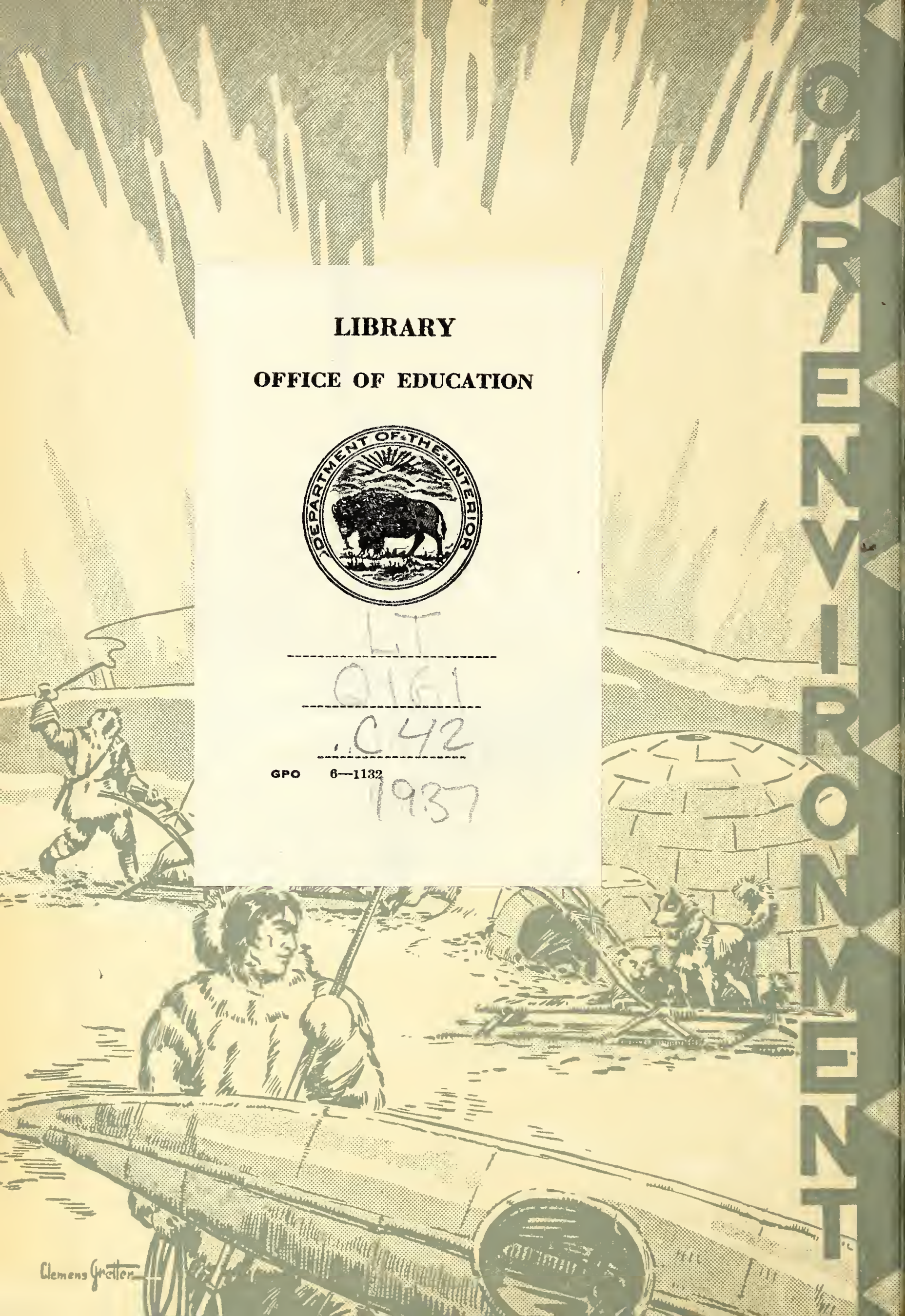
OUR ENVIRONMENT

HOW WE ADAPT OURSELVES TO IT

CARPENTER AND WOOD



OUR ENVIRONMENT
Clemens Gretter

HOW WE ADAPT OURSELVES

Soon as the evening shades prevail
The moon takes up the wondrous tale,
And nightly to the listening earth
Repeats the story of her birth.

— Addison

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

BOOK II

OUR ENVIRONMENT

HOW WE ADAPT OURSELVES TO IT

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PREFACE

LEARNING is a continuous process. A sequential science program for schools is important, so that the knowledge and training values may be developed continuously and gradually. While this second-year volume of the Modern Science Series may be used as an independent text, it is so organized that it integrates the material of Book I with that of Book III, and thus provides for continuous mental growth in science.

A brief reference to the tables of contents of the several volumes in the series will show a uniquely useful pyramiding of emphasis upon the fundamental principles of general science. Certain topics constantly recur, but always with different, though closely coherent applications of what the pupil has already learned. This intensive building up of specific, scientific concepts, actively allied with daily environmental interests, cannot fail to establish an effective and substantial foundation for later science work.

In addition to laying a foundation on which future study can be based, the text acquaints the pupil with those manifold practical facts of environmental science which have such an important bearing on his daily life. Health guidance, economic interests, and the simpler but richly cultural applications of science all find a place in the work of the course.

The book is organized into a small number of **units,** each unit presenting a unified picture of some phase of the pupils' environment. Each unit is composed of a series of **topics,** developed in logical order, an understanding of which comprises a complete grasp of the larger unit division.

Problem-solving abilities are cultivated by the **general problems** into which each topic is analyzed. Each general problem may include a number of **experimental problems** (laboratory work), **field research problems,** or **projects** for independent choice and individual or group solving.

The problem method involves first, a realization of the problem on the part of the pupil; and second, a background or foundation upon which he can base his attack. To these ends the pupil's natural everyday experiences must be reinforced by carefully directed observational training. Not only must the work of the classroom comprehend these purposes, but that work should be supplemented by out-of-school contacts which will crystallize the habits of careful, accurate observation and judgment. For this reason, a **Science Discovery Calendar** is included in the Appendix. The observational work necessary in connection with the reports in this calendar is extremely valuable in putting into practice the "scientific method" without specific guidance or authority from the textbook.

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 num-

ber of related topics, the general problems of which are minor generalizations and provide a framework for the building up and fitting in of the facts that are discovered, observed, and learned for the unit as a whole.

3. Each topic is introduced by a page of informal chats which serves as a motivation *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*. The latter offer an opportunity for taking care of 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 summarizing 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 using this book.

The *Glossary* provides simple understandable definitions of the key words and other science terms.

9. *Experimental Problems* are numerous. The fun-

damental experiments are labeled *Key Experimental Problems* because they are especially important units in the organization of the subject matter. They focus discussion and develop the scientific attitude of mind. 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. Because some classes may find it impossible to perform all of the experimental problems the text has been made completely coherent without dependence upon the experiments in any way.

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 and often questions requiring close study of the picture and direct association of it with its context.

Every effort has been made to keep the vocabulary and the phraseology of the Modern Science Series as simple as possible. To that end scientific terms beyond the comprehension of the pupil have been omitted. An outstanding feature of the series is its logical, coherent development. Transitions are carefully worked out so that progress is natural and smooth. The pupil is certain to carry from his science work a sound grasp of the *relations* of natural phenomena, a realization of his need for *adaptation* to them, and a knowledge of how best to *control* them.

HARRY A. CARPENTER
GEORGE C. WOOD

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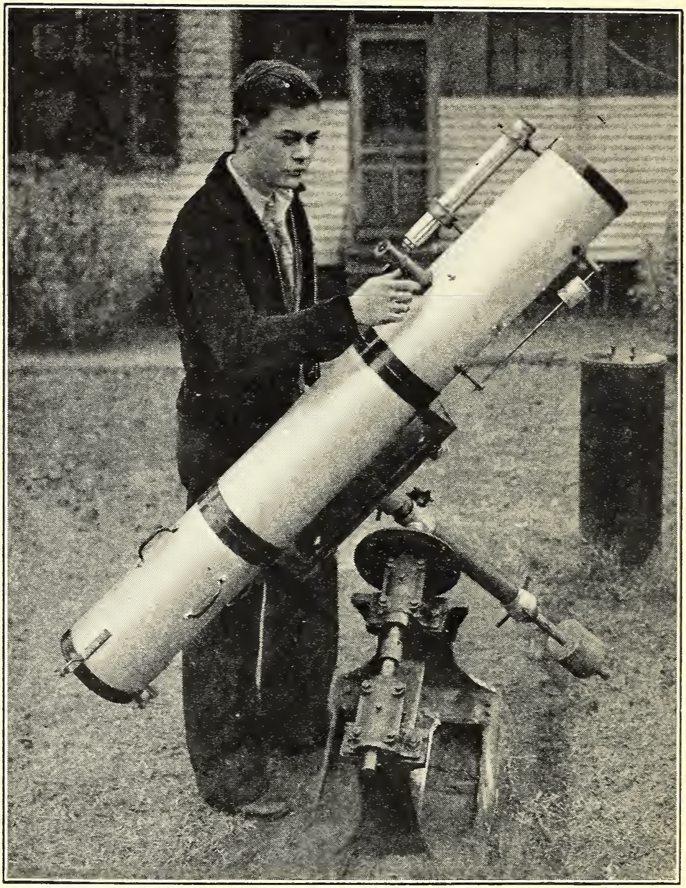


© Keystone

"WHERE THERE'S A WILL . . ."

A homemade telescope will expand a boy's world to almost immeasurable distances.

OUR ENVIRONMENT

HOW WE ADAPT OURSELVES TO IT

INTRODUCTION

1. Making a Telescope. — "I never saw you stick to anything so long before, Bill. What in the world are you doing?"

Bill gave George a withering look and said, "That's it exactly. I am making a telescope to help me look at something beyond this world. Do you realize, young fellow, how really small and insignificant this world is? Wait until I get my telescope finished, and I'll show you some things."

"I have seen those telescopes that cost a dime for a look at the moon," said George, "but I didn't suppose a fellow could make one. What is that tin pipe for, Bill?"

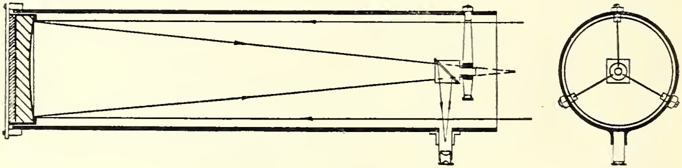
"That pipe, as you call it, is a galvanized iron tube that will form the barrel of my telescope. One end is left open, and at the other end I put this mirror which I am grinding."

"Yes, that grinding job is what looks phony to me. Do you expect that to become a mirror?"

"Of course, George. When it is finished, the mirror will be curved like the inside of a saucer. It will be six inches in diameter. After I have finished grinding the glass to the correct shape, it must be polished and silvered. It will be like the inside of the bowl of a shiny silver spoon, only the shape will be round, not oval like the spoon."

"Can anyone grind a mirror, Bill?"

"Yes, George. Only it takes a lot of hard work and patience. I don't think you had better start one. I have been working on this one for a long time. Five other fellows of the Astronomy Club are making some too. Professor Jones of the University is helping us.



Bill's Telescope

The mirror which Bill ground is at the left end of the telescope. The image mirror is in the center of the pipe above the eye piece. The drawing at the right shows how this mirror is fastened to the pipe.

Our telescope, you know, will be like the new 200″ telescope you have read about — a reflecting telescope. But, where my mirror is 6″ in diameter, the big one will be 200″ in diameter."

"Perhaps you think I don't like to work, but I'll show you. Tell me, how do you use the mirror?"

"It is fastened to one end of the metal tube. Then when rays of light from a planet shine in the other end, they reach the mirror, which reflects the rays to a focus or image, just as a camera lens brings light rays that pass through it to a focus."

"But how do you see anything, Bill?"

"A little flat image mirror is placed inside the telescope just before the rays come to a focus from the curved mirror. The rays form an image of the object the telescope is pointed at. Here is a drawing to show you how it works. You see, the reflected rays are seen through a regular magnifying eyepiece at the side cf the tube."

"That certainly is interesting, Bill. I would like a chance to look through your telescope when it is ready."

"You may, George, but better than wait for that come over to our Astronomy Club meeting Friday night if it is clear. You can meet the fellows and take a look at the moon. What do you say?"

"O. K. I'll be there, Bill."

2. **Things to Think About.** — Friday night was crisp and clear, and George was on hand. Professor Jones adjusted the telescope on the crescent moon, and George put his eye to the eyepiece. "Whew! I don't wonder that astronomy is interesting if you can see things like that. I can see shadows on the moon. It looks as if there were mountains up there. Are there mountains on the moon?"

"There are," said Bill; "and can't you imagine how Galileo (gä′lē-lā′ō) must have felt when he invented the telescope and saw the mountains on the moon for the first time?"

"How did he happen to make a telescope? How did he find out how to do it? Who was Galileo? Didn't everyone always know about the moon?" George's questions seemed endless.

"No," answered the teacher. "Until Galileo made his telescope the moon was thought to be perfectly smooth. But I can see, George, that you are expanding your mind; you are wondering how men learned.

"There are many things happening every day for you and all of us to think about, things just as wonderful as the moon and its mountains. How would you like to prove that the earth moves, and that the seasons, and day and night, result from its motions? Perhaps you would like to discover the relation between navigation and the motions of the earth."

"Yes," said Bill. "I was reading in our history book this afternoon about those early navigators. I'd

© *N. Y. Times*

Weather Forecasting in Antarctica

Here, amid the frozen spaces of Little America, is Admiral Byrd's weather bureau — a meteorological shelter, an anemometer post, and a wind vane. Why does the opening of the hut face as it does?

like to know how they found their way across the sea, and why some of them thought the earth was round."

"And there's weather. Who knows what the weather is to be? You have read how Byrd, in his expeditions to the South Pole, watches and studies the weather conditions. How can he tell anything about the weather? How can you learn to foretell weather?"

"I'm more interested to know about water," said George. "Someone told me it is made of two gases. Is that true? How can it be? You can't see gases, but you can see water."

"Yes, it is true," answered the teacher, "and more than that. In the laboratory you can separate water into the gases and put them together again."

"That sounds like 'Humpty Dumpty,'" replied George. "It's all right for you to talk about those things. You have a laboratory in which to experiment, and a telescope to help you study the moon and stars. But what's a fellow going to do in a school where they don't have science?"

4. Learning by Experimenting. — It is true that many schools do not have laboratories, telescopes, and other expensive apparatus. However, every school has the whole out-of-doors for a laboratory, and many things can be done indoors with books and common everyday materials. "Where there's a will, there's a way." Who knows but what you might even make a telescope better than the one Galileo made!

You who have science laboratories perhaps can do more than George, but if George works, and tries experiments with home-made apparatus, and thinks while he works, he is very likely to become famous ahead of you. George and Bill are going to improve their minds because they are learning how to be successful thinkers.

5. Successful Thinkers. — Thinkers must be doers. The most successful thinkers of history and of to-day are men and women who have closely, patiently, accurately, and thoughtfully observed the workings of Nature, both out-of-doors and indoors. And with their thinking have come problems they wanted to solve. To solve these problems they started at once on voyages of discovery into the unknown. Such voyages always include hard work and some disappointment, but, on the other hand, nearly always reward one with the joy of success.

Although Galileo died while a prisoner in his own house, he gloried in the knowledge that he had discovered certain great truths. The world owes much to his discoveries.

Aristotle, one of the greatest thinkers of all times, is sometimes called the father of our modern sciences. He was probably the first to give us a systematic plan for studying science according to the fixed classification which we indicate by such names as biology, physics, chemistry, and astronomy.

Wilhelm Röntgen, a man who liked to blow glass and take pictures, because of his interest in experimenting with electrical discharges through a vacuum, discovered the X-ray. What an aid his discovery is to-day in science, and in medicine and surgery!

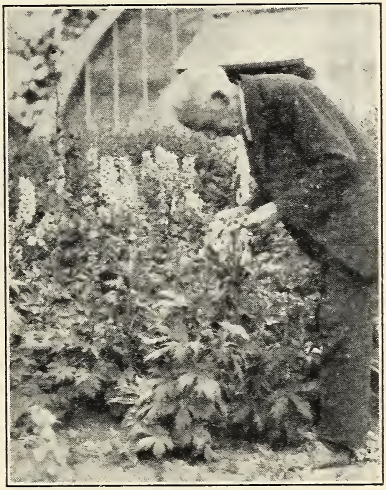
Kelvin, Pupin, Steinmetz, — scholars, engineers, inventors, — through their research and study have done much to give us our control over the giant power, electricity.

Louis Pasteur, one of the great men of all time, spent his life in scientific study of invisible organisms called bacteria. Because of him the world is a better and safer place in which to live.

Luther Burbank, one of our own countrymen, devoted his life to improving old and creating new fruits, flowers, and vegetables. It is due to his experimentation with *crossing* and *selection* in the reproducing of plants that we enjoy many new fruits and flowers.

Francis Bacon said, "Man can govern nature only by obeying her laws, and therefore he must find out what her laws are." It was Bacon who taught the world the *scientific method of experiment.*

6. How It Is Done. — Bacon told us how. First we must have a *problem:* something to do, something to find out, something we wish to discover. Then by observation, patient and painstaking, and by careful consideration of all the facts and their relation to one another, we may form an opinion, a *theory.* Next comes the task of testing, trying faithfully to learn whether the theory explains the facts that are related to it. If the theory explains all related facts, behold we have discovered a *law!* With the discovery of her laws we gain control of the forces of Nature and adapt ourselves to them as we see best.



LUTHER BURBANK

A man who spent his life among trees and flowers, making new kinds of fruits and blossoms.

7. Your Chance. — You are fortunate to be studying science, for you, too, can discover for yourself and perchance for future generations.

Like Galileo, Newton, Darwin, Pasteur, and all discoverers, you must *record your discoveries.* Your *Science Discovery Book* is to be the story of what you do, how you do it, what you think, and what you discover. Who can tell! You may be another Galileo!

YOUR SCIENCE DISCOVERY BOOK

A scientist is a person who *wants to know.* To learn what he wants to know he listens, looks, reads, and experiments. With his problem (what he wants to know) clearly in mind, he collects all manner of facts in all manner of ways. He then arranges his facts as they relate to his problem, discarding those that are not of use. With his facts laid out before him he searches for the answer to his problem.

The answer comes. Is it true? The scientist with infinite care and patience tests his answer by applying it to new conditions, to new but similar problems, until he is satisfied that his facts are accurate, his judgment good, and his answer true.

