pole-star?

Observe and *record by drawing* the manner of branching of the sugar maple tree. Is it like other trees? Why do trees branch?

Find and identify tracks of squirrels, rabbits, and birds in the park, along streams, or in the woods, as you can.

Plan a trip to a greenhouse.

Prune fruit trees and vines.

Third Week

Identify the constellation Orion. What is its position with reference to Jupiter? Does it rise before or after Jupiter? Record by drawing the relative positions of the larger stars of this constellation. Be very accurate as to distances and directions.

Venus rises about what time?

Saturn rises about what time?

Observe and report the direction and velocity of winds.

Chickadees eat seeds of the hemlock. Try to locate some hemlock trees. How can you tell them from pines and spruces?

Bring in bulbs — narcissus, daffodil, jonquil.

Send for seed catalogs.

Fourth Week

Observe direction and velocity of winds.

Observe temperature and sky conditions at 8 A.M. each morning. Learn to read a hygrometer.

Have you seen a winter bird this month other than the English sparrow? Bobwhites, partridges, tree sparrows, chickadees, pheasants, downy woodpeckers, and crows may be seen.

Start verbena seeds.

FEBRUARY

First Week

The sun rises and sets at what hours? Compare with January 1.

Venus rises at what time? When and where is it visible?

Saturn sets at about what hour? When and where is it visible?

Jupiter sets at what hour? In what part of the sky is it visible and at what hour?

Make and record weather observations every day. Observations should be made at 8 A.M. Record temperature, wind direction and velocity, condition of sky, precipitation, air pressure, humidity.

By means of weather maps trace the path of a storm (low-pressure area) across the United States. Note the position of "highs" with reference to the "lows."

Each day determine the temperature and humidity of the school room. Record in a notebook. Appoint class Health officers.

Does the northern shrike stay with you in winter?

Test some of your garden seeds to find what per cent of them will germinate (grow).

Second Week

Identify the constellation Andromeda. What is its position with reference to Orion? About what time does it rise? Draw the brighter stars as you did for Orion.

Again observe the relative position of Jupiter to the nearby stars and make an accurate drawing as you did before. Compare with the drawing which you made the second week in January. Is the latter drawing a better piece of work?

Remember the birds. Try to find and identify a "winter resident." Tie suet to the trees.

A bayberry bush supplies food for the birds.

Sow annual seeds in flats: phlox, larkspur, calendulas, stocks, snapdragons.

Sow bedding plant seeds: petunias, salvias.

Third Week

Study the weather map and determine the temperature in the lower California region, Florida, Washington, and your home.

Explain differences.

Observe different kinds of clouds. Do they indicate the kind of weather to be expected?

Plan nesting boxes for birds. (Farmers Bulletin 609, *Bird Houses and How to Build Them*)

White-breasted nuthatches hunt for insect eggs in the bark of trees. Goldfinches feed on red cedar berries.

Bring in bulbs: tulip, hyacinth, crocus. Keep dark and cool until they begin to show green.

Fourth Week

Make nest boxes.

Find and study another winter resident other than the English sparrow.

Be on the lookout for the first song sparrow, robin, and bluebird. (Farmers Bulletin 630, *Common Birds Useful to the Farmer*)

MARCH

First Week

The sun rises and sets at what hours? Compare with January and February. Why do the times change?

Continue observation and study of the planets Venus, Saturn, and Jupiter.

Continue weather observations and records.

Complete nest boxes and place them ready for the birds.

Have you heard the song sparrow yet?

Observe the English sparrow: size, shape, size and shape of beak, what he eats, and how his beak is adapted to his food.

Plant seeds of more annuals.

Plant radish and tomato seeds under glass.

Second Week

Plan and make bird baths and drinking places. (Farmers Bulletin 621)

The English sparrow. — Observe the number of toes on each foot. Are they all alike? Why? What are they for? Does the sparrow walk or hop? How long are its wings compared to the length of the body? Does it cross its wings over its back? Is the tail long or short, forked or straight across the end?

Song sparrow and purple grackle may be seen.

Sow seeds in boxes for early transplanting: peppers, celery, cabbage, and melons.

The spring equinox occurs March 21. Explain.

Transplant seedlings grown from last month.

Prepare hotbeds.

Third Week

Place the bird baths. Keep them supplied with clean water.

The English sparrow. — Study the markings on the breast, shoulders, wings, tail. What is the significance of these markings? Are all the English sparrows marked alike? Study its disposition. Does it "play fair"? Of what value is the English sparrow? What objections are there to the spread and increase of the English sparrow? (Farmers Bulletin 493, *The English Sparrow as a Pest*)

Pussy willows are beginning to blossom in the latitude of New York State.

Red-wing blackbirds are singing in the marshes. Has the female arrived yet?

Prairie horned-lark nest and eggs can now be found in open fields on the ground in the north.

Study the relation of the earth to the sun on March 21. Make your garden plan.

Fourth Week

Is the house ready for the bluebird?

The vesper sparrow may come this week.

Chickadees are about.

Burn apple-tree tent caterpillar nests in early evening. The caterpillar returns to its nest at night.

Seeds for the garden should be obtained and tested for per cent of germination. Make rose cuttings.

Make outside plantings of beans, onions, radishes, beets, carrots, and peas if spring is advanced.

Prune apple, pear, and plum trees.

Begin making plans for Arbor Day.

APRIL

First Week

The sun rises and sets at what hours? Compare with previous observations.

Continue observation and study of planets. Learn the distance and sizes of Venus, Saturn, and Jupiter.

Observe tip ends of twigs. Note color changes from now on.

Observe tree buds for shape, size, color, kind. Where are the buds located — at ends or side of twigs? What relation has this fact to pruning?

Look for the first robin. Which comes first, male or female? Why?

Look for the first bluebird. What do these birds eat? Is there plenty?

Look for the first chipping sparrow and flicker.

Begin making plans for Bird Day.

Cats. — Have all stray cats taken away by the Humane Society. Cats destroy about 3,000,000 song birds a year in New York State. Put bells on house cats. Keep them shut up early mornings and evenings.

Tie cotton, gunny sacks, or sticky fly paper around the trunks of trees to prevent spread of the white-marked tussock moth.

Harden off seedlings by exposing them to cool air for gradually increasing periods.

Second Week

Are the robins starting their nests? Put out mud and short lengths of string or yarn to help them. Worry the sparrow away from sites chosen by the robins.

Of what value are the robin and the bluebird?

Hunt for stray flies and destroy them. Why? How do flies distribute disease? What can be done to prevent increase of flies? (Farmers Bulletin 679, *House Flies*) See Board of Health and Chamber of Commerce bulletins.

Hermit thrush may come back this week.

Woodpeckers, partridges, and crows are here.

Red maples are blossoming. Shadbush is in flower. (Latitude of New York)

Sow asters, zinnias, calendulas, cosmos, verbenas, and snapdragons.

Third Week

Oil put on the surface of pools of standing water will save many a person a mosquito bite. (Farmers Bulletins 444 and 547)

Remove old cans and similar containers that may become breeding places for the mosquito.

Swat the fly.

Put out the nest box for the house wren. Be sure to have the proper size hole in the box. It will keep out other birds.

Hunt for fire risks and remove them.

Mercury may be seen soon after sunset low in the west, if your eyes are sharp.

Hepaticas are in bloom in the woods. Protect the wild flowers.

Young gray squirrels are born this month.

Air and water your cold frames.

Be on the lookout for plant lice.

Set seedlings out-of-doors.

Fourth Week

More birds are arriving from the south. Hunt for them and make a list of all you identify with certainty. You may find the following: myrtle warbler, towhee, house wren, brown thrasher, black and white warbler, yellow warbler, veery, and others. (See page 42, Cornell Rural School Leaflet, Vol. X)

Pull up weeds.

Make window boxes and hanging baskets.

MAY

First Week

Compare the times of rising and setting of the sun with those of previous months.

Follow the courses of the planets.

This week bird migration is at its height. Make the most of it.

Scarlet tanagers are looking after your orchards.

Fern buds are unfolding.

Arbutus is in bloom. Do not destroy its roots. It is protected by law in some states.

Keep after the weeds.

Divide old ferns. Start young ferns for fall.

Keep on planting, transplanting, and sowing until garden space is filled.

Second Week

Search the woods for hepaticas, spring beauties, etc. Be very careful not to pull up any roots of the wild flowers; they are easily exterminated.

Why are the lilac blossoms more fragrant during the night than during the day?

Chipmunks are born this month.

Have humming birds come to protect your vines?

Plant beans, peas, corn, and potatoes.

Transplant tomato seedlings.

Third Week

What new wild flower have you found?

Burn more caterpillar nests.

Rose-breasted grosbeaks arrive.

Horse-chestnut trees are in bloom.

Observe the habits of earthworms.

Fourth Week

Violets are blossoming in the meadows and woods.

Baby robins leave their nests. *Watch the cat.*

JUNE

First Week

Mother robin is feeding her babies. *Watch the cat.*

The wild roses of June are in blossom.

Plant lice, if on the tender new growth of rose bushes, should be sprayed.

Cultivate the garden to keep down the weeds and preserve the water and air in the soil.

Plant a second crop of beans and similar vegetables.

Plant melon seeds.

Second Week

Kingfisher may be laying her eggs.

Barn swallows are nesting.

Pheasants are nesting in the fields.

Third Week

June 21 — summer solstice. What does it mean?

Promethea moths come out of cocoon.

Lady slippers are in bloom in the swamps. Conserve them.

Wood thrush babies are ready to leave their nest.

Fourth Week

Water lilies blossom in ponds. What makes them float?

Orioles are building nests. In what part of the trees?

TABLE OF RELATIVE HUMIDITY IN PER CENT

Locate the dry-bulb temperature in the column at the left marked *t*. Opposite this, in the column headed by the number of degrees difference in temperature between your wet- and dry-bulb readings, you will find the number of per cent of humidity.

t	Difference between the Dry- and Wet-Bulb Thermometers																
	1°	**2°**	**3°**	**4°**	**5°**	**6°**	**7°**	**8°**	**9°**	**10°**	**11°**	**12°**	**13°**	**14°**	**15°**	**16°**	
55	94	88	82	76	70	65	59	54	49	43	39	34	29	24	19	15	**55**
56	94	88	82	77	71	65	60	55	50	44	40	35	30	25	21	16	**56**
57	94	88	83	77	71	66	61	55	50	45	40	36	32	27	22	18	**57**
58	94	89	83	78	72	67	61	56	51	46	42	37	33	28	24	19	**58**
59	94	89	83	78	72	67	62	57	52	47	43	38	34	29	25	21	**59**
60	94	89	84	78	73	68	63	58	53	48	44	39	34	30	26	22	**60**
61	94	89	84	78	73	68	63	58	54	49	44	40	35	32	27	23	**61**
62	95	89	84	79	74	69	64	59	54	50	45	41	37	32	28	24	**62**
63	95	89	84	79	74	69	64	60	55	51	46	42	38	33	29	26	**63**
64	95	90	85	79	74	70	65	60	56	51	47	43	38	34	30	27	**64**
65	95	90	85	80	75	70	65	61	56	52	48	44	39	35	31	28	**65**
66	95	90	85	80	75	71	66	61	57	53	49	45	40	36	32	29	**66**
67	95	90	85	80	76	71	66	62	58	53	49	45	41	37	33	30	**67**
68	95	90	85	81	76	71	67	63	58	54	50	46	42	38	34	31	**68**
69	95	90	86	81	76	72	67	63	59	55	51	47	43	39	35	32	**69**
70	95	90	86	81	77	72	68	64	60	55	52	48	44	40	36	33	**70**
71	95	91	86	81	77	72	68	64	60	56	52	48	45	41	37	34	**71**
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	35	**72**
73	95	91	86	82	78	73	69	65	61	57	53	50	46	42	39	35	**73**
74	95	91	86	82	78	74	70	66	62	58	54	50	47	43	40	36	**74**
75	95	91	87	82	78	74	70	66	62	58	55	51	47	44	40	37	**75**
76	95	91	87	82	78	74	70	66	63	59	55	52	48	45	41	38	**76**
77	95	91	87	83	78	74	71	67	63	59	56	52	49	45	42	39	**77**
78	96	91	87	83	79	75	71	67	63	60	56	53	49	46	43	39	**78**
79	96	91	87	83	79	75	71	68	64	60	57	53	50	47	43	40	**79**

THE PLANETS

The planets in order of distance from the sun are Mercury, Venus, Earth, Jupiter, Saturn, Uranus, Neptune, Pluto.

TO GET BETTER ACQUAINTED WITH ROCKS AND MINERALS

So many of you girls and boys have started collections of rocks and minerals that the following information is given to help you identify some of the more common varieties. Careful observation of the properties of your specimen and comparison with the properties given in the table should enable you to find out for yourself the name of your sample. For meanings of new words, see the Glossary in your book.

Rocks[1]

Rocks are often more difficult to identify than minerals, because almost every piece of rock may be a mixture of two or more kinds. For example, a sample of limestone may contain enough clay to make it fail to fizz when acid is added. However, you will be able in most cases to identify the rock as belonging to one of the following varieties:

Igneous Rocks:

Granite. Coarse-grained, contains quartz, feldspar, and mica or hornblende. Where broken, the "faces" sparkle; colors vary.