Perhaps you will put down in your book a secret ambition to know more and more about something that has appealed to your imagination. Has that imagination to do with a shooting star, a hurricane at sea, the changing form of the insect, an epidemic of disease? What is it you want to know? To help you make discoveries use the *Science Discovery Calendar* in the Appendix. Each week plan to make some of the observations called for in this calendar and record them carefully in your Science Discovery Book.

Your Science Discovery Book is the place for your records of facts and their relationships, your own conclusions or answers to your problems. It is the place for you to put down what you do and what you find to be true.

UNIT I. THE HEAVENS

LOOKING AHEAD INTO UNIT I

"In the infinite meadows of heaven blossom the lovely stars, the forget-me-nots of the Angels."

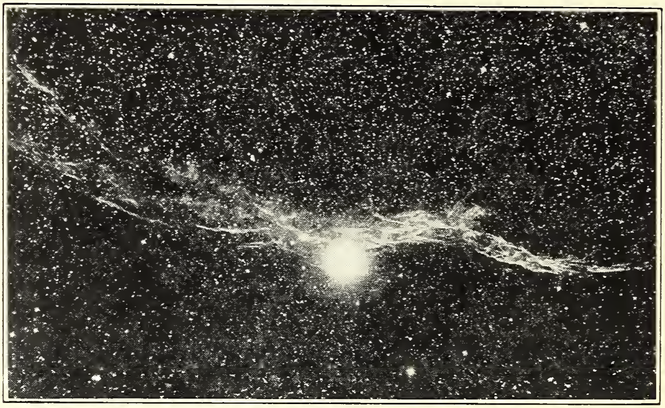
Who of us has not thought of the evening sky as Longfellow did when he wrote these words? How like a meadow it is, set with countless shining blossoms! No wonder the fates of men have been related to the stars through superstitions born in admiration!

Science serves to explain the "stars in their courses" but not to dispel the glory of their beauty. Knowledge of the firmament does not detract from its majesty but helps one to appreciate all the better the "hand that rules the universe."

Where there is order, there is planning. It is our problem to discover order and relationships among the celestial bodies. We shall learn the truth about motions of suns and planets; how the mariners by sea, by land, and by air, use the stars and the sun to guide them and to give them accurate time.

To reach out with one's mind and view the universe as a great number of orderly working systems, and to adapt one's living to day and night and to the seasons that are caused by the motions of our planet, require careful study and accurate thinking.

SURVEY OF TOPIC I



The starry dome of the heavens is a familiar sight to everyone. And the stories of the stars, from the long-ago myths of the Greeks to the story of the star that shone down on Bethlehem one Christmas eve, are legion.

Lovely as these stories are, as a scientist you are interested in discovering facts and truths about these "diamonds in the sky." As you discover what a star is, how far away it is, and how stars behave as parts of a universe, you will learn how far from the truth ancient and modern astrologers are who claim to read your future according to the star under which you were born.

Poets talk of the "star-studded sky," as if the great arch of the blue heavens were set with brilliant jewels, — some large, some small, — placed there by the hand of the creator of the universe. We shall learn that our earth is not the center of creation about which the stars revolve and shine nightly in their appointed places, but that it is one of a family of celestial bodies belonging to Our Star. Let us begin our study by getting acquainted with some of the stars of the heavens.

TOPIC I

THE ROOF OF OUR ENVIRONMENT

Twinkle, twinkle, little star, —
How I wonder what you are,
Up above the world so high
Like a diamond in the sky!

— Taylor

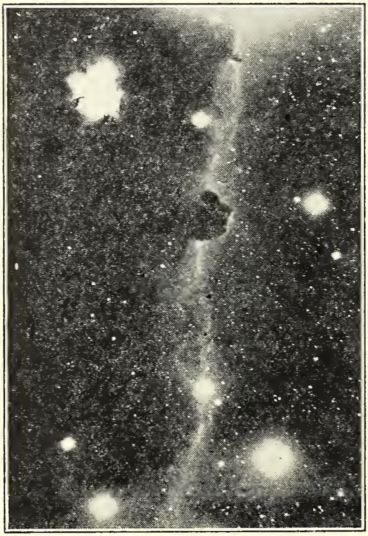
Do you know:

1. **What a star is?**
2. **What constellations are?**
3. **How far away the stars are from the earth?**
4. **That you can see the stars in the daytime?**
5. **Whether the stars control your future?**

General Problem 1. What Are Stars and Star Groups?

8. Star-Gazing. — Long, long ago the ancients learned certain facts about the stars which many times since have been useful to men as they journeyed about the earth. They discovered that the stars rise and set like the sun and the moon; that some of them come and go in our sky with the season; that many of them follow courses which seem to describe a circle about the *North Star* as a center. More interesting still, these ancient star-gazers observed what we too have noticed, that the stars remain fixed in position with respect to each other, and many are grouped in such a way that they form easily recognized figures or patterns against their background of sky.

To begin your study of the stars you will need a starry night, the star maps in your book, and your Field Research Notebook. As you learn to know the names of some of the stars and the groups they help to form, you will find yourself entering into a circle of friends who will be friends for life. And though at first it may seem otherwise, they are not merely fair-weather friends. Even though the sky should be stormy, you will learn to know just where, up above the storm, your friends are waiting to send you their greeting. Remember the stars are there and still to be seen if you could ride in an airplane above the storm clouds.



Courtesy Mt. Wilson Observatory

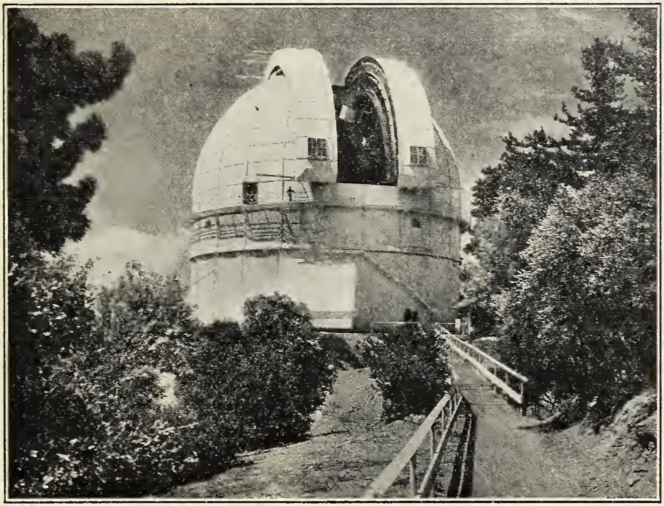
THE HORSE'S HEAD

Clouds and starlight! It is beauty like this that astronomers discover.

Field Research:

On a clear evening in September or October, you and a friend or two should star-gaze awhile. Just look, look, look, until here and there you come to recognize a star, or a group of stars, by certain characteristics of brightness, position, and color which set it off from other stars in the heavens. Perhaps someone with you may know the name of a star group. Make notes of your first impressions of stars and drawings of star groups in your Field Research Notebook.

9. What Are the Stars? — The stars are great *suns* like our sun. Some of them are many, many times larger than our sun. For example, Betelgeuze (bĕt′el-gûz′) is 27,000,000 times larger than our sun. These great hot bodies send out heat and light as our sun does. Most of the heat is lost before it reaches us, but the



Mt. Wilson Observatory

Through this open dome the wonders of the sky lie revealed.

light comes to us undimmed except by our own atmosphere. This light does not *seem* so bright and widespread as that from our own sun for the same reason that the farther away you are from a glowing lamp, the smaller the lamp appears and the less intense its rays seem. By means of a telescope some stars can be seen even in the daytime, but without such a device their rays are not visible because of the more intense light with which our sun blankets them.

The light from the faintest stars and the light from the brightest may be compared to the light from a firefly and the light from a powerful searchlight. Light from our sun would compare with a house electric light bulb much as a searchlight compares with a firefly.

THE MILKY WAY

This picture was taken in the southern hemisphere. Alpha Centauri is the bright star at the top.

The twenty brightest stars or suns are called *stars of the first magnitude*, not because they are the largest but because they are the *brightest* stars. They differ in *size, color (blue, red, white), composition, and position.* There are about 6000 stars that are bright enough to be visible to the naked eye although not from one position. Because of misty air, only about 2000 stars are visible to the naked eye from one place of observation. With powerful telescopes, however, and by aid of photography countless millions of stars are revealed.

"*Look now toward heaven, and tell the stars, if thou be able to number them.*" — GENESIS

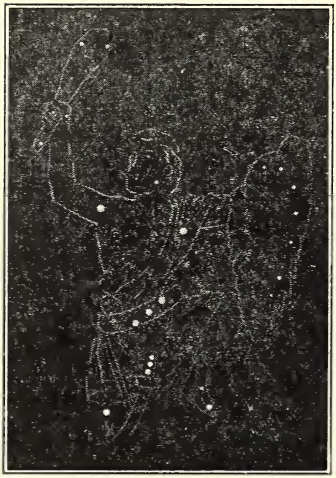
10. The Milky Way. — Across the heavens, nearly dividing it into two parts, is a broad white path. It is one of the most striking star groups in the sky and is called the *Milky Way.* Ancient Egyptians called it Pharaoh's River, believing it was the river over which the spirits of dead Pharaohs sailed their boats. Until astronomers were able to use high-power telescopes, the Milky Way was thought of as a mass of gas. The "milky" appearance is due to the fact that the stars of this group are so numerous and so distant that their "feeble" lights form only a lacy pattern in the celestial

THE BIG DIPPER

The arrow points to a double star. In which direction lies the North Star?

sphere. A good time to observe the Milky Way, with its innumerable points of light, is during the fall and winter evenings when it is high in the sky. We shall learn later why it is now believed that the stars of the Milky Way are part of a great rotating system.

11. A Constant Companion. — From early times people have seen resemblances to animals or people in certain groups of stars. One ancient race gave us the name "constellations" for these star groups. One of the easiest star groups to recognize is the *Big Dipper.* It is always to be found in the northern sky because it is so close to the *North Star* that it never passes below the horizon as do most other star groups. Therefore, it is a constant companion in our study of the stars and should be one of the first that we learn to know. It is called "the Dipper" because its seven stars are arranged in the shape of a dipper, four of them set at the corners of the bowl and three forming the handle.



ORION
As the Greeks saw this star group.

Some other prominent star groups are: *Cassiopeia* (kăs′ĭ-ō-pē′yȧ), the *Northern Cross*, *Orion* (o-rī′on), and *Peg′asus*.

If you are studying Latin, find out why the name *constellation* is given to star groups.

If we want to find a star, we ask to what constellation it belongs. The brightest star in a constellation is called *Alpha*, the next brightest, *Beta*, and so on, according to the letters of the Greek alphabet. It is like finding a house by knowing its number and the name of the street it is on.

How did these star groups get their names?

12. How the Constellations Got Their Names. — All of us have let our imaginations form fanciful pictures in the flames of the fireplace, or in the delicate tracery of frost on the window-pane, or in the changing cloud forms of a glorious sunset. In the same way, the Greeks and Romans drew mind pictures across the pages of the sky with star groups as outlines. Many of their mythological heroes were placed on those pages and the star groups serve as an unfailing record of ancient song and story. The Big Dipper is part of the constellation called by the ancients the *Great Bear*, or, in the Latin, *Ursa Major*. Here is one story of its naming:

Callisto and Her Son [1]

In Arcadia lived a beautiful woman, *Callisto*, who had a son called *Arcas*. Juno, the queen of the Greek gods, became very jealous of Callisto because Jupiter, the father of gods and men, was very fond of Callisto and her handsome son. As a mark of her power and envy, Juno changed Callisto into a bear.

Callisto dared not mingle with the other bears in the woods of Arcadia because she retained her human fear of them; and yet she fled from hunters, since naturally they would pursue her at sight and slay her if they could.

One day, however, she caught a glimpse in the distance of her own son Arcas, grown now to splendid manhood. Her love and yearning overcame her, and approaching him with clumsy gait, she stood on her hind legs and sought to embrace him. But he drew back in mingled wonderment and alarm; and as the bear persisted in following him, he raised his spear and would have killed the strange but terrifying animal. As the spear-point was about to enter Callisto's breast, Jupiter, looking down from the heavens, saw what was happening and in pity stayed the spear of Arcas. Then he snatched both of them from the earth and placed them as constellations in the heavens. One is a group of stars that we call the Great Bear and near by is the Little Bear, — Callisto and her son Arcas.

It is said, in the ancient legends, that Juno complained bitterly to the gods of the sea at the way Jupiter had treated

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[1] After the story in *Myths and Their Meaning*, by Max Herzberg, in the *Academy Classics for Junior High Schools*, published by Allyn and Bacon.

her rival and her rival's son; and these gods granted to her as a special boon that the Great Bear and the Little Bear should never come into their waters. Hence it is that these constellations constantly circle the pole, but do not sink into the ocean, as do the other stars.

Whenever you learn of a new constellation, go to a good mythology or to some similar reference book to see if you can discover the reason for its name. This will not only reveal many an interesting story, but will also help you to become better acquainted with the star groups.

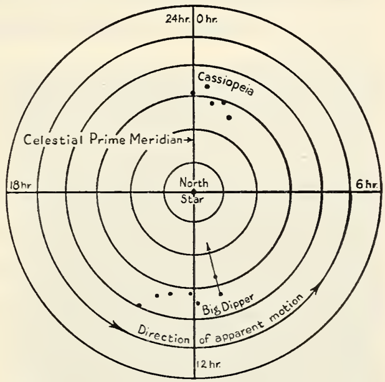
The stars of the Big Dipper always appear in exactly the same relative position or pattern. While the positions of the stars of this constellation are fixed with respect to each other, the constellation as a whole seems to swing around a point in the northern sky like the hand of a great clock, only in the opposite direction.

Field Research:

Observe the position of the Big Dipper soon after dark in the evening, and again two or three hours later. Repeat the observations several nights later. In your Field Research Notebook record the time of night and dates when you made each observation and make a star map of that part of the heavens, showing especially the Big Dipper. Did you notice that the point in the sky about which it appears to turn is marked by a bright but lonesome star? Did you know that the Big Dipper is always above the horizon in the north temperate zone?

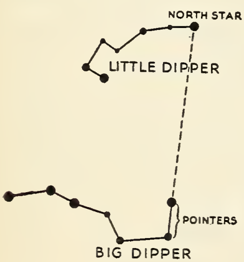
You have probably guessed by now that the point about which the Big Dipper appears to turn is the *North Star* or *Polaris.* It is easily found by sighting up along the line of the two stars which form the outer edge of the bowl of the Big Dipper. (See diagram on page 15, stars α and β.) The two stars are called *pointers.* At a distance from the top of the bowl of about five times the apparent distance between the two stars themselves, you will always find the North Star, a fairly bright, lone star of the second magnitude.

Distances between the stars in the sky are really measures of the angle you must turn your eyes as you sight from one star to the other. The angle between the two "pointers" is five degrees and twenty minutes. The angle between the pointer nearest the North Star and the North Star itself is twenty-eight degrees. Recalling that there are 360 degrees in a circle, you may be able to estimate angular distances between other stars and constellations.



THE NORTH STAR

To locate the North Star, hold this picture so that the Big Dipper here is in line with the real Big Dipper. The rest of the problem is simple.

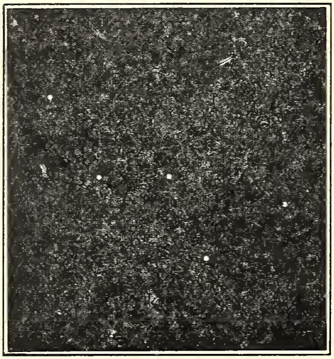


The relative position of the stars of the Dipper and this lone star does not vary from hour to hour, nor from night to night. The Big Dipper seems to turn about the lone star as a center, always keeping its "pointers" in the direction of the lone star. The North Star is also called the *Pole Star* because it is near the spot in the heavens toward which the north pole of the earth's axis points.

Field Research:

Cut a piece of cardboard in the shape of the Big Dipper. Place it at the proper distance from a paper star on the wall representing the North Star and turn the Dipper as described. Should the Dipper turn with the hands of the clock or counter-clockwise?

13. A Company of Constellations. — The Big Dipper and the North Star can be used as a starting point from which other constellations in the northern hemisphere can be located. On the opposite side of the North Star from the Big Dipper are five conspicuous stars forming a rather flattened *W*. These five stars are part of the constellation *Cassiopeia* (kăs′ĭ-ō-pē′yȧ).



CASSIOPEIA

This constellation is often called "Lady in her Chair." Five of the brightest stars form a "W."

Locate this constellation.

On a clear summer evening look overhead to see six stars in the form of a cross, lying nearly along the Milky Way. This constellation is called by its Latin name, *Cygnus* (sig′nus), meaning swan, or by the more popular name, *Northern Cross*. It lies in the heavens nearly at right angles to a line from the Big Dipper to the North Star. Since it is not always above the horizon, as is the Big Dipper, it is visible only during the evening hours of a certain part of the year.

Field Research:

There are other constellations that can readily be located by the use of the star maps. Try to locate Androm′eda, the

Pleiades (plē′a-dēs), Pegasus, Orion, and the Little Dipper. Polaris is the end star of the handle of the Little Dipper.

The constellations have no scientific importance outside of the fact that they serve as a ready means of locating and naming various stars. For convenience, as we have already stated, the astronomer calls the brightest star of each constellation *Alpha*. The Alpha star of the Big Dipper happens to be the one nearest the North Star. The second brightest star is called *Beta*. Often, the Greek symbols α, β, and so on are used instead of the words. It must be remembered that the brightness of a star depends upon its distance away from us. The Alpha star of one constellation may therefore be brighter than the Alpha star of some other constellation.

THE PLEIADES

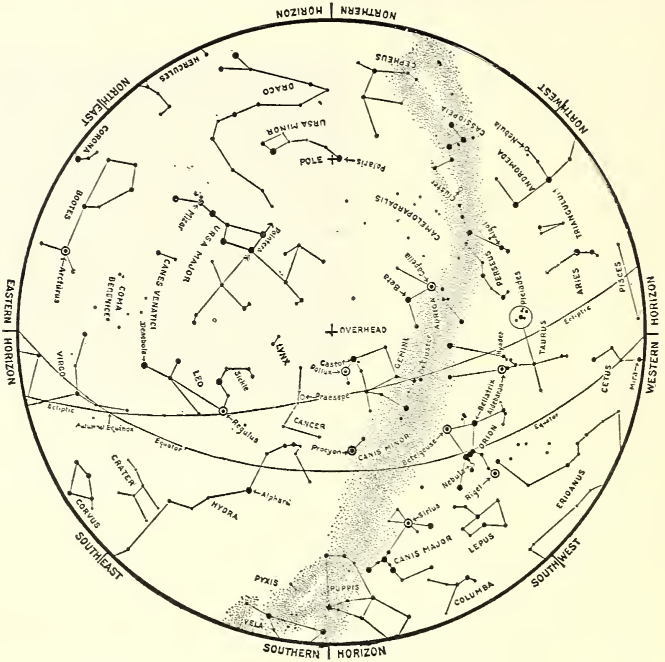
Legend has it that the seven bright stars are the daughters of Atlas.