Variation in the amounts of mica, hornblende, and quartz gives rise to several varieties of igneous rocks, more or less resembling granite.

Lava. Any material from volcanoes.

Basalt. Black, fine-grained.

Glassy rocks. Obsidian is black and glassy; breaks with sharp edges, conchoidal fracture.

[1] For more detail about rocks and minerals, see *Getting Acquainted with Minerals*, George L. English, McGraw-Hill Book Co.; *Tables for Determination of Common Minerals*, W. O. Crosby.

Pumice (gray) is similar to obsidian except that it is very cellular. Because of its cellular structure, it is light and will float in water.

Sedimentary Rocks:

Formed from sediments deposited in the ocean. Hardened by pressure, heat, and cementing materials.

Sandstone. Grains of sand cemented with lime or iron oxides or silica (quartz).

Shale. A common clay rock. Clay is weathered feldspar. Because shale contains a lot of tiny flakes of mica or other flat particles, it can be split into sheets, which are easily broken.

Limestone. Formed from carbonate of lime ($CaCO_3$) taken from sea water by minute living organisms to make their "bony" structure. From the dead animals this material "rains" to the bottom of the ocean, forming layers of lime mud which later harden by pressure. Limestones usually contain fossils.

Chalk consists partly of the actual "shells" of the lime-secreting animals (foraminifera).

Dolomite limestone is a mixture of calcium and magnesium carbonates. It is not affected very much by cold HCl, but is dissolved by hot HCl.

Travertine, limestone deposited by water; called tufa when deposited by hot springs, stalactites and stalagmites when formed in caves.

Impure limestone may contain clay or sand.

Marl, an earthy deposit of limestone and clay.

Conglomerate. Composed of rounded particles of any kind of rock, cemented in a mass by clay or lime.

Breccia is a conglomerate in which the rock fragments are angular, not rounded.

Metamorphic Rocks:

Rocks altered by heat, pressure, and chemical action are called metamorphic rocks.

	Original		Metamorphic
A.	Igneous		
	Granite	forms	Gneiss
	Basalt	forms	Hornblende

B. Sedimentary

Limestone	forms	Marble
Sandstone	forms	Quartzite
Shale	forms	Slate

How to Tell the Common Minerals[1]

Minerals as a rule are much more simple substances than rocks, because when a substance forms in a crystal shape, it is likely to be a fairly pure material. You have made crystals of sugar from a sugar solution, and know the sugar crystals are always the same general shape. This is true also of salt crystals made by allowing a solution of salt to evaporate to dryness. So we may think of minerals being formed as crystals by similar processes. Sometimes the crystallized mineral forms from a hot or cold water solution, and sometimes from a melted rock material.

To learn the name of a mineral, it is necessary to make certain systematic observations to determine its properties, such as color, appearance, shape of crystal, hardness, and occasionally certain other properties. The Key or plan that follows is arranged by steps. Each "step" suggests a property to be discovered. As you discover each property, you should write it down. Then by reference to the charts you should be able to find the name of your mineral. You will have fun identifying minerals as soon as you learn how to use the Key.

Steps to Follow for Each Mineral:

A. Has it a metallic or non-metallic luster? Glossy (vitreous) or earthy (dull) appearance?

B. Note the color of the mineral and color of the streak. The streak is determined by scratching the mineral on white unglazed porcelain.

C. Determine the hardness of the mineral:

Very soft (*VS*) (*less than 2.5*). Can be scratched with the thumbnail.

Soft (*S*) (*2.5 to 3.5*). Can be scratched with a penny, but not with the thumbnail.

Hard (*H*) (*3.5 to 5.5*). Can be scratched with a steel knife or nail, but not with a penny.

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[1] See footnote on page 24.

Very hard (*VH*) (*above 5.5*). Cannot be scratched with a steel knife.

NOTE: Ordinary window glass is about 6 in hardness and can be scratched with a piece of quartz (or flint). Quartz is 7 in hardness.

NOTE: In testing for hardness, try always to work on a smooth surface. Do not mistake crumbling or brittleness for hardness.

Following are minerals representing the scale of hardness:

1. talc	3. calcite	5. apatite	7. quartz	9. corundum
2. selenite	4. fluorite	6. feldspar	8. topaz	10. diamond

Hardness of Some Common Substances

Read this table by reference to the one above. For example, *iron* has a hardness that varies between that of *fluorite* and that of *apatite*. Gold has a fixed hardness; it is half a unit harder than gypsum.

Coal	2.5	Iron	4–5
Common salt	2.5	Iron ore (hematite)	4.5
Emery	7–9	Lead ore (galenite)	2.5
Garnet	6.5–7.5	Mica	2–3
Gold	2.5	Pyrite (fool's gold)	6.
Graphite	1–2	Silver	2.5–3

D. Specific gravity: Specific gravity is determined by weighing sample, first hanging in air, and then hanging in water. Subtract the "weight in water" from the "weight in air." Then divide the weight in air (the first weight) by the difference. This number will be the specific gravity. It means that the mineral is that many times heavier (or lighter) than water. For example, suppose a piece of mineral weighs:

In air	25.7
In water	15.9
Difference	9.8

$25.7 \div 9.8 = 2.6 +$ specific gravity of the mineral.

The mineral is 2.6 times heavier than water. In most cases of common minerals, this need not be done accurately, but the weight of a given mineral may be compared to the weight of a known sample by "hefting" it. Using equal-sized pieces, the following may be used for comparison:

Mineral	Specific Gravity
Gypsum	2.3
Rock salt	2.5
Quartz	2.65
Talc	2.8
Pyrite (fool's gold)	5.0
Hematite (iron ore)	5.2
Iron (metal)	7.5
Sandstone	2.3

E. Crystal — shape: All minerals under certain conditions may exhibit specific crystal forms. Each mineral has its own form.

There are six fundamental crystal forms, depending upon the lengths and arrangement of the axes.

The cube, for example, has its three axes *all equal* and *at right angles* to each other. Many crystals exhibit this characteristic, although the crystal may have its corners "cut" off, forming octahedrons, dodecahedrons, etc.

A rectangular prism may have its three axes *all different lengths* but *all at right angles.*

Crystal forms may be identified as follows:

I. Isometric (three equal axes, right angles)
II. Tetragonal (three axes, right angles, one axis longer or shorter than the other two, which are equal)
III. Orthorhombic (three axes, right angles, all different lengths)
IV. Monoclinic (three axes, axes unequal, two at right angles and third at an oblique angle)
V. Triclinic (three axes, axes unequal, no right angles)
VI. Hexagonal (four axes, three are equal and horizontal, fourth is perpendicular to the other three and longer or shorter than three)

These six fundamental crystal shapes listed on the previous page are observed in spite of the fact that they may occur as variations by virtue of the fact that "corners" are "cut" off. For example, the six-sided "cube" may become an eight-sided "octahedron" if six corners of the cube are cut off.

NOTE: Cut a cube out of a potato and then slice off the corners equally and you have an octahedron. Try cutting out other shapes of crystals.

Likewise, each fundamental shape gives rise to many varieties. Quartz, for example, which crystallizes in the hexagonal form (VI, six-sided), may be pointed as a six-sided prism or a three-sided prism.

F. Tenacity — that property of matter described by such terms as brittle, elastic, sectile (can be cut), earthy, malleable (can be hammered into sheets), ductile (can be drawn into wire).

G. Cleavage. This is a tendency that certain minerals have to break or split along certain lines. For example, mica splits into leaves or sheets.

H. Fracture. This is a break that does not occur along definite lines. Flint "fractures" in such a way as to leave concave surfaces. This makes it possible to chip flint, making arrow-heads with sharp edges. Obsidian also exhibits this same kind of fracture, called "conchoidal" fracture.

I. Determination of specific gravity, application of chemical tests, etc., are only necessary to differentiate similar minerals.

J. Having closely observed as many of the properties of the mineral as possible, refer to the Key that follows on the next page.

MINERAL KEY

With Metallic Luster

Color	Streak	Hardness	Mineral	Tenacity	G	Form	Cleavage	Other Properties
Black		VS	Graphite	Sectile	2.2	Foliated	Perfect	Greasy
Lead-gray		S	Galena	Brittle	7.4	Cubes	Perfect cube	
Brass-yellow	Green-black	H	Chalcopyrite	Brittle	4.1–4.3		Uneven	Tarnish
Yellow	Brown, green, black	VH	Pyrite	Brittle	4.8–5.2	Cubes	Uneven	
Bronze-yellow	Gray-black	VH	Marcasite	Brittle	4.9	Globular	Prismatic	

Without Metallic Luster

Color	Streak	Hardness	Mineral	Tenacity	G	Form	Cleavage	Other Properties
Red-brown	Same	VS	Kaolinite	Earthy	2.6	III, clayey	Earthy	
Red-orange	Same	VS	Realgar	Brittle	3.5	IV, massive		Transparent to translucent
Bright red	Scarlet	VS	Cinnabar	Sectile	8.2	VI, massive	Uneven	
Red to orange	Orange	S	Zincite	Brittle	5.5	VI		
Dark brown–yellow	Yellow	S	Limonite	Brittle	3.6–4			
Gray to brown	Same	S	Siderite	Brittle	3.8	VI	Rhombohedral	Fizzes with HCl
Brown-black	Yellow-brown	S	Sphalerite	Brittle	3.9	I	Dodecahedral	
Red, steel gray	Red	S	Hematite	Brittle	5.3	VI	Scaly	

Without Metallic Luster (Continued)

Color	Streak	Hardness	Mineral	Tenacity	G	Form	Cleavage	Other Properties
Yellow	Yellow	VS	Orpiment	Sectile	3.5	III		
Brown-yellow	Yellow	VH	Quartz (jasper)	Brittle	2.6	VI, compact		
Brown-black	Same	VS	Asphaltum	Brittle, sectile	1–1.8	Amorphous	Conchoidal	Will burn
Green	Pale green	S	Malachite	Brittle	4	Fibrous, earthy		
Blue	Pale blue	H	Azurite	Brittle	3.8	IV, massive		
Black to green	White	VS	Biotite (mica)	Elastic, sectile	2.7	IV, foliated	Basal, perfect	Micaceous
Yellow-brown	White	VS	Phlogopite (mica)	Elastic, sectile	2.8	IV, foliated	Basal, perfect	Micaceous
Colorless to gray	White	VS	Muscovite (mica)	Elastic, sectile	2.75	IV, foliated	Basal, perfect	Micaceous
White-gray	White	VS	Gypsum	Sectile	2.3	IV, foliated	Perfect	Transparent
Green to white	White	VS	Talc	Sectile	2.7	Foliated		Greasy feeling
White	White	VS	Calcite (chalk)	Earthy	2.6	VI, compact	Earthy	Fizzes with HCl
White	White	S	Calcite	Brittle	2.7	VI	Rhombohedral	Transparent, double refraction, fizzes with HCl
White to gray	White	S	Aragonite	Brittle	3	III		Transparent to translucent Fizzes with HCl
White to gray	White	S	Dolomite	Brittle	2.9	VI	Rhombohedral	Fizzes in hot HCl
Green to blue	White	S	Fluorite	Brittle	3.2	I, cubes	Octahedral	

Without Metallic Luster (Continued)

Color	Streak	Hardness	Mineral	Tenacity	G	Form	Cleavage	Other Properties
Gray-green	White-gray	H	Smithsonite	Brittle	4.4	VI	Rhombohedral	Fizzes with HCl
Green, brown to yellow	White	H	Apatite	Brittle	3.2	VI, prisms		
Various colors	White	H	Opal	Brittle	1.9–2.3	Amorphous	None	Pearly
Colorless, purple, smoky		VH(7)	Quartz	Brittle	2.65	VI, prisms	Conchoidal fracture	Transparent to opaque
Blue	White	VH(6)	Turquoise	Brittle	2.8	Amorphous	Conchoidal fracture	
Black	White	VH (6)	Obsidian	Brittle	2.2–2.8	Amorphous (glassy)	Conchoidal fracture	Pearly
White-green	White	VH (5, 6)	Orthoclase (feldspar)	Brittle	2.5–2.6	IV, V		Translucent
Purple, yellow brown	White	VH (7)	Quartz (amethyst)	Brittle	2.65	VI		Transparent, opaque
White-gray, red, brown	White	VH (7)	Quartz (chalcedony)	Brittle	2.65	VI	Conchoidal	Waxy, translucent
Banded colors	White		Quartz (agate) (onyx)	Brittle	2.65	VI	Conchoidal	Waxy, translucent
Gray-brown, black	White	VH (7)	Quartz (flint)	Brittle	2.65	VI	Conchoidal	
Red-brown	White to gray	VH (6.5)	Garnet	Brittle	3.2–4.3	Irregular I, dodecahedrons		

BENEDICT'S SOLUTION

Dissolve 85 grams of sodium citrate and 50 grams of anhydrous sodium carbonate in 400 cubic centimeters of water.

Dissolve 8.5 grams of cupric sulfate in 50 cc. of hot water.

Now add the 50 cc. hot solution of cupric sulfate to the citrate carbonate solution slowly, stirring constantly. Filter if necessary.

To make the test for sugar in solution, add 8 drops of the sugar solution to be tested to 5 cc. of the reagent in a test tube. Boil for two minutes. Presence of sugar is shown by the formation of a brick-red precipitate.

FEHLING'S SOLUTION

Fehling's solution is best made up in two solutions, A and B, which are kept separate until used.