14. A Superstition of the Stars. — The stars are governed by the laws of Nature just as all other subjects of her kingdom are. There are some people, however, who do not know this fact.

Star light, star bright,
First star I've seen to-night,
I wish I may, I wish I might
Have the wish I wish to-night.

Of course you have said these magic words and wished many a time, but your study of science will convince you that the stars have nothing to do with the outcome of your wishes.

Time was when man thought that his fate was somehow fixed by the stars. The astronomers of old



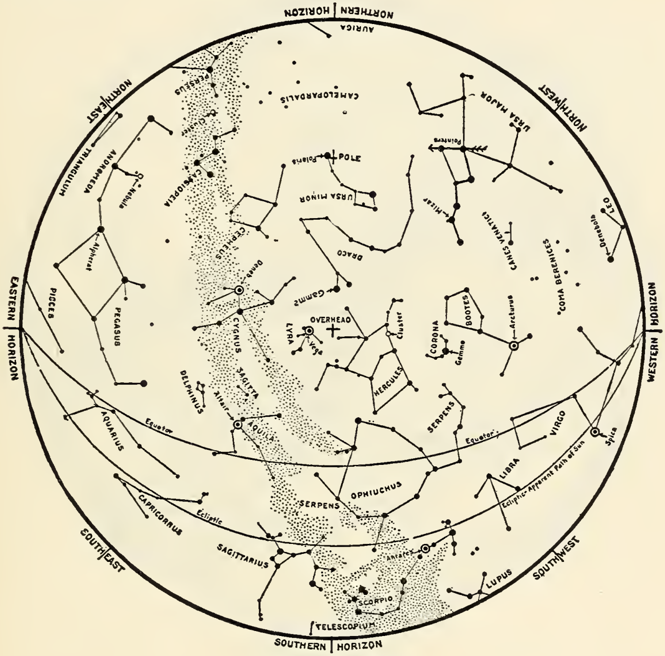
The Spring Sky [1]

presumed to read his destiny in the stars. This was merely superstition. Science has displaced such super-

[1] This map and those on pages 23, 24, and 25 are reduced copies from the *Pathfinder Star Maps*, by Edward S. King. (The Cosmos Press Inc., Cambridge, Massachusetts, publishers, $1.25.)

This booklet has twelve charts of convenient size with descriptive matter explaining what special features may be observed each month of the year. To use a map, hold it over head, turned as indicated by the directions along the outside.

stition by a true knowledge of the stars and of their actual relation to our sun and our world. Except among savages there are comparatively few star-worshipers or sun-worshipers to-day.



THE SUMMER SKY

GENERAL PROBLEM 2. HOW GREAT ARE CELESTIAL DISTANCES?

15. The Yardstick of the Heavens. — If you speak about the distance of a certain city from your own, you say it is so many *miles* distant; or if you are talking about the length of a table, you say it is so many *feet* long. In other words, to speak of distances it is very necessary to have some convenient *unit of length.* A few of the common units of length are the *inch,* the *foot,* the *yard,* and the *mile.*

The Autumn Sky

The distances between the earth and the stars are so great that we must have a very special unit of length to measure them. It must be a very long "yardstick" so that we can represent the distance of a star in readable numbers.

Try to imagine a table 186,271 miles long, at the far end of which stands a boy with a powerful electric light. Suppose at a given signal the boy turns on the light. Just one second later the light will reach your eye. It has traveled the full length of the table, 186,271 miles in a single second.

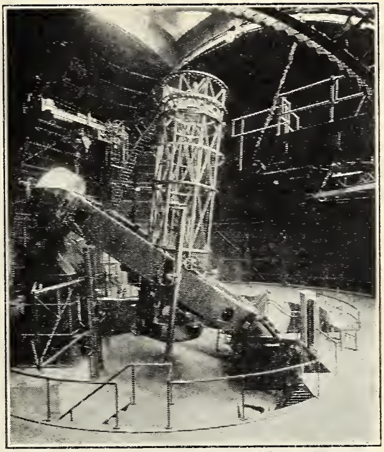
The Winter Sky

Light actually travels at this tremendous speed of *186,271 miles in one second.* Radio waves travel at the same speed as light. To get a good idea of this speed, recall that the earth is about 25,000 miles in circumference at the equator. Therefore, 186,271 miles is nearly eight times the distance around the earth. Light, then, can travel in a straight line in one second a distance equal to nearly eight times the circumference of the earth. (For ordinary calculations the even number 186,000 is accurate enough.)

Write down on your paper the number 186,000 and multiply this by 60. Your answer will be the distance that light travels in *one minute.* Multiply this number by 60 (60 minutes in an hour), then multiply by 24 (24 hours in a day), and then by 365 (the number of days in one year), and your answer will be the number of miles that light will travel in *one year.* This will be 5,865,696,000,000. You may have trouble in reading this number unless you recall the order — hundreds, thousands, millions, billions, trillions, quadrillions, etc., etc. This number, which can be read but is too vast for us actually to sense, is the distance in miles that light travels in one year in a straight line. It is five trillion, eight hundred and forty billion. In round numbers we may use six trillion miles. It is the yardstick of the astronomer and is called a *light year.* A light year is the distance light travels in one year.

16. How Far Away Are the Stars? — Some stars change their brightness in a short time, others change very slowly. By study, astronomers discovered that the longer it takes a variable star to change from one time of full brightness to the next, the greater is that star's sun-power. These changing light messages gave him a measure for distance. *Alpha Centauri* is a star of the first magnitude (page 14), visible in southern latitudes. It is the nearest bright star that we know, and yet it is so far away that it takes about four years for its light to reach us. To express the distance of this star in miles would involve an impossibly long string of numbers, and so astronomers use the astronomical unit of length, the light year, to measure its distance from us.

Astronomers have worked out some interesting comparisons to help us sense the great distances of stars. They tell us that a train traveling at the rate of a mile a minute would require 47 million years to make the journey to Alpha Centauri. To make this journey on a mile-a-minute train, one would need to live 670,000 times the ordinary length of life.



Courtesy Mt. Wilson Observatory

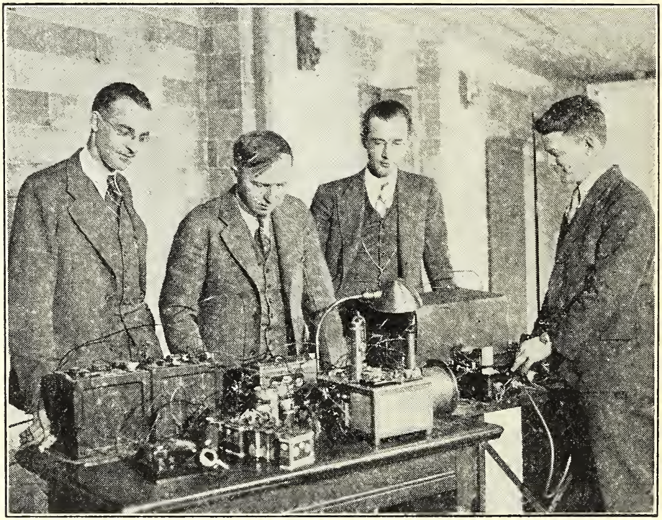
A Giant Telescope

Observe the arrangements for moving the telescope to follow the movements of the stars.

Picture to yourself the fineness and lightness of a spider's web. From a story the author heard told by the late John A. Brashear, a noted astronomer and telescope maker of Pittsburgh, Pennsylvania, we learn that a spider's thread long enough to reach around our earth (25,000 miles) would weigh only a little more than a pound and a half, but that one long enough to reach Alpha Centauri would weigh 500,000 *tons*.

Vega, a blue star of the first magnitude, is in the constellation *Lyra* (The Harp). Vega is visible in the summer sky. It is the second brightest star of the heavens. It is about 26 light years away or 1,500,000 times farther away than our sun. If it were as near as the sun, it would seem about 50 times as bright. It is known that the axis of the earth is very slowly shifting its direction in such a way that Vega will become the "North Star" in about 12,000 years.

Arcturus, a star of the spring and summer, sent forth a beam of light about 40 years before it was used to turn on the lights of the Century of Progress Exposition held at Chicago in 1933. Arcturus is about thirty times as



CATCHING A BEAM FROM ARCTURUS

By means of a great mirror, light from Arcturus was reflected to this apparatus, which turned on the handmade lights at the Century of Progress Exposition.

far across as our sun, and more than 100 times as bright. Arcturus is in the constellation *Boötes* (The Herdsman).

The North Star is about 270 light years away, and other stars vary in distances from four to millions of light years away. Though such distances are incomprehensible to us, mathematics, photography, and the telescope enable men to measure the distances of stars with great accuracy. They are measured by determining a star's changes in angular direction from a given point. The observations are made six months apart. From the distance between the two positions and the sizes of the two angles, the distance of the star is calculated.

Courtesy Mt. Wilson Observatory

THE NEBULA OF ORION

In the celestial sphere glitter thousands of stars — some near, some very far away.

17. Stars Are Hot. — Stars are great suns. They are thought of as huge quantities of matter, extremely hot and probably gaseous. The temperatures of the stars vary from 41,000° F. for blue stars, 12,000° F. for those like our sun, to 2800° F. for red stars.

Where one star was known by the ancients, now a million suns tell their stories to the scientist who knows how to study them. The color of the stars has told the scientist how to determine their temperature.

18. The Home of the Stars. — The stars seem to be placed on the inside of a great hollow sphere made of some blue material. Because of the fact that when distances are very great, our eye fails to distinguish differences in sizes and in distances, they all seem to be about the same distance away. To the naked eye the stars appear to differ only in brightness. This imaginary sphere, of which the observer is the center, is called

Courtesy Lowell Observatory

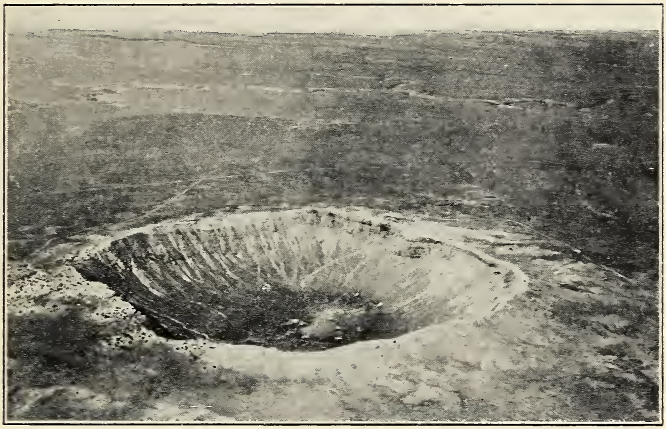
HALLEY'S COMET, MAY 5, 1910

Note the divided tail — the upper part was composed of gases, the lower of sunlit dust particles.

the *celestial sphere.* The word celestial means "having to do with the sky." Actually the stars are at very different distances from us. However, the imaginary celestial sphere provides a convenient plan for mapping the angular position of the stars.

While to the naked eye the stars appear to maintain fixed patterns in the sky, yet they do change their relative positions at rates of 10 miles to 20 miles per second. Some move much faster. Arcturus is said to be changing its position at the rate of 84 miles per second, which in 800 years will change its direction only about the width of the moon.

19. Shooting Stars — Have you sometimes looked up at the sky on a summer's evening and seen a star shoot across the heavens and quickly made a wish? Millions of these shooting stars are moving about the sun and earth all the time, but they are not visible to us until they enter the earth's atmosphere. By that time



Courtesy Santa Fe Railway

A METEOR CRATER NEAR WINSLOW, ARIZONA

they can do no harm; their energy is burned up by the pressure of our protecting atmosphere.

Once in a while a shooting star (meteor), bigger than the rest, does reach earth. It is called a *meteorite.* Some of our museums contain great pieces of meteoric rock which have been found in various places in our country. In Arizona there is a huge hole in the earth where a meteor struck thousands of years ago. The rocks on the sides of the hole are burnt, showing how hot the meteor must have been.

From ancient records to those of to-day accounts of these meteoric displays can be discovered. In November, 1833, it is recorded that the sky was full of shooting stars, until it seemed like a Fourth of July celebration. Is it any wonder that primitive man feared such displays, when he could not understand them?

One star in this celestial sphere is of more importance to us than all of the others put together. This star is the sun, and its relation to our world and the other planets of our solar system will be our chief interest in the next chapter.

KEY WORDS

"Amongst men who confound their ideas with words there must be endless dispute." — Locke.

Words are useful to convey our ideas to others. Proper choice of words will lead to the clearness and understanding which are so necessary to successful work in science. It was the custom of certain ancient philosophers to use words to express ideas without the foundation of proof by experiment. Hence they "confounded their ideas with words." In science, words are used to express ideas based upon facts and their relationships.

Your science study provides you an opportunity to discover facts and their relationships. You will need the right words to indicate these facts. The *Key Words* at the end of each chapter deserve your special study in this respect. Be certain that each *Key Word* has a real significance so that you can use it without "confounding your ideas." Always complete the *Key Word* exercise in your Science Discovery Book to the best of your ability.

Key Words

Alpha	Cassiopeia	magnitude	sphere
Arcturus	celestial	meteor	star
Beta	constellation	Milky Way	suns
Big Dipper	light year	North Star	Vega

KEY STATEMENTS

Complete thoughts in a discussion are like the foundation timbers of a building. They are the framework upon which the strength of the structure depends. In the development of science, *Key Thoughts* follow facts. Facts come from the study of things and their relationships.

These *Key Statements* are *Key Thoughts* gathered together to assist you in the mastery of your science. They should help you to express your understanding of facts and relations accurately. They represent learning that should result if you have done your work thoroughly.

Mere memory of these statements, however, will be of little value unless they have real meaning and significance for you. Test your understanding by discussing each *Key Statement* in some detail. When *Key Statement* exercises are provided in your Science Discovery Book, complete them in simple, concise sentences to show that you have fully grasped the meaning of each.

Key Statements

1. Stars are great suns.
2. The stars appear to be on the inside of a great sphere which we call the celestial sphere.
3. Stars always appear in the same relative positions for patterns in the celestial sphere.
4. Certain groups of stars are called "constellations."
5. The stars are at very great distances from us, the distances varying for different stars.

6. The special unit of length used by astronomers is the "light year," the distance light travels in one year.

7. The stars have nothing to do with one's fate.

8. Superstition about the stars and how they control the destiny of man has been overcome by scientific truths about the stars.

9. The brightest twenty stars are called "stars of the first magnitude."

Thought Questions

1. How are stars like our sun?
2. By what means do astronomers measure the distances and count the number of the stars?
3. What facts prove that the stars do not rule your fate?
4. Why can you ordinarily see the stars after dark only?
5. How can you locate the North Star?
6. Why do astronomers use the light year instead of miles when telling about stars?
7. Would you give the distance from New York to San Francisco in inches or miles? Why?
8. How have astronomers added to our knowledge?
9. Of what value are the old myths about the constellations?

PROJECTS FOR YOUR SCIENCE DISCOVERY BOOK

These projects are for your own scientific investigation and report and should be completed as directed by your teacher. This is your opportunity to do some original and independent work, and to prove your ability as a scientist. Be sure to enter your findings of each project in your Science Discovery Book. If space has not been provided, the project may be done on notebook paper and inserted at the proper place. Use drawings wherever you can, for illustration.

Projects for Your Science Discovery Book

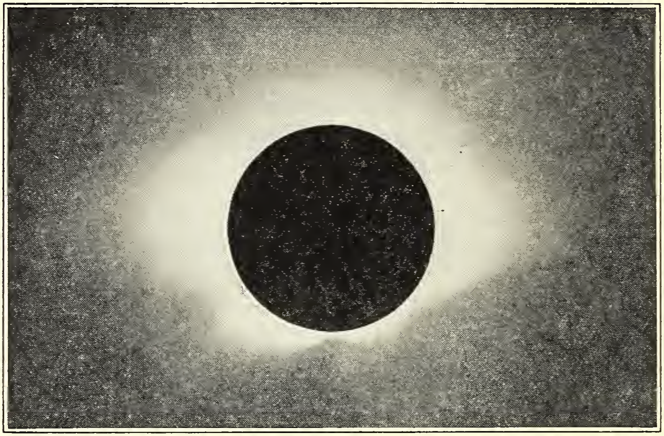
1. Locate and name at least three stars and three constellations.

2. Draw a star map of the brighter stars near the North Star. Indicate the constellations that are visible to you in this region. Allow space to enlarge the area covered by the map. You will be called upon to add to the map from time to time. It will be *your star map.*

3. Locate, observe, and describe the Milky Way.

4. Make a report on the composition of meteoric rock.

SURVEY OF TOPIC II



There is one " star " that means a great deal to us here on earth; a star that sheds its light and warmth by day and illuminates our moon by night. It is our sun!

Each one of you knows how dreary days are when the sun does not shine; how, in the northern climates, days are shorter in winter, and the sun seems very far away.

The great, round sun seems to move across the heavens from horizon to horizon, from the first faint golden lights of dawn until it sets in the amethyst splendors of twilight. Is what we see the true fact?

At night, when the moon casts its silvery light on the world below it seems nearly as big as the sun — sometimes, in the early fall when it appears above the horizon like a great, golden pumpkin, it seems much bigger — and it seems to swing across the sky in the pathway of the sun. On the nights when the moon floods the earth with light, we can feel no warmth. Why? Keep on your thinking caps and let us see what truths we can discover!

TOPIC II

OUR SOLAR SYSTEM

The heavens declare the glory of God;
And the firmament showeth his handiwork.

. . . .

In them hath he set a tabernacle for the sun.

— PSALMS

Do you know:

1. How much bigger the sun is than the earth?

2. Whether the sun has anything to do with life on the earth?

3. What holds the earth in place in its journey about the sun?

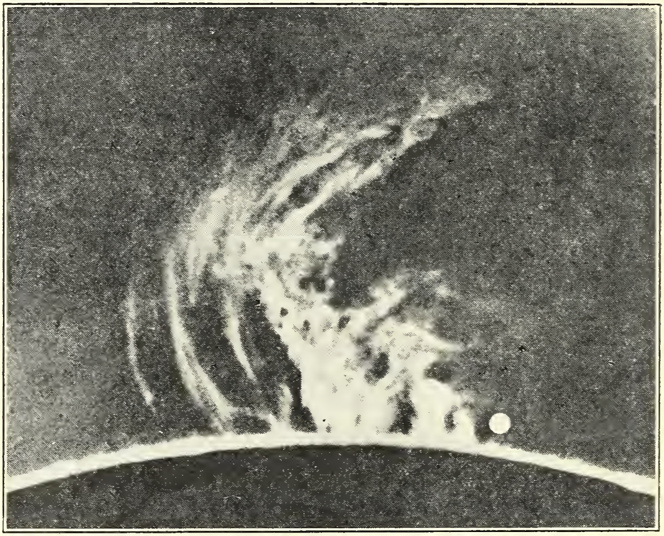
4. What causes an eclipse of the sun? of the moon?

5. What gravity is?

GENERAL PROBLEM 1. WHAT IS OUR SUN?

20. The Center of Our Sky System. — If you have ever studied anything about the stars, you will recall that the solar system consists of nine known major planets (and their moons) and over one thousand comparatively small celestial bodies, all of which revolve in fixed courses about the sun. They are at varying distances from the sun and differ from each other in size, color, and the number of their moons. We shall study several of them in some detail a little later, but just now we are concerned with their "guiding star."

Who of us has not hoped for a bright sunny day for a picnic without any special thought of the great heat and light giver, our sun. But have there not been other times when you have wondered how big the sun is, how far away it is, and what its purpose is? Is it only to give us light and heat and to serve as a timepiece that our sun exists, or does it serve us in still other ways?



Courtesy Mt. Wilson Observatory

THE SUN AND ITS FIERY GASES

The disk represents the earth.

21. The Size of the Sun. — The sun is a great mass of matter, heated white-hot, with a temperature at the center possibly about as high as 180,000,000° Fahrenheit. It is wrapped in dense clouds of vaporous gases. These surface gases have a temperature of about 12,000° F. It is nearly 870,000 miles in diameter or nearly 110 times the diameter of our earth. In volume it is 1,300,000 times as large as the earth. It will help you to realize this difference in size, if you will compare the space occupied by yourself with the space that would be occupied by 1,300,000 pupils of your size.

The materials of which the sun is made are not packed as closely at the surface as are the materials of the earth. At the center the pressure is said to be as much as 200 million tons per square inch, which causes the density there to be 28 times that of water. The sun weighs only about one and one half times as much as an equal volume of water. On the other hand, the materials of which the earth is composed are so closely packed that the earth weighs five and six tenths times as much as an equal volume of water.

Which one of your class is good enough in mathematics to calculate the relative weight of equal volumes of the earth and the sun from the data given?

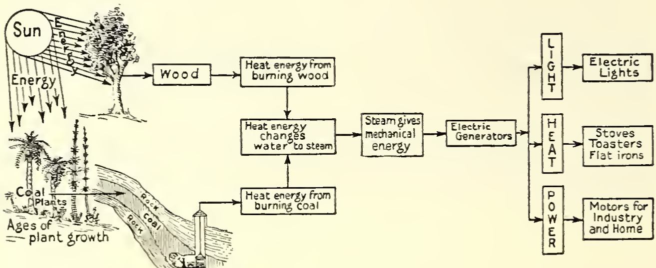
The *force of gravity* tends to hold you to the earth's surface. This force of gravity is the force which a heavenly body exerts on objects near it. We do not know what gravity is. We only know what it does and how it behaves. The power of this unknown force extends to the farthest star. The force of gravity of the earth tends to draw all objects on or near its surface towards the center of the earth. You must have strong muscles to jump over a bar three or four feet high. Because of the great mass of the sun the force of gravity at its surface is 28 times as great as that of the earth. If you were on the surface of the sun, you would have hard work to jump over this text-book.

Can you give two reasons why no one could live on the sun?

Another interesting comparison of the force of gravity of the earth and of the sun is that a man weighing 150 pounds on the earth would weigh nearly 4200 pounds or more than two tons on the sun.

22. How Far Away Is the Sun? — While this great incandescent body is so vast in size as compared with the earth and still more vast as compared with our moon, yet to the naked eye it looks no larger than the moon itself. This is because the sun is so far away. A fast train running day and night could reach the moon in about eight months if such a thing were possible. It would require about 258 years to reach the sun.

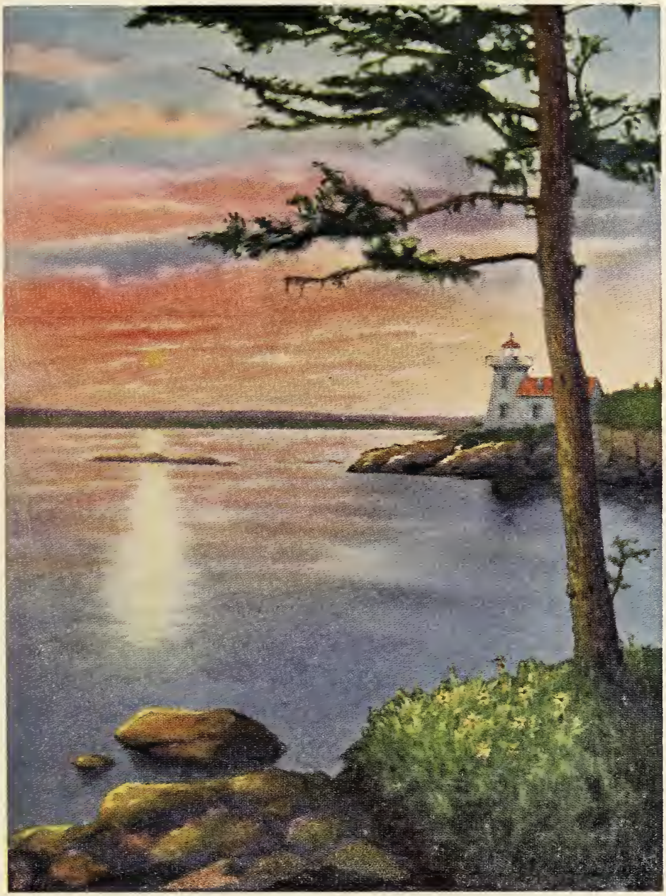
Such vast distances are incomprehensible to us, and yet we must try to realize the significance of these distances between the heavenly bodies. The average distance of the sun from the earth is about 93,000,000 miles. Traveling at the speed of light, one could make the journey from the earth to the sun in about eight minutes.



TRANSFORMATION OF ENERGY

Using the diagram, explain how light, heat, and power really come from the sun.

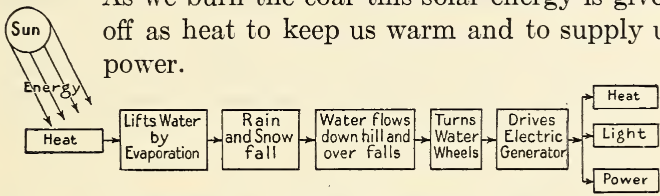
23. A Source of Energy. — The sun sends forth energy which, when absorbed by plants, enables them to grow and manufacture food for animals. Every green leaf with the help of energy from the sun is manufacturing food and storing energy for the use of the animals. Every square yard of the earth's surface



"Thou art beautiful, great, glittering, high above every land.
Thy rays they encompass the lands, even all that thou hast made.
Thou bindest them by thy love.
Though thou art far away, thy rays are upon the earth."

— From an Egyptian Hymn to the Sun

receives energy from the sun at the rate of $1\frac{1}{2}$ horsepower. Nevertheless the whole earth receives less than one billionth part of the energy given out by the sun. Some of the energy of the sun, stored up through the ages in coal-forming plants, is now tied up in the coal. As we burn the coal this solar energy is given off as heat to keep us warm and to supply us power.



THE RELATION OF WATER POWER TO THE SUN

Heat from the sun causes the evaporation of water from land and sea into the atmosphere. *Evaporation* is the process by which water rises into the atmosphere as an invisible gas. When the gas cools, the water again becomes liquid by *condensation*, and forms clouds from which the moisture falls as rain or snow. This water cycle carries water to mountain slope and hillside. It flows downward to drive water wheels and turbines. Hence water power really comes from the sun. Also when certain rays of the sun's energy strike the eyes, they are changed to light and enable us to see. The sun is the real source of energy on which all our activities and our very life depend. A great astronomer said that we are "Children of the Sun." Why?

Scientists are trying to discover the source of the energy of the sun. Is it gradually cooling off as a hot iron cools, or are forces at work in the sun itself that serve to produce more energy? The answer seems far off as yet.

24. A String to the Sun. — The force of attraction, *gravitation* (page 39), between the sun and our earth prevents the earth from being hurled off through space by other forces. It tends to pull the sun and the earth closer together. This force of gravitation acting opposite to the other forces helps to keep the earth, traveling year after year, century after century, in nearly the same path around the sun instead of straight out into space. In the same way it holds all heavenly bodies in their places, as we shall see later.

Field Research:

Attach a light ball to a stout string and whirl it rapidly around your head. Compare the motion of the ball to the motion of the earth about the sun. To what would you compare the string and muscles of your arm? What would happen if the string should break?

25. Sun Substances. — Man has not always known the elements that compose the sun. Little more than a lifetime ago the composition of the sun was not known. Now, by means of the spectroscope and other measuring instruments in combination with powerful telescopes and photography, much is known especially of the outer gaseous portion of the sun.

When certain substances are heated very hot and viewed through a spectroscope, various combinations of bright colored lines are seen. Like combinations of such colored lines can be given off only by the same substances. By applying this principle the elements in the sun are found to agree in kind with those that compose the earth and other planets of our solar system. This is one proof that once the sun and its planets were parts of a single mass of matter.

Field Research:

With the help of a physics or chemistry teacher arrange to observe bright colored lines in a spectroscope.

Elements are both metals, such as iron, zinc, and tin, and non-metals, such as oxygen, carbon, nitrogen, and the like. The metals have been easier to discover in the sun than the non-metals because their lines are brighter. Magnesium, iron, silicon, and sodium are the four most abundant metals in the sun's outer portion and are also abundant in our rocks.

It is estimated that hydrogen makes up most of the sun's atmosphere by volume, perhaps 90% to 95%. Oxygen and helium form 2% to 4% and the metals and other non-metals the rest.

For many years a substance was known to exist in the sun's atmosphere, called coronium, but it did not correspond to any known element of the earth. Recently Dr. D. H. Menzie of Harvard Observatory and Dr. J. C. Boyce of the Massachusetts Institute of Technology have made discoveries which practically prove that the mysterious element coronium is really oxygen such as exists in our atmosphere.

26. Sun Spots. — Of course, the outer portion of the sun is the sun's atmosphere and consists of gases. Of what do gases consist? Groups of tiny particles called molecules, which move about constantly. When gases are heated very hot, the molecules of which they are composed move very fast and jump far apart, and break up into the tiny particles which are called atoms and into even smaller particles called electrons. Scientists now believe that atoms consist of electrons and a central part made of protons and neutrons. However, we may think of it all as a mixture of very hot gases in violent motion. Toward the interior of the sun, where it is still hotter, the violence of the motion increases.

This tremendous disturbance acts like a terrific storm compared with which our tornadoes are a mere trifle. It is thought that this whirling mass of hot gases rises and forms a dark spot in the sun's atmosphere somewhat as a dark thunder cloud forms in our atmosphere. That dark spot is called a sun spot. Sun spots vary from 500 miles to 50,000 miles in diameter.

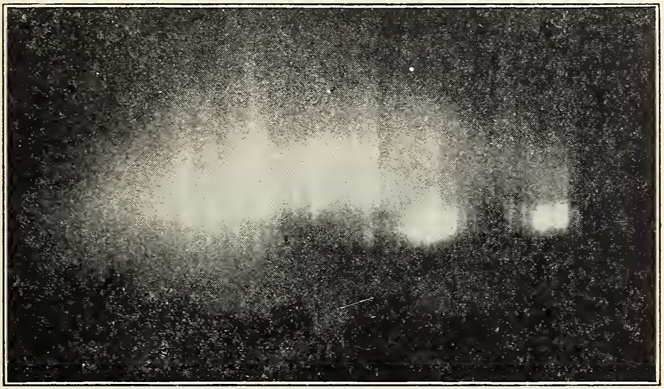
Courtesy Mt. Wilson Observatory

A Great Sun-Spot Group

Just as thunder storms occur within our atmosphere more frequently at certain seasons and in certain zones, so it seems that spouting sun spots occur more abundantly in certain zones of the sun. Also, the sun spots increase and decrease in number quite regularly, approximately every twenty-three years. A minimum of sun-spot activity occurred in the fall of 1933, with the first spot of a new period observed at Mt. Wilson Observatory early in October, 1933.

Since the sun spot represents a terrific whirl of atoms and electrons at the sun's surface, it is probable that electrons are hurled toward the earth's atmosphere.

This may help to explain the Aurora Borealis (northern lights) which are more frequent and brilliant at times of great sun-spot activity.



Courtesy of Professor Carl Stormer

THE AURORA BOREALIS

This picture was taken at Oslo, Norway. The lights at the right were rose color, the rest a yellow-green. The two stars in the center are in the handle of the Big Dipper.

Radio transmission and reception appear to be related to the height of the layer of ionized air (air having large numbers of electrons), called the Kennelly-Heaviside layer. The position of this layer appears to be related to sun-spot activity. This helps us to understand why local radio reception is better at times of sun-spot activity and long-distance radio is helped by fewer sun spots.

For many years observers have tried to discover relationships between sun-spot activity and the weather. Since the earth's atmosphere is affected by the results of the great electric storms on the sun, it would not be illogical if our world weather should be affected by sun-spot activity.

General Problem 2. How Does the Moon Affect Us?

27. Our Nearest Neighbor. — If we could start on a journey to visit the members of the solar system, the moon would be our first stop because it is closest to us. Of all the objects in the heavens the one most looked for, the one about which the greatest number of

Moonlight on the Water

Across the dark shapes of boats at anchor lies the broad, silver pathway of the moon's reflected light.

stories have been written, and one of the most interesting of all is the *moon.* When visible, it is the most conspicuous object in the evening sky and always attracts our attention.

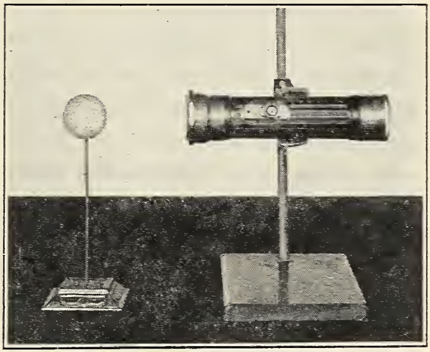
The moon is strictly our property. It belongs to our earth and revolves around it once in about twenty-nine days. It is a solid ball about 2160 miles in diameter and is nearly 240,000 miles from the earth. Although the moon is the most conspicuous object in the night sky, it is, nevertheless, a very small body when compared with the sun or any of the planets.

28. The Light of the Moon. — On a clear night the moon glows with much brilliance, yet it really gives out no light of itself. The moonlight that you see is sunlight reflected from the surface of the moon.

Experimental Problem 1. — *How does the moon give light?*

What to use: A golf ball to represent the moon; a focusing flashlight to represent the sun; a piece of black velvet; and a dark room.

What to do: Make the room so dark that you cannot see the ball when it is held across the room with the velvet behind it. Adjust the flashlight to make a narrow beam of light. Then let a pupil behind the class turn the beam of light on the ball.



Experiment 1

What does the flashlight represent? the golf ball?

What happens: 1. Does the ball become light enough to be seen when the beam of light strikes it? 2. Does the velvet appear as light as the ball? 3. Why?

Conclusion: 1. Do you think the light that enabled you to see the ball in the darkened room originated from the ball or the flashlight? 2. Why did the ball show light while the velvet did not do so?

Applications: Explain how light from automobile headlights makes objects alongside the road visible. How automobile headlights make cats' eyes appear.

29. High Jumping on the Moon. — When you jump up from the earth's surface, you jump against the force of gravity (page 39). Most people can hurl themselves upward in this way only a few feet. On the moon, however, one could jump high enough to clear a house, since the force of gravity exerted by the moon is only about one sixth that of the earth. The 150-pound man who would weigh 4200 pounds on the sun would weigh only 25 pounds on the moon.

Solids, water, and the gases of the air of the earth are held to our earth and prevented from escaping by the force of gravity of the earth. The moon, on the other hand, is so small that its force of gravity is not great enough to hold water vapor or other gases on its surface. That is why to-day it is a barren waste of rock — airless, waterless, and soundless. Its history is written in its craters and its long, barren valleys where the leveling action of rain and snow, rivers, and glaciers has been conspicuously absent.

30. Heat and Cold on the Moon. — Daylight on the moon lasts a little more than fourteen of our days, and the night is the same length. During this long day of two weeks of our time, the rays from the sun, undiminished by any atmosphere, beat upon the surface of the moon. As a consequence of this long-continued heating, it is probable that the temperature of the rocks is raised above the boiling point of water, possibly as high as 244° F. But when the moon turns on its axis so that this same surface is away from the sun, its temperature drops rapidly to − 243° F., perhaps nearly to absolute zero (− 459.4° F.). During an eclipse of the moon its temperature fell 335° F.

In like manner, if our earth had no atmosphere, we should be baked by day and frozen by night. Fortunately for us, atmosphere and clouds about the earth act as a blanket which prevents rapid heating by day and rapid loss of heat by night.

A natural law tells us that a warm body or object always tends to lose heat by *radiation* to colder objects or gases about it. For example, when you stand near a fire, the part of you toward the fire receives energy radiated (sent out in all directions) from the fire, while the rest of your body does not receive any. When the radiant energy strikes your body, it is changed to heat energy. The same result occurs when you hold your hand near a hot flatiron. The hot iron gives off energy in every direction. The energy stopped by your hand is transformed to heat and your hand becomes warm.

31. Light and Darkness on the Moon. — An atmosphere, with its moisture and dust, serves also to *diffuse* (scatter) light from the sun. On a body with no atmosphere the sun would illuminate only those objects in its direct, or reflected, light. Where the light did not strike, there would be darkness. For example, suppose one had a house on the moon, a house with non-reflecting inside walls. In the rooms facing the sun, only those portions in direct line with the windows would receive light. The other portions would be darker than any nights we know. The rooms on the opposite side of the house would receive only that light which might be reflected from surfaces in the paths of the sun's rays.