Solution A. — Dissolve 34.6 grams of finely ground copper sulfate in 500 cc. of water. Heating and stirring will hasten the solution.

Solution B. — Dissolve 125 grams of potassium hydrate and 173 grams of sodium potassium tartrate (Rochelle salts) in water making up to 500 cc.

To test for sugar, equal quantities of A and B are mixed, heated to boiling, and an equal or smaller quantity of the solution to be tested for sugar is added and the solution boiled for two to three minutes. A brick-red precipitate shows the presence of sugar.

NOTE

Benedict's solution is permanent. Fehling's solution is permanent until the solutions A and B are mixed. It must then be used promptly.

These reagents test for simple sugars only. Some fruits and some vegetables contain sucrose or cane sugar, which is not shown by these solutions unless it is first converted into the simple sugar. This may be done by boiling a solution for a few minutes, after adding two or three drops of an acid.

FOODSTUFFS

What They Do in the Body — Where Vitamins Are Found

1. Carbohydrates — give heat or energy.
   a. starch
   b. sugar
   c. cellulose
2. Fats — give heat or energy.
3. Proteins — build the body; give heat or energy.
4. Mineral matter or ash — builds the body; regulates body processes.
5. Water — regulates body processes.
6. Vitamins:

Vitamin A

Found in whole milk, dairy products, egg yolk, green-leaf vegetables, carrots, sweet potatoes, liver, and cod-liver oil.

Helps (*a*) to make us grow;
(*b*) to resist disease, especially infections of the eyes, nose, and throat;
(*c*) in reproduction.

Vitamin B

Found in root and leaf vegetables, whole grains, dried seeds, fruits, nuts, and milk.

Helps to (*a*) make us grow;
(*b*) give us an appetite;
(*c*) resist disease, especially a disease of the nerves called beri-beri.

Vitamin C

Found in fresh fruits, especially citrus fruits, tomatoes and raw cabbage and turnips.

Helps to (*a*) prevent scurvy, a disease affecting the blood vessels, skin, gums, and teeth;
(*b*) prevent defective teeth.

Vitamin D

Found in cod-liver oil, liver, egg yolk, and dairy foods.
Helps (*a*) to prevent rickets, a common children's disease, affecting the bones and all parts of the body;
(*b*) probably, to prevent decay of teeth.

Vitamin E

Found in wheat grain, green lettuce, and meat.
Helps in reproduction.

NOTE: Recent investigations indicate that *vitamin B is not a single vitamin*, but *contains at least two independent vitamins.* Different terms are used to distinguish between the two vitamins. The terms *vitamin F* and *vitamin* G are thought by some authorities to be the least confusing. It is believed that neither vitamin F nor vitamin G makes us grow in the absence of the other. Available reports show the following about vitamins F and G.

Vitamin F

Found in whole wheat and other seeds.
Helps to resist a disease of the nerves called beri-beri.

Vitamin G (*B_2*)

Found in green leaves, cow's milk, and bananas.
Helps (probably) to prevent a disease called pellagra, affecting the skin and other parts of the body.

TABLE OF VITAMINS

	A	B	F	G	C	D	E
Fruits							
Apples	*	**			**		
Oranges	*	**			***		
Pineapple	**	**			***		
Cereals							
Wheat germ			***	***			***
White bread	—	*			—	—	
Whole wheat, rye, etc.	*	**	*				*
Vegetables, fresh							
Tomatoes	**	***		*	***	*	
Lettuce	**	**			***	*	*
Carrots	**	*			*		
Spinach	***	***			***	—	
Potato, boiled	*	**	*		**		
Cabbage, cooked	**	**			*		
raw	**	***			***		
Peas	**	**			***	*	
Animal products							
Fish-liver oils	***					***	
Lean meat				***			
Liver	**	**	**		*	**	*
Heart	*	*	**		*	*	
Egg yolk	***	*			—	*	
Milk	***	**			**	**	*
Cheese	*			**		*	
Beans, dry			***	*			
Nuts			***				
Yeast			***	***			

The stars (*) indicate the relative value of the food as a vitamin source. Three stars, excellent, two stars, good source, one star, fair source of vitamin.

PEDOGRAPH PRINTS AND ANGLES[1]

Footprints for showing foot conditions and measurements of defects in the position of the longitudinal arch may be made with a Pedograph.[2]

The Pedograph consists of a frame, on which can be placed a sheet of paper for the record and an inked sheet of rubber. To make the footprint the sheet of rubber, inked on the under-side with printer's ink, is placed on the sheet of paper. The pupil, walking naturally, steps on the rubber sheet, causing an impression on the paper.

The footprints indicate various characteristics of the longitudinal arch and its position. For accurate comparison purposes, an angular measurement is made as follows:

With a ruler draw a line along the inner arch of the foot tangent to the heel and to the ball of the great toe. Draw a second line, intersecting this one, tangent to the front edge of the longitudinal arch. The angle between these two lines is measured with a protractor and noted on the print.

A narrow angle, other things being equal, indicates a flat foot, while a wider angle indicates a better condition. For a flat foot the angle may be as small as 17°, while a high-arched foot may show an angle of 36°.

Improvements in the condition of the longitudinal arch, as a result of remedial exercises, is indicated by increase in this angle.

Pupils with defects in foot conditions which do not improve as a result of remedial measures should consult their physician.

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[1] Courtesy of the Health Education Department, Rochester Public Schools.

[2] Manufactured by the School Manufacturing Company of Philadelphia, Pennsylvania.

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GLOSSARY

Scientists must be exact, not only in measuring but in speaking and writing; therefore it is important for science pupils to use words in their correct scientific meaning. Often the same word is used in different connections with slightly different meanings. If you look up the word "cloud" in a large dictionary, you will discover that it has several meanings only one of which applies to science. In using a large dictionary, therefore, you must be careful to choose the meaning of a word as it relates to the subject in which you are interested.

It is important also for you to know the correct pronunciation of every word you use. One evidence of good culture is the correct choice and pronunciation of words.

In this glossary the words are defined in their science meaning only. Use them accurately.

For references, see Index.

absorb — to take in; as a blotter takes in ink, or as soil takes in water.

acid — a substance (usually a solution) having a sour taste, and which will turn blue litmus pink and dissolve some metals.

adaptation — fitness to live under certain conditions or fitness to do a certain thing.

adenoids — growths in the upper back part of the throat.

air — mixture of gases which we breathe.

air (atmospheric) pressure — force of the air pressing against objects, due to its weight.

air sacs (in lungs) — very small divisions of the lungs with extremely thin walls through which the exchange of gases takes place.

alcohol — a substance which, if taken as a beverage, acts as a narcotic poison to the body. It is used as fuel and in medicine.

alkali — a soluble substance that tastes bitter and that turns pink litmus blue.

alluvial soil — river-deposited soil.

apparatus — materials such as cup, spoon, beaker, test tube, ring stand, Bunsen burner, used for performing experiments.

aquarium — a tank of water suited to the life of fishes or other water creatures.

artificial — an imitation of nature made by man.

asbestos — a mineral substance used in a manufactured form for insulating purposes (or as a protection against fire).

atmosphere — the gases surrounding the earth. (See *air*.)

bacteria — plants too small to be seen with the naked eye; one-celled plants.

baking soda — sodium bicarbonate ($NaHCO_3$); a white powder used in baking, and in fire extinguishers.

bark — the outer covering of a stem.

barometer — an instrument which measures changes in atmospheric pressure.

beaker — a straight-sided, lipped, glass cup used in the laboratory.

bed rock — rock in place where originally formed.

boiling point — the fixed temperature to which a liquid must be heated to cause it to change rapidly to a gas.

breathing — the action of inhaling and exhaling air.

breccia — a mass of broken rock material cemented into a hard mass.

Bunsen burner — a device for burning gas so that soot will not deposit on dishes that are heated.

burn — to be oxidized rapidly, giving off waste gases, heat, and light.

by-product — a useful substance obtained as an "extra" when manufacturing any substance.

canyon — a deep, narrow valley formed by stream erosion; a gorge. (See *gorge*.)

capillary attraction — the lifting of liquids within or through small tubes.

carbon — an element usually occurring in combustible substances; when free, it occurs as charcoal, coal, graphite, soot, or diamond.

carbon dioxide (CO_2) — an odorless, colorless gas which is a product of combustion and of respiration; makes up a very small part of the air.

carbon monoxide (CO) — an extremely poisonous gas resulting from the incomplete combustion of carbon in the fuel.

carbon tetrachloride — a volatile, non-combustible liquid useful for putting out small fires and for cleaning purposes (CCl_4).

carbonic acid — formed when carbon dioxide unites with water ($H_2O + CO_2 = H_2CO_3$).

cell — the microscopic unit of structure of all living things.

cellular — made up of little cells.

cement — a substance which holds other substances firmly together.

characteristics — those qualities or properties by which anything is recognized.

charcoal — a form of carbon obtained from wood, bones, and oil by partial burning.

chemical change — a change which results in the formation of a new substance.

chest cavity — the upper division of the body cavity containing the heart and lungs.

circulation (of air) — movement of air from place to place.

clamp — a piece of apparatus used to hold objects in position.

clay — soil composed of very finely divided particles of feldspar which becomes sticky when wet and either hard or powdery when dry.

cliff — a high bank, steep rock, or rock layers.

clouds — masses floating in the atmosphere consisting chiefly of condensed water vapor.

cocoon — nest-like covering in which a larva rests while changing its form.

coke — a form of carbon left after coal gas is made from coal.

combine — to unite, forming a compound.

combustion — rapid oxidation, forming heat and light.

combustion, spontaneous — rapid oxidation started because of slow oxidation and confined heat.

composition — the materials of which anything is made.

compound — a substance composed of two or more elements combined, *e.g.*, water, sugar, salt.

conchoidal — having a hollowed out or concave depression.

concrete — a mass of sand, gravel, etc., held together by cement; used for sidewalks, pavements, etc.

condensation — the process by which a gas is changed to the liquid form.

conglomerate — a kind of rock made of several varieties of stones cemented together in a hard mass.

conservation — the wise and careful use of natural riches.

continent — a large body of land.
contract — to draw together; to occupy less space.
crop rotation — the practice of planting three or four different crops in turn, one year each on the same piece of land, to enrich and improve the soil.
crown (*of a tree*) — its branches and leaves.
crystal — a mineral substance which nature has formed in a regular shape.
cultivate — to work the soil; to stir the soil.
cycle. (See *water*.)
dam — a wall built across a stream behind which water is stored.
damper — the part of a stove or furnace used to regulate the flow of air through the fire.
decay (*of plant and animal tissue*) — a form of slow oxidation.
decay (*of rock*) — to rot; to break up or fall apart.
decomposition — breaking up by some form of decay or chemical action.
delta — land built of sediment deposited at the mouth of a river.
deposit — to drop; as a noun, material that has been dropped or allowed to settle.
digestion — to make soluble.
dilute — a solution containing a large proportion of water or other solvent. (Lemonade is dilute lemon juice sweetened with sugar.)
dissolve — to cause a substance to be equally distributed throughout a liquid so that it will not settle, and cannot be filtered out; *e.g.*, sugar or salt dissolved in water.
distillation — the process of separating liquids and solids by means of heat.
divide — a height of land separating two or more water drainage systems.
dolomite — a variety of limestone containing both calcium and magnesium carbonate.
earthquake — a trembling of a portion of the earth's crust due to slipping of rock strata.
effervescence. (See *foaming*.)
electricity — a form of energy used to light lamps, run motors, etc.
element — a simple substance, *e.g.*, iron, oxygen.
energy — the capacity to do work; it exists as heat, light, electricity, and mechanical and chemical energy.

erosion — wearing away of rocks and soil.
ether — a colorless, highly inflammable and volatile liquid, having a characteristic odor.
evaporation — the change from liquid to gas; the process by which a liquid is changed to a gas.
exhale — to breathe out.
expansion — the process of enlarging anything in volume or size.
experiment (verb) — to use materials in such a way as to solve a problem or test the correctness of an idea.
explosion — any sudden release of confined pressure.
feldspar — a mineral having smooth, shiny surfaces at angles (not right angles) to each other.
fertilize — to enrich the soil; to make productive.
filter — to strain out undissolved matter from a liquid.
fire-extinguisher — an implement containing a substance which will put out a fire.
foamite — an extinguisher which produces a pasty mass containing bubbles of carbon dioxide (CO_2) which smothers the fire.
Pyrene — an extinguisher filled principally with carbon tetrachloride.
water — an extinguisher using water, acid, and baking soda to produce carbon dioxide, which causes enough pressure to force the water out of the extinguisher.
fire hazard — a condition that makes a destructive fire possible.
fire-made — referring to rocks formed by heat.
fires, non-preventable — fires resulting from causes beyond human control; *e.g.*, lightning.
fires, preventable — fires caused by carelessness which may be guarded against.
fish — an animal adapted to live in the water.
flame — a burning gas.
flint — a form of quartz used by Indians for making arrowheads, and with steel to start a fire.
foaming — the formation of bubbles of gas in a liquid. (See *effervescence*.)
foraminifera — very tiny sea animals having a shell.
fossil — stony remains or impression of an ancient animal or plant.
fracture — to break.