The moon's surface is not so good a reflector of light as that of our earth. It is about equal to that of ordinary sandstone. Shadows on the moon are very sharp. This is due to the absence of *diffused light*. Diffused light is light scattered in all directions by tiny reflecting surfaces. The earth's atmosphere contains millions of these tiny reflecting surfaces and so diffuses light in all directions. Therefore, when there is an atmosphere such as our earth possesses, an object held in a bright light does not cast nearly so sharp a shadow as that cast by the mountain peaks on the moon, which has no atmosphere.

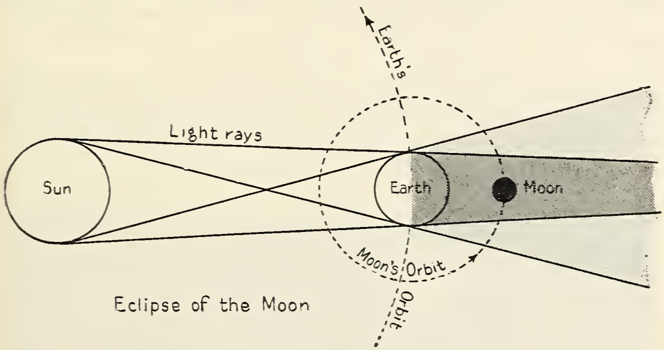
Field Research:

Hold an object between a bright light and the wall. Do you observe two depths of shadows — one darker than the other? How could there be any light behind the object, if it did not come in from the sides as diffused rays?

32. No Sound on the Moon. — When a person on the earth speaks, his voice is carried in all directions by a wave-like motion of the air much as waves spread from a stone thrown into water. On the moon there must be absolute silence, for there is no air to carry sound.

On the earth we are conscious of the air because it moves, fans our faces, blows dust into our eyes, carries clouds along with it, even tears down buildings and trees, and carries sound to our ears. Yet fully to realize all that air means to us we must think of what we should miss if there were no air.

Another curious thing about the moon is that it rotates on its axis only once in about twenty-nine days; hence a complete day on the moon is nearly as long as our month. At any one place on the moon there would be continuous daylight for a little more than fourteen days and then utter darkness for another two weeks of our time. Now it happens that because the moon's time of rotation on its axis is nearly equal to its time of revolution around the earth, we see only one side or portion of the moon. This explains why we always see the same "man in the moon." No one on earth has ever seen the other side of the moon. Actually, 59% of the moon's surface has been observed at one time or another. Forty-one per cent will never be seen.



Eclipse of the Moon

33. An Eclipse of the Moon. — Because the moon is visible by the reflected light of the sun, you can understand that if an object passes between the sun and the moon, some of the light will be cut off. The moon would then be partly invisible.

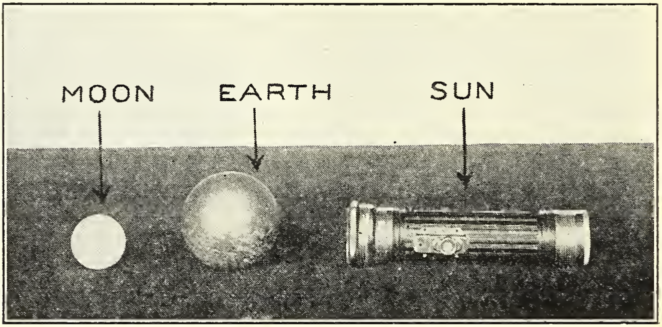
This is just what happens when an eclipse of the moon occurs. It is the earth itself that gets in between the sun and the moon. The sun, earth, and moon get into a straight line so that the shadow of the earth falls upon the moon.

The shadow of the earth frequently covers a portion only of the moon's face, and then we have what is known as a *partial eclipse.* Because the edge of the earth's shadow on the moon's face is always circular, we know that the earth is round like a ball, for only a round object can make a circular shadow if it is turning on an axis all of the time.

Experimental Problem 2. — *What causes an eclipse of the moon?*

What to use: A golf ball (moon); an indoor baseball (earth); and a flashlight (sun) or a stereopticon lantern.

(The flashlight is not a true illustration of the sun, for the sun should be many, many times larger than the earth. Also if an indoor baseball represents the earth, the golf ball is much too large to represent the moon proportionally. With these differences in mind, however, these objects will serve for the experiment.)



Experiment 2

Do you think these objects truly represent the relative sizes of the moon, earth, and sun?

What to do: Make the room as dark as possible. Adjust the flashlight to give a broad beam of light. From behind the class let a pupil turn the light on the golf ball, held in front and rather high. Let another pupil slowly pass the "earth" between the "sun" and the "moon."

Find a location for the "earth" where the shadow of the "earth" just covers the "moon" (total eclipse).

Now move the "earth" so as to cause a shadow to appear on the edge of the "moon" and to cross the face of the "moon," passing off the "moon" on the other side.

Make the shadow move from right to left as it moves over the "moon."

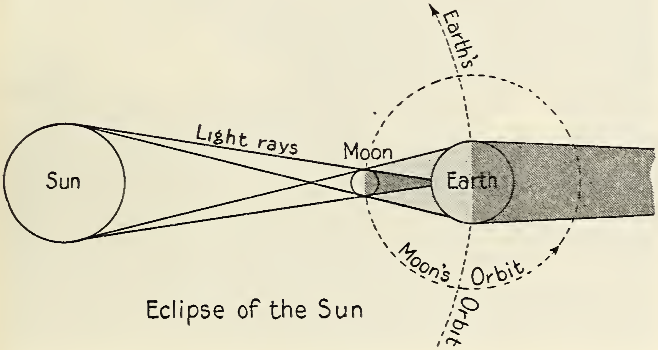
Try to find a location for the "earth" so that only a portion of the "moon" will be covered as the "earth" is moved (partial eclipse). Turn the "earth" as if on its axis.

What happens: 1. Could you see the shadow on the "moon"? 2. Was it circular? 3. Did it continue circular in shape as the "earth" turned on its axis?

Conclusion: 1. What causes an eclipse of the moon? 2. Why is the eclipse total sometimes and partial at others? 3. How does an eclipse of the moon help to prove that the earth is round?

Application: Explain how the moon might eclipse a star or planet.

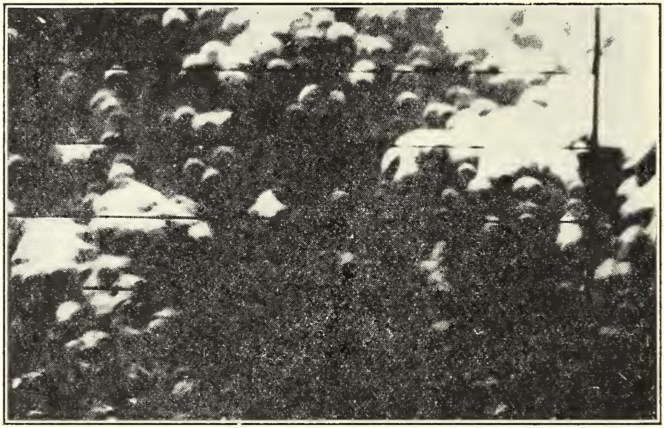
34. An Eclipse of the Sun. — Once in a while the moon gets between the earth and the sun and cuts from our view a portion of the sun's face, causing an *eclipse*



Eclipse of the Sun

of the sun. There is an interesting observation to make at such a time. Smoke a piece of glass by setting fire to a very small piece of camphor gum placed on a piece of sheet iron or asbestos. Camphor gum burns with a low temperature and produces a very dense smoke. The flame can be extinguished by blowing on it. With this smoked glass through which to look at the sun during the eclipse, you can see the shape of the moon silhouetted against the face of the sun. The shape will be circular. What does this prove?

Still another interesting observation to make before and during an eclipse of the sun is to note, as the sunlight shines through tiny openings of the leaves of trees, the shape of the lighted areas where the sunlight falls. Usually these areas are circular in shape, but, during a solar eclipse, the shape is crescent because part of the light is cut off by the moon and the spaces through the leaves are small enough to act like a hole of a pinhole camera to reproduce an image of a bright object.



Courtesy "Science Service"

Crescent Images during the Solar Eclipse of August, 1932

This is how the crescents appeared on the side of a house.

Field Research:

Learn how to make a camera obscura (pinhole camera) to demonstrate the shape of images of bright objects.

Experimental Problem 3. — *What causes an eclipse of the sun?*

What to use: Use the same apparatus as in the preceding demonstration.

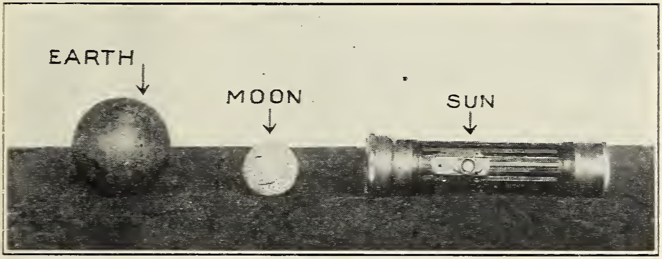
What to do: Think out for yourself how to arrange the golf ball, baseball, and flashlight to cause a shadow of the "moon" to be cast on the "earth."

What happens: Make a drawing to illustrate what happens.

Conclusion: What causes an eclipse of the sun?

Application: Using a pencil, an electric light bulb, and a piece of paper demonstrate the cause of the shadow having a darker and lighter portion (umbra and penumbra).

The most recent total eclipse of the sun visible in the United States and Canada occurred August 31, 1932. Not again until July 20, 1963,[1] will another total eclipse of the sun be visible in any part of the United States. The eclipse of 1963 will be visible in its totality in Vermont, New Hampshire, and Maine.



EXPERIMENT 3

Compare the positions with those in Experiment 2.

In 1970, on March 7, a total eclipse will be visible in Florida. Others will occur in 1979, 2017, 2022, 2045, visible as total eclipses in various parts of the United States.

The eclipse of 1932 was predicted by astronomers many years in advance. Not only was the day and year predicted, but the hour and minute when it would start and end. The exact path and width of the shadow of totality was predicted so people could go to that area and be sure of seeing the sun in a total eclipse. Only the cloud masses could not be foretold and in some localities they spoiled observations by obscuring the sun.

[1] Data from *Science News Letter,* July 30, 1932.

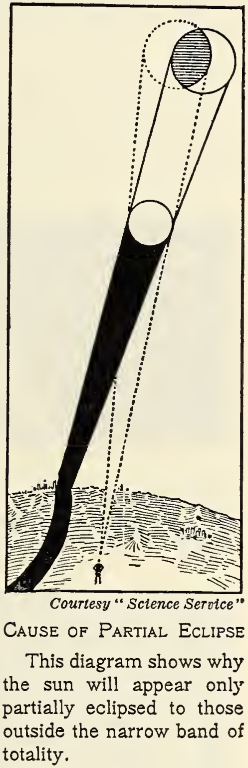
Of course, the eclipse was seen as a partial eclipse by people all over the United States. The diagram on

THE SOLAR ECLIPSE OF AUGUST, 1932

About twelve minutes elapsed between the first exposure and the last.

the next page shows how the sun could be seen as a total eclipse to some people and as a partial eclipse to others.

As the moon, invisible in the bright light, comes between the observer and the sun it appears through a smoked glass as a dark circular object making a curved nick in the edge of the sun. As the moon covers more and more of the sun, the world grows dark with a weird disappearing light. The shadow of the moon moves across the earth at a speed of 2000 miles per hour. Animals prepare for the night, stars and planets shine. When the sun's disk is all covered, flames of hydrogen and other gases flash from behind and form a lighted corona.



Courtesy "Science Service"

CAUSE OF PARTIAL ECLIPSE

This diagram shows why the sun will appear only partially eclipsed to those outside the narrow band of totality.

The totality on August 31, 1932, lasted only about 100 seconds, viewed from the center of the path. During this brief time astronomers from all parts of the world made observations from land and from airplane. Months of preparation had been required to set up and test instruments for use those few seconds. Men and women practiced their manipulations ahead, timing every action, because if there were a slip, a mistake, or a wait, all would be lost in the quest for the knowledge that could be gained only during those 100 seconds, and not again for thirty years.

Field Research:

Look up some of the earliest records of eclipses and report your findings to your class.

35. The Moon's Travels. — Is there anyone who has observed the full moon on a cloudless night and not marveled at its beauty and wonder? Coupled with one's interest is always the question, "Why is the moon full?" "Why is there a half moon?" These questions are not difficult to answer, if you will reason carefully concerning the problem they present. Since the bright side of the moon is always nearest the sun, and since the moon travels around our earth, we see that bright

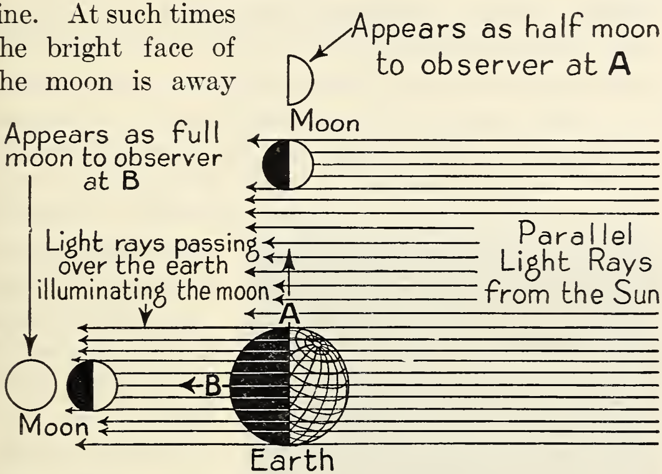
Courtesy Yerkes Observatory

PHASES OF THE MOON

Reading from left to right, the pictures show the age of the waxing moon at 2 days, 6 days, $9\frac{3}{4}$ days, and $14\frac{1}{2}$ days. For each phase, determine the position of the sun with respect to your position as you view the moon.

side in various stages or phases. The *phases* (shapes) *of the moon* in order of appearance are called: *new moon, first quarter, full moon, third quarter.* They really tell us how much of the moon's journey around the earth each month is completed. Starting with the thin crescent of the "new" moon, the completion of the first quarter of the journey is indicated by a "half moon"; the "full moon" tells us the journey is half done; the "half moon" that follows the full moon marks the finish of the third quarter of the journey. With the next new moon the complete journey has been made and a new one started.

As the earth and moon swing in their courses, the sun, moon, and earth regularly fall into a nearly straight line. At such times the bright face of the moon is away from us and the moon is faintly visible only as revealed by the reflected light of the earth. This is the time of the new moon.



Phases of the Moon Explained

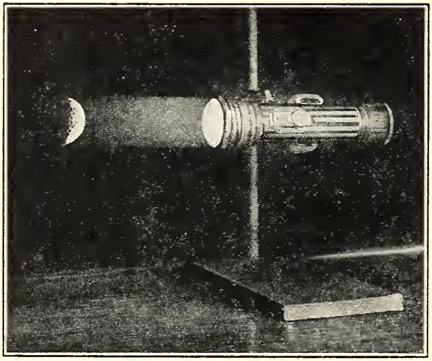
As the companions journey on a little farther, the sun's rays strike the moon at an oblique angle from our right, and we see a small strip of crescent-shaped light on the moon. As the days pass on, a night comes when the sunlight strikes the moon squarely from our right as we look toward it, and we see the half circle of light (half moon). The first

"Earth-Lit" Moon

Light reflected from the surface of the earth faintly illuminates the moon.

quarter of the moon's journey about the earth is completed.

When the sun is shining on the opposite side of our earth, leaving us in darkness, you may, at the right time of the month, see the full face of the moon illuminated by the light rays from the sun which pass by and beyond our earth and strike the moon. As you stand facing a full moon, the sunshine is coming from behind you, passing a little above or below the earth. Carefully study the diagram on page 59 to help you understand these positions of sun, earth, and moon.



EXPERIMENT 4, FRONT POSITION

Suppose you could move to the right around the ball, what shapes would the lighted part assume?

When the sunlight comes from your left as you face the moon and half of the lighted face of the moon is visible to you (half moon), it shows that the third quarter of the moon's journey about the earth is finished. At that time the sun and moon are again at right angles to each other with reference to the earth.

Experimental Problem 4. — *What causes the phases of the moon?*

What to use: The apparatus of Experimental Problem 1.

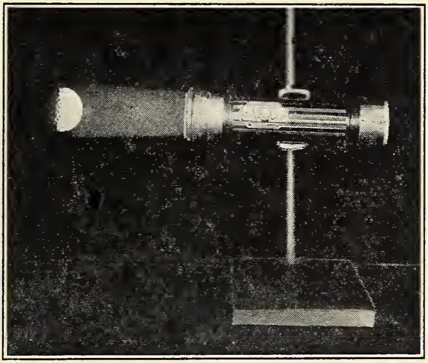
What to do: Read the text again and try to arrange the apparatus and observer so as to illustrate what you read.

What happens: Make labeled diagrams to illustrate what you do and what you see.

Conclusion: State the cause of the apparent change in shape of the moon.

Application: Explain why it is possible for Venus to appear in different phases as viewed from the earth and why Mars cannot.

From your observations and experiments you have learned that the moon does not change its shape. Its apparent change of shape is due to the fact that you see only a portion of the lighted surface at any one time. If you see the whole of the lighted surface, it is circular in shape (full moon). If you see only half of the lighted surface from one side, it looks like a half circle, for you cannot see the part not lighted (half moon). As the change from "new" to first quarter occurs, the moon appears crescent-shaped. Likewise from the third quarter to the new moon, it appears crescent-shaped. The horns of the crescent are always away from the sun. (Why?)

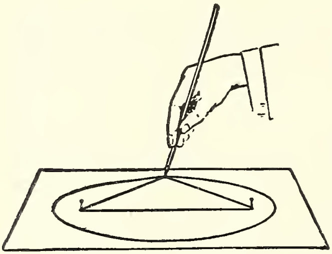


EXPERIMENT 4, SIDE POSITION

What would be the shape of the lighted part, if you viewed it from the direction of the flashlight?

36. The Path of the Moon. — In your experiments to illustrate the motions and positions of the moon, earth, and sun to explain how the moon gives off light, and what causes the apparent changes in the shape of the moon, you have probably discovered that the moon travels in a circle about the earth as a center. Also you may have discovered that the "sun" was held more or less stationary near the center of the room and that to get the light to fall on the moon from different directions, the earth and its moon were moved around the sun.