freeze — to change from a liquid to a solid state.
friction — the resistance that is offered when one body rolls or slides over another.
frost — frozen dew or water vapor; minute crystals on grass, window panes, and other objects formed by the freezing of moisture as it is deposited from the air.
fuel — a combustible substance commonly used to supply heat by burning.
galvanized — coated with zinc.
gas — an air-like substance.
active — a gas which combines easily with other substances; *e.g.*, oxygen. (See *oxygen.*)
inactive — a gas which combines slowly or not at all with other substances; *e.g.*, nitrogen. (See *nitrogen.*)
gasoline — a liquid commonly used for burning to produce heat and power, and as a solvent for many substances.
germinate — to sprout.
germs — one-celled plant or animal organisms. (See *bacteria.*)
glacial soil — soil deposited by a glacier.
glacier — a field or stream of ice moving slowly over the country.
gorge — a steep-sided, narrow (young) valley.
granite — a hard, coarse-grained rock composed chiefly of quartz, mica, feldspar (or hornblende).
gravel — rock particles larger than sand (usually water worn).
gravitation — the attraction which the earth has for solids, liquids, and gases.
grubs — larvae of some insects.
hardness — the ease or difficulty with which a substance can be scratched.
heat — energy set free by combustion and other chemical actions, by friction, etc.
hornblende — a mineral occurring in some varieties of granite and by itself.
horsepower — the rate at which work is done.
humidity — the invisible moisture in the air.
humus — decayed plant or animal matter in the soil.
hydraulic — referring to water.
hydrochloric acid (HCl) — an acid which causes effervescing (foaming) when placed on limestone and marble.

hydrogen — the lightest known gas. Combined with oxygen, it forms water.

hygiene — the science of health.

hygrometer — an instrument for measuring the relative percentage of moisture in the air.

ice sheet — a glacier covering a large part of a continent.

identify — to be able to recognize, or tell the name of.

igneous — pertaining to fire (or heat).

ignite — to begin to burn; to set on fire.

ignition point (*kindling temperature*) — the temperature at which a substance begins to burn.

inflammable — capable of taking fire quickly.

inhale — to breathe in; to take air into the lungs.

inorganic — matter which has never had life.

insect — a small animal that lives in various stages and has six legs at the final stage.

insulator — a substance which retards or prevents the passage of heat or electricity.

invert — to turn upside down.

invisible — that which cannot be seen with the unaided eye.

iron filings — small particles of iron.

kaolin — a pure form of clay.

kerosene — a liquid obtained from petroleum by distillation, commonly used for burning to produce heat and light.

kindling temperature. (See *ignition point*.)

larva — the worm-like stage in the life of an insect.

lava — melted rock thrown out of volcanoes.

lead — a very heavy metal used in making paints, pipes, etc.

limestone — a sedimentary rock identified by the foaming action of acid when placed on it.

limewater — a solution made by dissolving lime, CaO, in water (used in detecting CO_2), $Ca(OH)_2$.

liquid — a substance which takes the form of the containing vessel and fills a certain part of it. Most liquids are wet.

litmus paper — a paper colored with litmus, for testing for acids and alkalies.

loam soil — principally a mixture of sand, clay, and humus.

luminous — giving out light.

lungs — a pair of organs in the chest cavity by which oxygen is supplied to the blood and carbon dioxide removed.
maggots — larvae of flies.
marble — a metamorphic rock formed from limestone.
matter — anything which occupies space.
meandering — the curving and bending of a stream.
melt — to liquefy by heat.
mercuric oxide — a red powder composed of mercury and oxygen, HgO.
metallic — a metal-like substance.
metamorphic — changed in form; *e.g.*, coal, diamond, graphite, marble, slate, quartzite.
meteor — fragments flying through our atmosphere ("shooting stars").
mica — a mineral sometimes occurring in very thin glass-like sheets. Occurs in granite.
mineral — inorganic matter of which rocks are composed, usually occurring as crystals.
mixture — the result of stirring two or more substances together without changing their identity; *e.g.*, sand and sugar.
moisture — water in finely divided state.
mold — a low form of plant life; a kind of fungus.
muck soil — soil containing much decayed plant material.
mucus — a liquid on the walls of the air passages.
narcotic — a poisonous substance that paralyzes the nerves.
nasal passages — the air passages reaching from the nostrils to the throat.
nitrate — a soluble mineral in the soil containing nitrogen used by plants.
nitrogen — an inactive gas which makes up about 78%, by volume, of the air.
nitrogen-fixing bacteria — bacteria that can make nitrogen compounds from nitrogen of the air and minerals of the soil.
nodules — swellings containing bacteria, found on roots of some plants.
non-combustible — that which does not burn in air.
non-inflammable — non-combustible.
non-metallic — appearance unlike a metal.
nostrils — the openings in the nose through which air passes.

ocean — a large body of salt water.
octahedron — a regular twelve-sided solid related to the cube.
ore — a mineral containing a useful metal.
organic — matter which forms a part of, or has come from, living things.
organism — any plant or animal which is living or once had life.
ovary — the part of the flower containing the ovules (seeds to be).
oxidation — the process by which oxygen combines with another substance.
rapid — combustion; burning.
slow — oxidation which takes place too slowly to produce noticeable heat or light; *e.g.*, rusting or tarnishing of metals (except silon); decay of plant and animal tissue.
oxide — composed of an element combined with oxygen; product of oxidation.
oxygen — an active gas which makes up about 21%, by volume, of the air.
particles — small pieces of anything.
pasteurization — the process of destroying bacteria by heating to 140° F. to 145° F. for about 30 minutes.
petroleum — a natural liquid fuel obtained from the ground through wells.
phosphates — salts derived from certain acids containing phosphorus.
phosphorus — a soft, yellowish, non-metallic element of waxy structure. Very inflammable and poisonous.
planet — one of the bodies traveling around the sun.
poison — a substance which is injurious to living things.
polluted — mixed with filth.
porcelain — a substance made from feldspar or clay used in making bathtubs, dishes, etc.
porous — a term applied to a substance when it is filled with small holes or air spaces, like a sponge.
pressure — a force exerted by one substance against another.
prism — a solid whose ends are similar, equal, and parallel figures and whose sides are parallelograms.
process — the way in which a result is obtained.
product — that which is made or which results from some process.
properties — the characteristics (appearance, color, etc.) which belong to a substance and by which we recognize it.

protoplasm — matter composing cells.
quartz — the hardest common mineral (No. 7), occurring in granite and by itself.
quartzite — a rock formed from granite by heat and pressure.
reduce — to remove oxygen from an oxide.
residual soil — soil resulting from the decay of rock where it was formed; not transported.
respiration — the process by which an organism takes in and uses oxygen to oxidize the food, producing heat and energy, and waste gases such as carbon dioxide and water.
revolution — one body traveling or revolving about another body.
ribs — parts of the bony framework of the body inclosing the chest cavity.
river flats — level land along the banks of a river which is occasionally flooded during high water.
river soil — soil formed by action of streams.
root — the underground part of a plant which is adapted to absorb water and minerals from the soil.
rotation — a body turning about its axis, like a wheel turning on the axle.
sand — mostly small grains of quartz.
sandbar — a bar or ridge of silt and sand formed in rivers, lakes, or oceans.
sandstone — a rock composed chiefly of particles of quartz cemented together.
sandy soil — soil composed chiefly of sand.
sediment — any rock or soil material deposited by water or air.
sewage — water containing wastes from the body.
shale — a rock formed by hardening of clay-mud.
silica — a mineral composed of an oxide of silicon.
slate — a metamorphic rock formed from shale.
soil — finely divided rock material mixed with decayed plant or animal matter.
solar system — our sun and the planets that travel around it.
solid — a form of matter that holds its shape under ordinary conditions.
soot — carbon deposited by a flame.
specific gravity — the number of times a substance is heavier (or lighter) than water.

steam — water in the gas state.
sterile — containing no living bacteria.
strata — layers of rock.
stratified — applied to material that has settled in layers.
substance — any kind of matter; the material of which anything is composed.
sulfur — a yellow element that will burn and form sulfur dioxide gas.
supporter of combustion — a substance (oxygen) which enables things to burn.
test tube — a glass tube, closed at one end, used for testing substances.
thermometer — an instrument for measuring changes in temperature.
tissue — material which makes up the body of a plant or animal.
tobacco — dried leaf of the tobacco plant, containing a narcotic poison called nicotine.
tonsillitis — infection of the tonsils, which are spongy growths on each side of the throat.
transported soil — soil carried by wind, rivers, or glaciers.
travertine — a variety of limestone formed by hot springs and in caves.
tributary — a stream flowing into a larger stream.
tufa — a variety of limestone deposited by the water from hot springs.
vacuum — an empty space; a space containing no air or other gases, no solids, no liquids.
valley — low land between hills.
vaseline — a salve obtained from petroleum.
vegetable matter — plant life.
vitamins — substances required by the body to promote certain functions.
vitreous — glassy.
volcano — a mountain that occasionally sends out hot gas and rock.
water (H_2O) — a compound of hydrogen and oxygen.
water cycle — the circulation of water in nature through the processes of evaporation and condensation.
waterfall — water falling over a projecting shelf of rock.
watershed — a drainage area.
water vapor — water in the form of a gas.

weathering — the breaking up of material such as rock into smaller parts by some of the forces of the weather — *e.g.*, frost, ice, wind, rain, air — and by organisms.

weight — an effect of gravity on all matter; the measure of the force of gravity.

wind — air in motion.

wire gauze (*screen*) — a piece of apparatus used to prevent a flame from coming in contact with a piece of glass apparatus.

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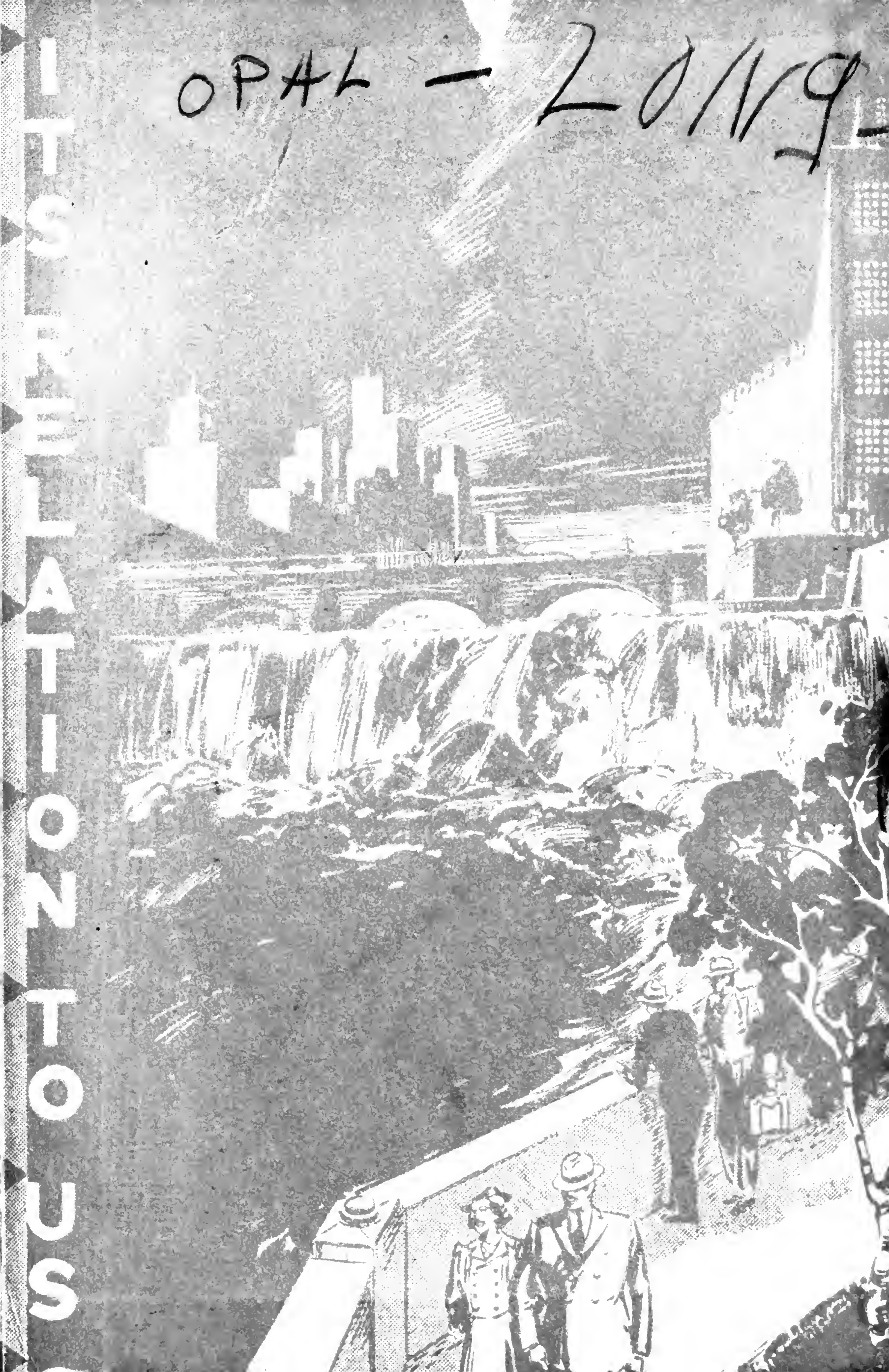
OUR ENVIRONMENT


ITS RELATION TO US