The path of the moon about the earth is called the *moon's orbit.* Likewise the path of the earth about the sun is called the *earth's orbit.* The moon's orbit is nearly circular and the earth's orbit is elliptical, that is, one diameter is longer than the other. The actual line of the path forms an *ellipse,* that is, a somewhat oval figure. (Practice drawing an ellipse as in the accompanying diagram, using a string, two pins, your pencil, and paper.)



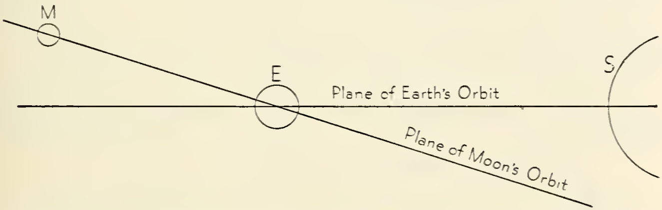
Drawing an Ellipse

The orbit of the moon and of the earth each determine a plane. It happens that the earth's orbit and the moon's orbit are not in the same plane. Instead, they are on planes that form an angle with each other. In other words, if viewed from one edge, the plane of the moon's orbit would intersect the earth's orbit plane in such a way that part would be a little below and part a little above the plane of the earth's orbit.

To illustrate the angles between the earth's orbit and the moon's orbit, draw an ellipse on a piece of stiff paper or cardboard to represent the orbit of the earth. The longest diameter should be about one thirtieth as long again as the one which crosses it at right angles. The paper itself represents the *plane* of the earth's orbit. Draw circles to represent the earth in four positions on the orbit.

On another piece of paper draw a small circle to represent the moon's orbit. That paper represents the plane of the moon's orbit. Then draw smaller circles to represent the moon in four positions on its orbit.

Now draw the sun in the center of the earth's orbit on the paper. It will, of course, be in the same plane. Cut out the moon's orbit and place it in a slit at the



THE PLANE OF THE MOON'S ORBIT CROSSES THE PLANE OF THE EARTH'S ORBIT AT AN ANGLE

edge of the earth's orbit. The two pieces of paper should not be in the same plane. The plane of the moon's orbit should be at a small angle to the plane of the earth's orbit.

Partial and total eclipses are due to the fact that *the planes of the orbits of the earth and the moon make an angle with each other.* The varying positions of the rising and setting moon are also due to the angle between the planes of the orbits.

KEY WORDS

atmosphere	moon	revolution
eclipse	orbit	rotation
energy	phase	solar system
force	plane	space
gravitation	planet	sun
horizon	radiation	sun spot
illuminate	reflect	telescope

Key Statements

1. The sun is the largest body in our solar system.
2. The planets revolve around the sun, all in fixed courses, but at different distances from it.
3. The force of gravity is greater on a large, heavy body than on a small, light one.
4. Directly or indirectly, practically all of the energy used on earth comes from the sun.
5. The sun, the nine known planets, and the many small bodies revolving about the sun, make up the solar system.
6. Sun spots are caused by terrific storms on the sun.
7. Radio, Aurora Borealis, magnetic condition of the earth, and world weather conditions are related to sun-spot activity.
8. Moonlight is sunlight reflected by the moon.
9. The moon belongs to and revolves about the earth.
10. The moon is a comparatively small, cold body without an atmosphere.
11. An eclipse of the moon occurs when the earth is directly between the sun and the moon. The shadow of the earth passes over the face of the moon.
12. The shadow of the earth on the moon is circular, which helps to prove that the earth is round.
13. An eclipse of the sun occurs when the moon is directly between the sun and the earth.
14. Eclipses can be predicted many years in advance.
15. The different phases of the moon are due to the different directions, with respect to the observer, from which the light rays from the sun strike it.
16. The four phases of the moon are called new, first quarter. full, and third quarter.
17. The new moon occurs when the moon and sun are in line with the observer, — the sun behind the moon.

    The full moon occurs when the sun and moon are opposite each other, — the moon in front and the sun behind the observer.

    The first and third quarters occur when the sun and moon are at right angles to each other with reference to the earth.
18. An orbit is the path traveled by a planet or other celestial body around a central object.

Thought Questions

1. What are some of the consequences of the great size and weight of the sun?

2. About how heavy would this book be if the earth were as large as the sun? or as small as the moon?

3. Explain how the electric energy produced at Niagara Falls or some other waterfall really comes from the sun.

4. If the moon is a "cold" body, how is it that we can see it at night?

5. Why is the force of gravity less on the moon than on the earth?

6. What would be some of the consequences of no atmosphere on the earth?

7. What causes an eclipse of the moon? of the sun?

8. Does the shape of the moon really change? Explain.

Projects for Your Science Discovery Book

1. Make a list of the activities that would be impossible if the earth were as large as the sun, and tell why.

2. List six ways in which you are dependent directly or indirectly upon the energy from the sun.

3. Locate Cassiopeia by sky observation and place it on your star map. Look up the stories of Cassiopeia and give an account of one to your class.

4. Locate Cygnus by sky observation and make a map of its near-by stars.

5. Locate Vega by sky observation and indicate its location on your star map.

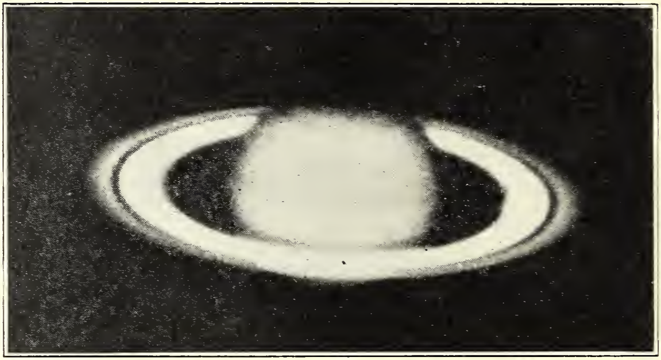
6. Locate Arcturus and show its position on your star map.

7. Locate Pegasus and Andromeda by sky observation. Look up the story of Pegasus and Andromeda and write a story about them.

8. Through a small telescope or powerful field glass observe the moon when it is crescent-shaped and when it is full and make drawings of what you see.

9. Observe the phases of the moon over a month's time and record drawings and observations.

SURVEY OF TOPIC III



Although we talk about the stars twinkling, not all "stars" twinkle. Some shine with a constant, steady light and move about the sun in nearly circular paths, at varying distances from the earth. "They are the gypsies of the sky." Seen through a small telescope they appear as disks, while other stars seem like mere points of light. These gypsy stars are not properly called stars; they have a more descriptive name — planets.

The planets, of which our earth is one, form a family of relatives with whom you should become well acquainted. Four of them are easily seen with the unaided eye; once you know them by name and have learned something about them and their motions, you will get much pleasure out of watching for them on their regular visits. For, as we have already said, they travel in pathways around the sun, just as we know the earth does, each turning on its own axis as it journeys in its orbit. When we have studied these planets, we shall discover the family tie which binds them together in their ageless and never-ending wandering.

TOPIC III

OUR SOLAR RELATIVES, THE PLANETS

I saw Eternity the other night,
Like a great ring of pure and endless light,
All calm as it was bright:
And round beneath it, Time, in hours, days, years,
Driven by the spheres,
Like a vast shadow moved, in which the World
And all her train were hurl'd.

— H. Vaughan

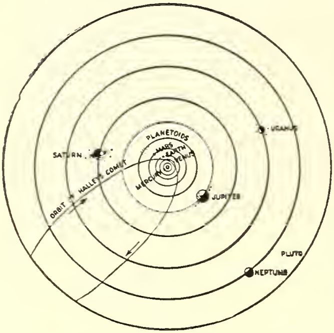
Do you know:

1. **How to tell a planet from a star?**
2. **The names of the planets in our solar system?**
3. **What a "morning star" is? an "evening star"?**
4. **What causes the tides?**
5. **Whether or not there is more than one universe?**

General Problem 1. What Are the Family Traits and Names of the Solar System?

37. The Sun's Family. — From your observations night after night, and from the star maps you have made, you have discovered that to the eye the stars of the Big Dipper do not change their relative positions. They always form the shape of a dipper. The stars in the "W" of Cassiopeia do not change their relative positions, nor do the stars in the cross of Cygnus. These bright bodies of the heavens which do not visibly change their positions in relation to each other are sometimes called *fixed stars*.

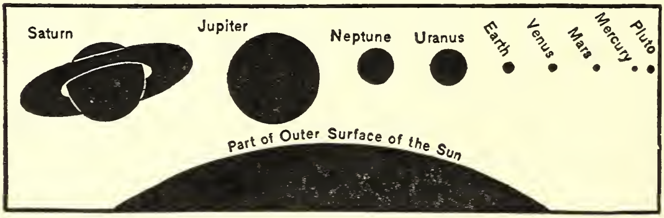
In contrast with the fixed stars there are certain other celestial bodies called *planets*, from the Greek word meaning "wanderer." The planets visibly change their positions in relation to each other and to other heavenly bodies. The paths of these planets are constant and well known to astronomers, who can tell you just when and where you can observe them.



Orbits of the Earth and Other Planets

Some of the planets look much brighter than the stars because they are so much nearer and because their surfaces are good reflectors of light. All of the planets are illuminated by light from the sun.

In the order of their distance from the sun, the nine known major planets in the sun's family are *Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune,*



Comparative Sizes of the Planets

and *Pluto*. There are a large number (about one thousand) of very small planets revolving around the sun, but we do not have occasion to study them at present.

38. Long-Distance Journeys. — The earth is nearly a spherical body flattened a little at the poles. We know that it travels around the sun in an elliptical path called its "orbit," although in ancient times men thought that the sun and all the other bodies in the heavens revolved about the earth. It takes 365¼ days for the earth to make its journey around the sun, while Mercury, the smallest of the planets and the one nearest to the sun, completes the revolution in 88 days. Neptune, nearly 2800 million miles from the sun, requires 165 of our years for one revolution. In other words, Neptune's year is 165 times longer than the earth's. Pluto, the most recently discovered major planet, requires 247.7 times as long to make one complete revolution about the sun as does the earth. These planets are all revolving around the sun in about the same plane (page 62) as the earth.

MARS
Note the Polar Cap.

39. "The Red Planet." — Mars is one of the planets about which we hear many things. It is about one and one half times as far from the sun as the earth, and it takes 687 days for Mars to revolve once around the sun. This means that a year on Mars (reckoned in our time) is nearly twice as long as a year on the earth.

In some respects the earth and Mars are alike. It is probable that Mars has a thin layer of gases or atmosphere. It is known as "The Red Planet" because of the color of light which it sends out. There seems to be vegetation on Mars, but its character is not definitely known by the scientists. Both the earth and Mars are cold bodies, receiving heat and light from the sun. Since Mars is farther from the sun than is the earth, it receives on the average only about as much heat as our polar regions receive. Vegetation, therefore, must be unlike that of the earth. Since it has less atmosphere than our earth, animal life, if there is any, would differ from that on earth.

JUPITER AND ITS MOONS

What evidence can you see that the moons revolve about the planet?

Mars rotates on its axis once in a little more than 24½ hours, so the length of day is not very different from our day.

40. The King of Planets. — Jupiter is a planet a thousand times larger than the earth. Although Jupiter is 88,392 miles in diameter, it is so far away that it looks like a small star, whereas the moon (2160 miles in diameter), only 240,000 miles away, looks large.

Through a large telescope Jupiter is seen to possess nine moons which revolve around it as our one moon does about the earth. The moon nearest to Jupiter takes only about eleven hours to make one revolution. A small telescope will serve to reveal four of these moons. Galileo discovered them first with his new telescope in 1610.

Field Research:

Secure a small telescope or good field glass. Arrange to steady it on a support. Then when Jupiter is in a good position for observation, try to discover the four moons that Galileo saw.

There is evidence that Jupiter has a dense, extended atmosphere, full of yellow and red clouds. It is, however, probably an atmosphere different in composition from ours. For a long time astronomers thought Jupiter was hot; but we now know it is cold.

An interesting fact about Jupiter is that its polar diameter is nearly six thousand miles shorter than its

VENUS *Courtesy Mt. Wilson Observatory*

Venus, being nearer the sun than the earth is, appears in phases like the moon. These pictures were made in 1927 on the following days: June 6, June 21, June 26, July 6, and July 27. Was Venus waxing or waning?

equatorial diameter, and that it rotates much faster than the earth, once in a little less than six hours, or four times faster than the earth.

The flattening of the earth, and of Jupiter, is thought to be due to their whirling motion when they were plastic.

41. Venus. — Venus, the planet nearest to the earth, is a globe about the size of the earth, completely enveloped in fleecy clouds. It is about 67 million miles from the sun; yet we rarely see it in the night sky, for it never gets very far from the sun. It appears at twilight in the western sky, or just before dawn in the eastern sky; and when, in its orbit, it is on the same side of the sun as the earth, and nearer to the earth, it shines with great brilliancy. Its apparent shape is then like the crescent of the new moon. When it is farthest away, behind the sun, the sun's light falls on the whole of its face and it appears circular, like the full moon. Thus it shows phases, quite as the moon does, though they are not visible to the unaided eye. However, Venus is so bright that sometimes it can be seen in full daylight, if one knows just where to look.

Alike as Venus and the earth are, their atmospheres are very dissimilar. Water and oxygen, so necessary to earthborn creatures, are very rare on Venus. That fact seems to prove that there is no vegetation there, since it is earth's vegetation that supplies oxygen to earth-atmosphere.

Field Research:

The axis of Venus is nearly vertical. What effect would this have on the seasons of Venus?

42. Morning and Evening "Stars." — Trailing ahead to herald the rising sun, Venus is a sight well worth our getting out before sun-up to see. At certain seasons this beautiful star can be seen leading the sun across the sky and disappearing below the horizon before the sun gets there, to reappear ahead of the sun the next morning.

Then the setting changes and Venus follows the sun across the sky and can be seen as the Evening Star soon after sunset. But Venus appears to lose a little every day and so sets later and later after the sun until it becomes a morning star again.

Reference to the diagram (page 68) will help you to understand this interesting result. Because Venus is revolving about the sun inside the orbit of the earth, we see it part of the time to the right of the sun, that is, west of the sun; it appears to precede the sun in its path, hence it rises ahead of the sun and is a "Morning Star." However, a little later Venus appears to the left of the sun, that is, east of the sun, when it appears to follow the sun and hence sets later than the sun. It is then the "Evening Star."

There is another "Evening Star" which may be seen in the spring, very soon after sunset, and as a "Morning Star" in the fall. It is Mercury, the planet next nearest earth after Venus, and so near the sun that we never see it in the night sky. Because of its nearness to the sun, the Greeks believed that Mercury was a close friend of Apollo, the sun-god.

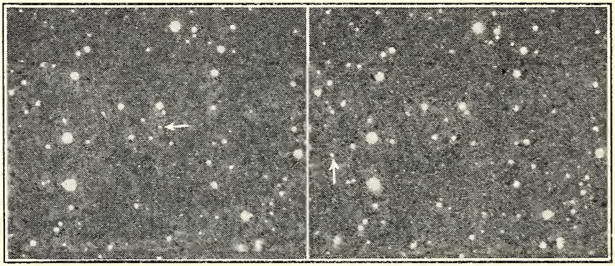
Mercury is considerably smaller than the earth, about the size of the moon, and because of its nearness to the sun it would be an uncomfortably hot place in which to live. It turns on its axis at about the same rate of speed that it moves around the sun, so that the same side is always exposed to the sun's heat.

Mercury's orbit, like that of Venus, is inside the earth's, so that it appears to go through phases, just as Venus does. And since the light reflected from its surface is like the light reflected from the moon, it is possible that the surface of Mercury is spotted with dead volcanoes, just as the moon's surface is.

43. Pluto. — The planet Pluto, the most recent addition to the solar family, was discovered in March, 1930. Its existence and position, however, had been predicted fifteen years earlier by Professor Percival Lowell of Flagstaff Observatory, Arizona.

Pluto is nearly forty times as far from the sun as is the earth. It requires 248 of our years for Pluto to make one revolution about the sun. And it takes from four to five hours for light to reach us. In size Pluto is thought to be comparable to Mercury.

The story of the discovery of Pluto is similar in many respects to the discovery of the planet Neptune many



Courtesy Lowell Observatory

January 23, 1930 January 29, 1930

PLUTO, THE NEW PLANET

What do the arrows show?

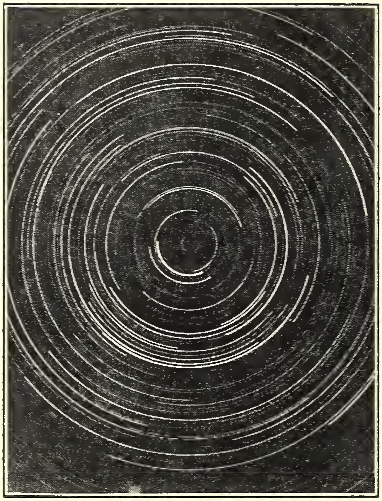
years previously. About a hundred years ago the planet Uranus was thought to be the most distant planet of the sun's family. However, astronomers and mathematicians knew the paths planets should take as determined from their size, weight, distance from the sun, and other properties. They found that Uranus, for some reason or other, did not move in the particular path they thought it should. Two young mathematicians and astronomers decided there must be another planet outside of Uranus which exerted gravitational forces upon Uranus, causing it to move in a different path than it would otherwise. Therefore, they assumed the presence of such a planet and calculated where it would be. Later the planet Neptune was discovered almost exactly where these young mathematicians had predicted.

However, even the existence of Neptune and the effects of its gravitational force were not enough to explain entirely why Uranus did not travel the path that it should. This led Professor Lowell to assume another planet still farther from the sun than Neptune, and he calculated its position and how it would move. His calculations resulted in the discovery of Pluto.

The discovery of these two planets after their prediction by scientists is an excellent example of the way in which scientists work in making new discoveries. Based on the motions of the planets already known, it depended on the laws of gravitation, for which we honor Sir Isaac Newton. It is striking evidence of the accuracy of the method of science.

44. Merry-Go-Round. — The rising and setting of the sun and the rising and setting of the moon are events of such common observation as to require no discussion, if it were not for the fact that their motion is apparent rather than real. Have you ever had the experience on a train or trolley car of thinking that a near-by car was moving when all the time the movement was that of your own car? In much the same way we can understand the *apparent* movement of the sun, the stars, the moon, and the planets, from east to west in our sky.

The earth *rotates* (*turns*) *on its axis from west to east.* Hence an object in the sky that is comparatively stationary in the sky pattern is seen first at the point where the earth and sky seem to meet in the east. As the earth continues to turn toward the east, the horizon line, where the sky and earth seem to meet, changes and the object appears to move upward through the sky, until it reaches a position directly overhead. As the earth turns still farther, the object appears to move closer to the western horizon. Consequently the sun and the moon appear to move, when actually it is the earth which moves and thus causes the march of these objects across our sky.



Courtesy Norman Lockyer Observatory

THE NORTH POLAR STAR-TRAILS

An exposure of eight hours shows the movements of the stars like grooves on a phonograph record.

For the same reason, many stars at night appear to rise above our eastern horizon and move across the sky finally to sink below the western horizon. But it is only an apparent motion, since the earth during our night completes its rotation about its axis.

Planets, being in almost the same plane with the sun and the moon, appear to rise nearly in the same position on the horizon as do the sun and the moon, and they take nearly the same path across the sky, setting at the western horizon. The stars each have their own parallel paths across our sky. Some, as you know, are above the northern horizon all the time. Of course another lot of stars have their paths above the southern horizon and are seen by people living south of the equator.

Why do not the sun and the moon rise and set at the same places on the horizon at different seasons? (Refer to page 62.)

45. Catching up with the Moon. — You have learned that the moon not only turns on its own axis, but that it also revolves about the earth from west to east. Therefore, the apparent speed of the moon (which is due principally to the rotation of the earth) is different from that of the stars or the sun, for they do not revolve directly around the earth.

The stars rise about four minutes (exact, 3 minutes 56 seconds) *earlier* each night, while the moon rises about fifty minutes *later* each night. It takes that fifty minutes more than twenty-four hours for an observer at a given place on the earth to catch up with the moon and see it again at the eastern horizon. It is, therefore, fifty minutes later by the clock each night when the moon rises.

Field Research:

Note the times given on a calendar for the rising of the moon each night and compare with your own observations.

General Problem 2. Are There Other Worlds Than Ours?

46. A Task for Your Imagination. — How far will your imagination reach? Are you satisfied to think of our own solar system with its planets or would you like to think on and on and out still farther beyond them into space?

The stars that you see are suns, many of them thousands of times larger than our sun. They are thought to form a great group, shaped like a huge lens, or perhaps like a wagon wheel, with most of the stars out near the rim. These star clusters, or island universes, are called *galaxies*. The diameter of our galaxy is possibly about 200,000 light years and its thickness is about 60,000 light years. These dimensions are approximate only, since thus far it has been impossible to

Courtesy Yerkes Observatory

THE GREAT NEBULA IN ANDROMEDA

measure them accurately. *A galaxy, then, is a great system of suns having an orderly motion and development.*

Our galaxy, whose outer rim is the Milky Way, is thought to be rotating like a great wheel once in about 240,000,000 years, and it may contain a hundred, or several hundred, thousand million stars. One of these stars is our sun, which is perhaps a third or more of the distance from the hub to the rim of the wheel. On this basis our sun with its family of plants is traveling perhaps 200 miles per second in its journey through space.

But this wheel-shaped system of stars is not the only system. Far out in space, almost beyond the power of the most powerful telescope, are other island universes. So far away are these star clusters that they look like dim clouds of light, and hence were called *nebulae*, a Latin word meaning "clouds." Beginning as revolving balls of atoms they flung out long wisps or streamers which broke up into thousands of sparkling objects called stars. The brightest of these, the great *Andromeda nebula*, can be seen with a telescope. It was long considered to be a mass of gas among the stars. Now the astronomers have evidence tending to prove that it is not a mass of gas but a galaxy, 800,000 light years away, and 40,000 light years from side to side, similar to our own galaxy in size and grouping of suns. Such thoughts are like stepping out into space and looking back at our own starry system. Where does it all end? No one can say.

General Problem 3. How Has It All Happened?

47. Theories Change. — The past can be inferred only from happenings of the present, and only infinite wisdom can truly picture the past. However, as scientific instruments are improved and new ones invented, new facts are discovered. On the basis of new discoveries, naturally the theories about the origin of the solar system with its planets, the relation of our sun to other suns that seem to be part of a great galaxy, and finally the relation of our galaxy to the millions of other galaxies have changed from those of Ptolemy, Copernicus, and Laplace. And present theories will change as new facts are discovered and more accurate measurements are made. If theories add to our understanding of the universe and of ourselves, and if laws can be discovered, then our efforts are worth while.

48. An Orderly Development. — In a sense, astronomers are viewing the past from to-day since the light reaching us to-day from far-off bodies really started on its way hundreds, thousands, even millions of years ago and so present pictures of things as they were in the distant past.

Just as Nature's activities to-day proceed with systematic order that may be expressed as laws, so it is thought that there has always been an orderly development throughout the ages. If this is true, it enables us to infer the happenings of the past by means of our knowledge of the happenings of to-day.

To tell the story of the beginning of the universe and its development in a few simple sentences is like trying to paint a great picture with one color, or one line. All details and supporting evidence must be omitted. However, as you go on with your study of science you may find the evidence and detail for yourself. Perhaps you will discover the divine guidance in it all.

49. A Developing Universe.[1] — From the many facts that are known to-day it may be assumed that the

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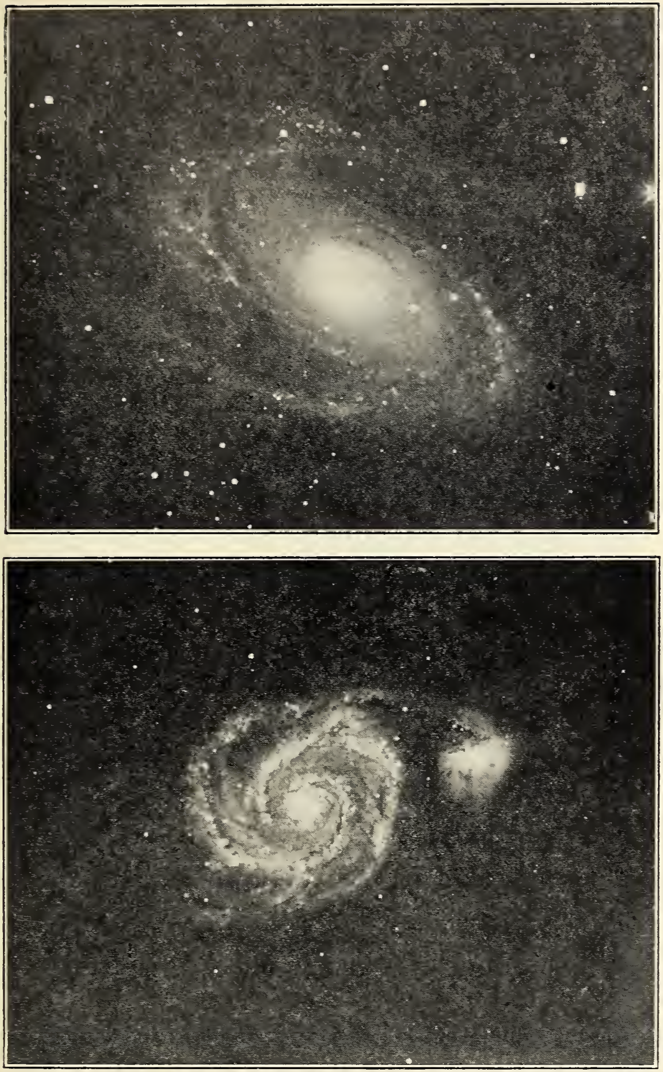
[1] Much of this discussion is based on a lecture by Sir James Jeans, published in The Report of the Smithsonian Institution, 1931.



Courtesy Mt. Wilson Observatory

SPIRAL NEBULAE

Fluffy balls of gas, such as these, become cities of stars.

material of all the universe was once a mass of gas, uniformly diffused through space, thousands of millions of light years in diameter and in rotating motion. The rate of motion changed and condensations occurred which may have resulted in the formation and separation of millions of nebulae at great distances from each other. These nebulae, starting out like fluffy balls of gas, end up as cities of stars. It is known that some 2,000,000 nebulae exist within a distance from the earth of about 140,000,000 light years, each nebula similar in many ways to the nebula in Andromeda and to the nebula of which our sun is a part.

Sir James Jeans [1] gives our imagination a help to picture this huge array:

"To construct a model, we may take 300 tons of apples and space them at about 10 yards apart, thus filling a sphere of about a mile diameter. This sphere is the range of vision of the 100-inch telescope; each apple is a nebula containing matter enough for the creation of several thousand million stars like our sun; and each atom in each apple is the size of a solar system with a diameter equal to or slightly larger than that of the earth's orbit."

Changing speeds of motions and other forces may have caused a rotating nebula to form with spiral arms thrown out from the central mass. Condensation in these arms perhaps forms stars or suns. Possibly these great suns and our sun reproduced on a small scale the great nebula and in turn threw out arms of gas influenced by the force of attraction of passing

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[1] *An Evolving Universe* by Sir James Jeans. A lecture delivered May 18, 1931, published in The Annual Report of the Smithsonian Institution, 1931.

Would You Believe!

Would you believe that a falling apple could have a profound effect on science for hundreds of years to follow? No? Well, that is just what happened.

A student 23 years old was sitting in his garden in deep thought when he was startled by the thud of a fallen apple. *Isaac Newton*, for it was he who was startled, looked at the apple and at the tree and wondered. He thought to himself: "The apple fell from the tree, — it could fall from a higher tree or from the top of a mountain. Can it be that this force reaches as far as the moon, and if to the moon, why not to the sun and stars? Can it be that gravitation extends to all bodies of the universe and acts between all bodies?" He set to work investigating his problem and proved by experiments that his theory was true.

As a boy Isaac was interested in making tools of various kinds — hatchets, hammers, and saws. He made sun dials, and a clock that was caused to run by dropping water. It is not to be wondered at that a boy so ingenious should prove to have a master mind for science.

If this much about Newton is interesting why not learn more about him in a reference book? How he proved his laws, why he seldom laughed, what obstacles he had to overcome — these facts will repay your study.

stars. Condensations in these arms formed the nucleus of planets, especially our planets, with attending satellites or moons.

The planet nuclei became centers of growth by attracting more matter about them and developed into the planets as we know them to-day.

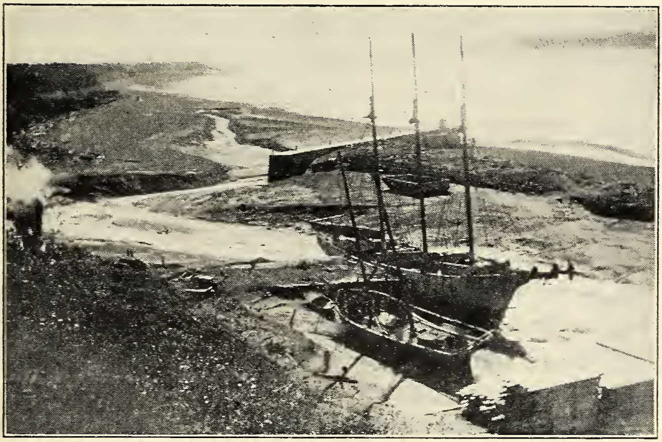
General Problem 4. What Holds the Suns and Worlds in Place?

50. Universal Gravitation. — Each one of the billion or more suns has a particular place in its own *universe* (galaxy) and has some relation to all the other suns in its universe. Out beyond, each galaxy has its place and function in a super-universe which has been described mainly from a theoretical knowledge.

The rules which produce this law and order in the universe have been recognized for hundreds of years by scientists. Early scientists knew that a stone falls to the earth because there is a *force of attraction* between the earth and a falling stone, and that unless they are held apart by some equal or greater force they will come together. You know that to be true from your own experiences.

Archimedes knew this fact, and Galileo knew it. In fact Galileo made a special study of falling bodies and learned that all bodies, large and small, fall at the same rate of speed for each second of time. He found, too, that they fall faster and faster each second.

Sir Isaac Newton went much farther in his studies of gravitation and proved to other scientists by means of mathematics and physics that the attraction which the earth has for the stone is a *universal attraction*, and



Beached by the Tide

Where has the water, as shown in the upper picture, gone? Will it return? Explain.

that *every body in the universe attracts every other body.* This is called *Newton's law of universal gravitation.*

All of the suns have an attraction or a pulling force for each other. Our sun has an attraction for our earth and all the other planets, and our earth and all the other planets have an attraction for the moon.

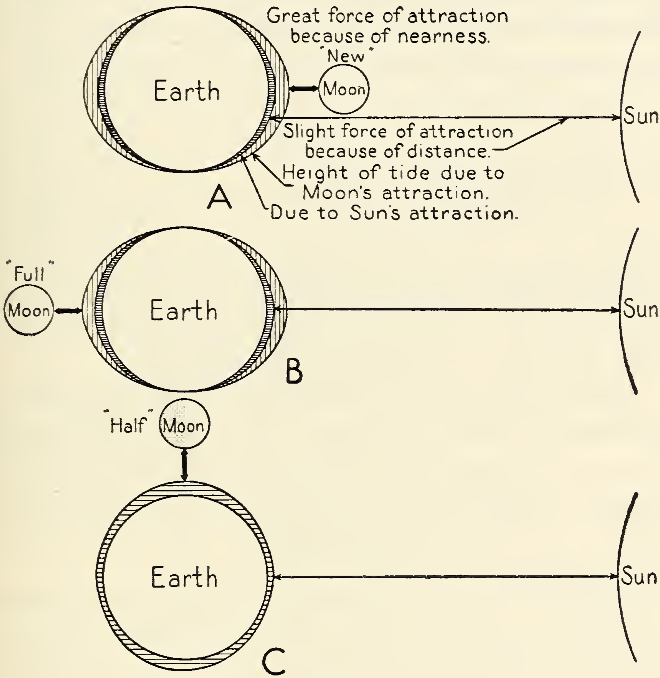
51. The Moon and the Tides. — One interesting evidence of the force of attraction between two bodies is the movement of the water in ocean *tides.* The moon attracts and actually lifts the water of the ocean nearest it into a kind of heap or wave crest. As the earth turns on its axis this wave crest shifts its position so that it is nearly always toward the moon. Of course, heaping the water in one place must make it shallower in another, and so we have *high tides* and *low tides.*

Another curious fact about tides is that a high tide occurs in the ocean on the opposite side of the earth at the same time that one occurs on the side toward the moon. This is due to the fact that the farther the force of the moon's attraction extends, the weaker it is. Therefore, the fluid water on the side of the earth away from the moon, being attracted with less force, heaps up into a wave crest like that on the side nearest the moon. Low tides occur between high tides.

Since the earth turns on its axis once every 24 hours, a high tide occurs at a given place on any ocean about every twelve hours and each high tide at that place is followed by a low tide six hours later.

52. What Holds the Earth in Place? — You are now ready to find out how it is that this earth of ours and all the other planets maintain their positions in space while they travel in their orbits about the sun.

To help you to understand the tremendous forces that hold the planets in their orbits, think of what happens when you tie a stone or an apple to a string and whirl it about your head. You know that as long as the string does not break the apple will continue in its circular



TIDES

A. The sun and moon pulling together cause highest tides. Explain *B*.
C. The sun and moon pulling at right angles. The moon's force is greater because it is so near.
Explain "New"; "Full"; "Half."

motion about your head as a center, but once it does break the apple will fly off in a straight line.

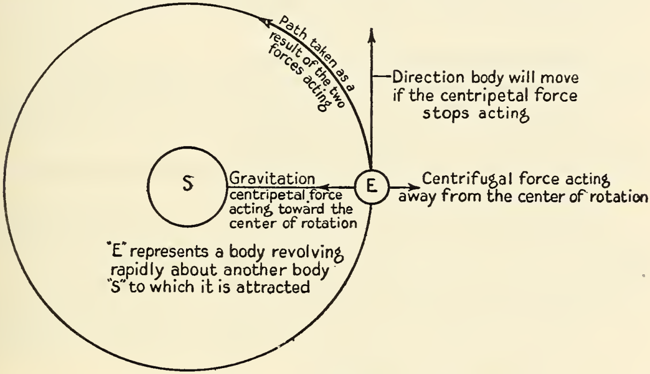
In the same manner mud flies from the wheel of a rapidly moving automobile. The mud sticks to a slow-moving wheel, and as long as the "sticking" force is greater than the "throwing" force the mud will stay on the wheel. But as the wheel goes faster, the force which tends to throw the mud from the wheel increases and the mud will fly off. The fact that the earth is revolving about the sun gives it a tendency to fly away from the sun just as the mud flies from the rotating wheel.

A force acting away from the center of a rotating body or bodies is known as centrifugal force; a force acting towards the center (like gravitation) is known as centripetal force. Therefore, there are two balancing forces in the case of the sun and the earth: one, *gravitation*, tending to pull them together, and the other, the *centrifugal force*, tending to force the earth farther away from the sun. Because of these balanced forces the earth maintains its position in its orbit.

All the other planets are also held in their places by a balancing of these two forces. Not only are the planets of our solar system held in their orbits by the balance of the force of gravitation and the forces resulting from motion, but these forces are acting to maintain the same orderly balance throughout the universe.

Perhaps now you can appreciate the gigantic scale on which our wonderful solar system is built. You can appreciate these great distances and yet you must not forget that the distances of the planets from each other and from the sun are very small when we consider the distances to other suns of the universe. For example, you have read that Alpha Centauri is over four light years away and that the North Star is two hundred seventy light years away. Many suns are hundreds, even thousands, of light years away. The nebula in Andromeda is nearly one million light years distant.

Your study of our solar system and the billion other suns of our galaxy and of galaxies out beyond reveals to you a law and order in Nature that almost surpasses human understanding. As a student of science you value facts and so should develop power to understand this gigantic universe of which our earth is such a little part. Small as you and I may be, we possess that



Centripetal and Centrifugal Forces

Explain how these forces and the earth's motions coöperate to keep the earth in its orbit.

which is greater, more wonderful, and more difficult to understand than all else in the universe, — minds with which to think, wills to direct our actions, and souls to appreciate the grandeur of the universe.

Key Words

centrifugal force	Jupiter	planet
centripetal force	Mars	Saturn
elliptical	Mercury	solar system
galaxy	Neptune	tide
Galileo	Newton	universe
gravitation	orbit	Venus

Key Statements

1. The nine known major planets are, in order of distances from the sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

2. Planets change their positions with respect to the stars, but nevertheless follow true courses.

3. The rising, the moving across the sky from east to west, and the setting of the celestial bodies are apparent rather than real movements. The apparent movement is due to the rotation of the earth from west to east.

4. Tides are caused by the force of attraction between the moon and the earth and between the sun and the earth.

5. Celestial bodies are held in their places by a balancing of the forces of motion and of gravitation.

6. Our sun and the billion or more other suns are parts of a great group of stars called a galaxy.

7. Our galaxy is thought to rotate once in about 240,000,000 years.

8. The nebula of Andromeda is an example of a galaxy beyond our own galaxy.

9. The universe is thought to consist of millions of galaxies in various stages of development.

10. Newton discovered the Law of Universal Gravitation: every body in the universe attracts every other body in the universe.

Thought Questions

1. How can you tell a planet from a star?

2. Does the sun rise, move across the heavens, and set? Explain.

3. The sun is a fixed star, yet its movements across our sky are, in general, like those of the planets. Explain this similarity.

4. What is meant by Newton's Law of Universal Gravitation? What relation has universal gravitation to you?

5. Why is it that high tides and low tides occur with great regularity?

6. Do high tides in any one locality differ in height? Do they differ from one time to another? Explain.

7. What might happen if the forces of Nature became unbalanced?

Projects for Your Science Discovery Book

1. Make diagrams to illustrate the positions of the earth and the moon during high and low tides. Is there a time of year when high tides are higher than at other times? How is it explained?

2. Make a list of the names of men and women who have contributed largely to our theories of the development of the universe.

3. Write a story of Copernicus and how his theory differed from that of earlier philosophers.

4. Construct a telescope and try to discover the moons of Jupiter.

5. If you ever listened to a broadcast called "Buck Rogers in the 25th century," did you get any ideas about the planets? How scientific do you think the facts presented were?

SURVEY OF TOPIC IV

We all know how, in our north temperate climate, flowers, trees, shrubs, and even some animals sleep through the cold winter months; birds fly south to warmer climates when the northern days grow shorter and their food becomes scarce; squirrels scurry among the fallen leaves of autumn in search of nuts to store away for winter's barren days; men plant in the spring and reap the harvest after the warm summer's sun has ripened the seeds. Eighteen hours a day, more or less, the members of the animal world (with a few exceptions) spend in work and play — then for six of the dark hours of night they sleep.

Why do these things happen? We know now that Phoebus does not drive his sun chariot over the sky and disappear at twilight over the horizon into some dark tunnel, through which he passes to appear again at dawn on the other side of the world. Instead, with clock-like precision, the earth turns on its axis and travels its appointed pathway around the sun; night follows day; spring, summer, autumn, and winter tread on each other's heels. These are the result of natural laws which mankind has no power to change. The best that he can do is to learn about them; by adjusting himself to them he can help to carry on the work of the world to better advantage.

TOPIC IV

THE ADAPTATION OF LIFE TO THE SOLAR SYSTEM

And God said,
Let there be lights in the firmament of heaven
To divide the day from the night;
And let them be for signs, and for seasons,
And for days and years.

— Genesis

Do you know:

1. What two important motions of the earth are?

2. How each of these motions affects you?

3. What causes summer and winter?

4. Why there is no winter near the equator except on high mountains?

5. What causes spring and fall?

6. How plants and animals know that the seasons change?

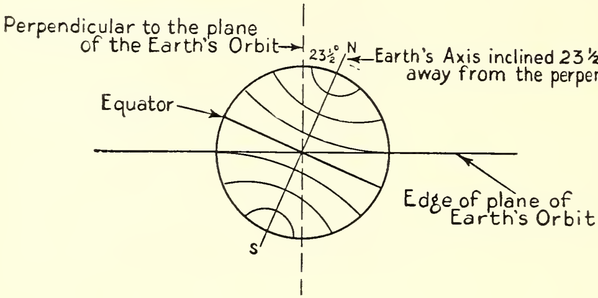
7. Why there is no twilight in the tropics.

General Problem 1. What Are the Motions of the Earth?

53. Revolution and Rotation. — From your study and observations you know that the earth has two motions: one, called *revolution,* is its journey around the sun; the other, called *rotation,* is its turning about its axis. You have learned also that the sun has in its family nine large planets all in approximately the same plane and all revolving around the sun in the same direction (diagram on page 68).

The revolution of the planets about the sun is from *west to east.* If you could look down upon our great solar system from the North Star, you would see that the sun is at the center, and that the planets are revolving about the sun *counter-clockwise* in nearly circular paths.

The rotation of the earth on its axis is also from *west to east.* If you could look at it with a telescope from the position of the North Star, you would see the earth turning *counter-clockwise.* Mars, Saturn, and



The Earth and Its Orbit

What are the effects of the inclination of the earth's axis?

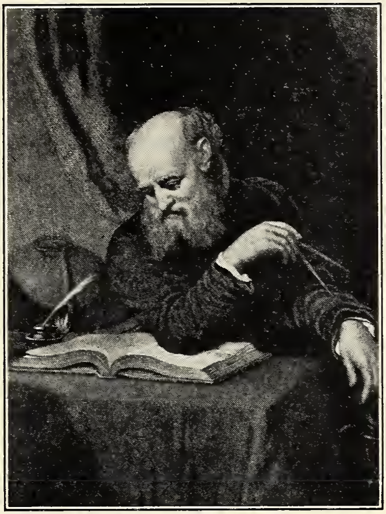
Jupiter rotate in the same direction as the earth. Uranus rotates in the opposite direction. The rotations of the other planets are not yet positively known.

54. The Axis of the Earth. — In studying the motions of the earth, we must consider not only its orbit but also the position of its axis with respect to the plane of its orbit. To understand what is meant by the *plane of its orbit,* imagine the orbit as the outer rim of a great flat surface and think of the earth as traveling around this rim.

The imaginary axis about which the earth rotates is not at right angles (vertical) to the plane of the earth's

Would You Believe!

Would you believe that a great scientist was arrested because he claimed that the earth revolved around the sun and rotated upon its axis? This actually happened to a great Italian scientist who was born of poor parents in 1564 at Pisa. As a young man he went to the university to study medicine. However, he became interested in mathematics and mechanics, and later in astronomy.



A great Greek philosopher, Aristotle, had said that a hundred-pound ball would fall a hundred times faster than a one-pound ball. Galileo — for it is he you are reading about — knew what Aristotle thought, but he believed that Aristotle was wrong. From the leaning tower of Pisa he dropped a heavy ball and a light ball together. They struck the ground at the same time. He had proved his theory.

The Greek philosopher, Ptolemy, almost 2000 years before the time of Galileo, had taught that the earth did not move and that the sun, planets, moon, and stars all revolved about the earth. Copernicus advanced the theory that the bodies revolved around the sun. Galileo proved that the rotation of the earth is responsible for the apparent movement of the heavenly bodies. He placed his confidence in facts. By trying to make his conclusions agree with the facts, he found the truth where others failed.

orbit but is inclined (tilted) at an angle of $23\frac{1}{2}°$ away from the perpendicular. The North Star (Pole Star) shows us about where the axis would pierce the celestial sphere if it were extended far enough.

In the diagram on page 98, I represents the earth with the north end of its axis tilted toward the sun. II represents the earth with the north end of the axis tilted away from the sun. Drawing III–IV represents the earth with its axis at right angles to the sun's rays. V represents the earth as if its axis were inclined 47° away from the vertical. Whatever the position of the earth in its journey around the sun, you must remember that the axis of the earth points always in one direction, namely, toward the North Star.

General Problem 2. What Is the Cause of Day and Night Varying in Length?

55. The Effect of Rotation. — The rotation of the earth on its axis causes day and night. That portion of the earth toward the sun receives light and it is day over that part of the earth. The portion of the earth away from the sun is in darkness, causing night. At all times one half of the whole earth is lighted and the other half is dark.

56. Long Days and Short. — If the axis of the earth were perpendicular to the plane of the earth's orbit, the lengths of day and night would be equal all over the earth at all times of the year. But since the earth's axis is inclined 23.5° from the perpendicular, a shortening or lengthening of day and night is caused at different seasons, except at the equator.

When the north end of the axis is inclined *toward the* *sun,* as in I in the diagram on page 98, the days in the northern hemisphere are longer than the nights. When the north end of the axis is inclined away from the sun, as in II, the days in the northern hemisphere are short and the nights are long. When the axis points neither away from the sun nor toward it, as in III, IV, the days and nights are of equal length all over the earth. This position occurs twice each year, once in the spring and again in the fall, and is called the equinox. At the equator the days and nights are always of equal length. Why?

The difference in the lengths of day and night increases as one travels from the equator toward either pole. For this reason when it is winter in the northern hemisphere, the *north pole* of the earth has night for six months and the *south pole* has day for those same six months. When it is summer in the northern hemisphere, the north pole has a six months' day.

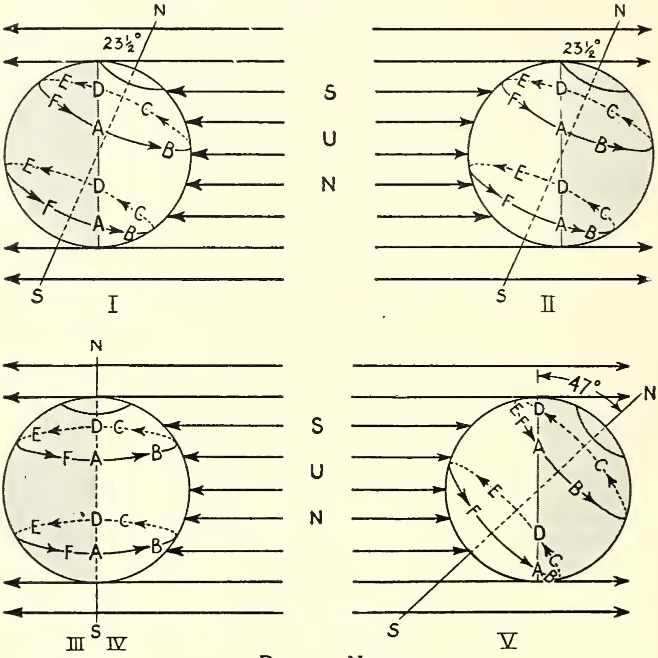
The six months' night at the north or south pole is not six months of absolute darkness. The twilight and the moon give light to the polar regions except for about three weeks.

Twilight is caused by the scattering (diffusing) of the sun's rays by dust and moisture in the air. After the sun sets, some diffused light finds its way out over the part of the earth turning from the sun. At the equator twilight is very short, while at the poles it is nearly six months long.

Do you think there can be a twilight on the moon? Why?

In diagram II, the sun is shining on the earth, lighting up one half of it. The other half is in darkness or shadow. The north end of the axis is inclined away from the sun. The diagram represents the positions of the earth when it is winter in the northern hemisphere.

Imagine that the circle *A-B-C-D-E-F* is the path you would take if you journeyed around with the earth on a



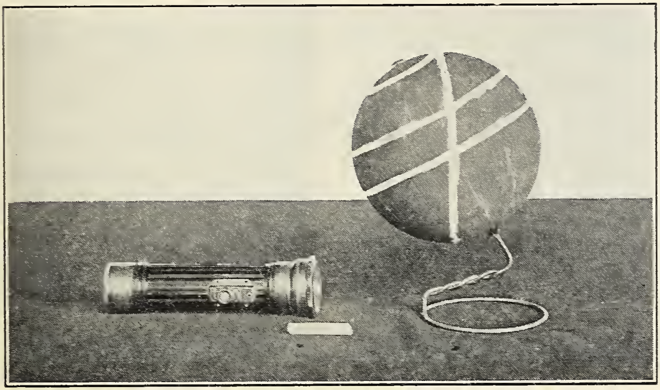
Day and Night

I represents the summer position of the earth with reference to its axis; **II,** the winter position; **III** and **IV** the spring and fall position.

V represents what would happen if the axis were inclined 47° instead of 23½°. What effect would this have on the lengths of day and night?

24-hour trip. If you start at *A* and journey with the earth to *B* and *C*, you will be traveling in darkness. When the earth brings you to the point *D*, you will come into the sunlight and it will be day. While you are being carried on to *E* and *F* and back to *A* you will be riding in daylight. Now measure your route and see how much more of it was in darkness than daylight.

On the same diagram trace a ride represented by a circle in the southern hemisphere. Will the daylight part of the ride be longer than the night? On the equator you would spend just 12 hours in daylight and 12 hours in night.



Experiment 5

Experimental Problem 5. *What causes unequal lengths of day and night?*

What to use: A six- or eight-inch slate globe on an axis; a flashlight; and a darkened room.

What to do: A. Draw a circle on the globe to represent the equator and parallel circles north and south of the equator.

B. Hold the globe in the beam of light with the axis in a vertical position.

Rotate the globe slowly and observe what proportion of each circle is in the light and in darkness during one complete turn.

C. Hold the globe to the right of the class with the axis inclined about 23½° from the perpendicular. Turn the beam of light on the globe. Rotate the globe and, as before, observe the proportion of each circle that is in daylight and in darkness during a complete turn.

What happened: In *B* what proportion of each circle was lighted? (Half, more than half, or less than half.)

2. In *C* what part of each circle was lighted?

Conclusion: What is the effect of the inclination of the earth's axis on the lengths of day and night?

Application: Why does the sun rise and set farthest north along the horizon when the days are longest in the northern hemisphere?

SUMMER AND WINTER

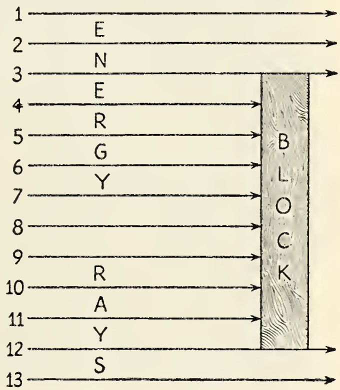
What has caused the changes in the winter picture?

GENERAL PROBLEM 3. WHAT CAUSES THE SEASONS?

57. Four Seasons. — The revolution of the earth about the sun together with the inclination of its axis causes the change of seasons. To understand the change of the seasons it is necessary to study the transfer of heat from one body to another. We must do this because the change of seasons is due to the way heating rays from the sun strike the earth.

When energy leaves a hot body, it goes out in all directions in straight lines like light rays. The energy is said to be radiated (page 49). You know that if you are facing a fireplace, the energy radiating from it strikes you in front but does not warm your back. If you would warm your back, you must turn it towards the fire. In the same way, only that part of the earth which faces the sun is able to absorb its rays of energy, and be warmed by them. When energy rays are absorbed by a substance, heat is formed. So we may speak of the energy rays which are thus absorbed as *heating rays*. This is illustrated in the diagram on page 102.

While heating rays actually go out in all directions from the sun, we are interested only in the parallel heating rays which strike the earth. The sun is so far away that all the rays that reach us are practically parallel. (Explain.)



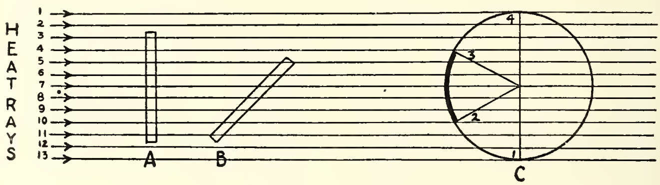
ABSORPTION OF ENERGY RAYS
What happens to rays 4–11?

If you hold your hand broadside to a hot body, more parallel heating rays will strike it than if you hold it edgewise, and you will feel more heat. To picture this condition we can use lines as shown on page 102. When block **A** is upright, nine of the parallel heating rays strike it, but if it is tipped as in **B**, only seven rays strike it in spite of the fact that its length is just the same; its position only has been changed. In other words, more heating rays strike an object when it is held broadside, that is, perpendicular to the rays, than when it is held either edgewise or in a slanting position.

Actually the nine heating rays would be absorbed by the first block. They are represented as passing on to **B** and **C** in the diagram to compare the number of heating rays that would act on equal surfaces.

In part **C** of the diagram equal lengths of arcs are marked off to show that more lines of heating rays are intercepted by the arc most perpendicular to them than by any other part of the circle.

You know that the earth receives energy from the sun; that changes in the amount of energy received by any part of the earth result in a change of temperature



HEATING RAYS
Explain **C**.

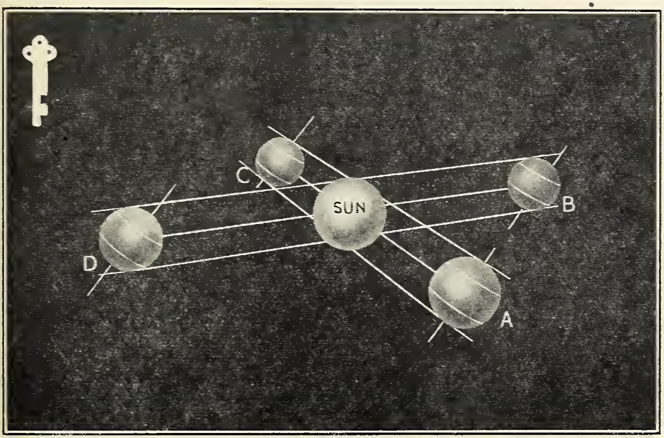
for that part; and that the change from summer to winter temperatures and from winter to summer temperatures is gradual and slow. About six months is required for either change.

The seasons, then, are caused by gradual changes in temperature of any one part of the earth. Another important fact about them is that they follow one another in an orderly sequence. The cause of seasons, therefore, must be due to orderly processes relating to the *variations* in the *amount of heat* the earth receives from the sun. Our problem is to determine what causes the variations in the amount of heat received by the earth under different conditions and to trace the events that produce an orderly sequence of seasons.

(**Key**) ***Experimental Problem 6: What causes the variations in the amount of heat a given portion of the earth receives from the sun?***

What to use: A small tellurian or a small mounted globe and a frame of parallel wires to represent heating rays, with one end of the frame wires cut to fit the globe.

What to do: A. Set the globe of the tellurian so that the axis of the globe is perpendicular to the heating rays, but with the



(Key) Experiment 6

The **A** and **C** positions represent fall and spring positions of the earth and the sun. **B** and **D** represent the winter and summer positions respectively. What do the white lines represent ?

axis inclined away from the vertical, as in **A**. Slowly turn the globe one complete turn.

What happens: 1. Where are the heating rays perpendicular to the earth's surface, as it rotates? 2. Where are they slanting? 3. Where are they most inclined to the surface? 4. How does the rotation of the globe affect the direction of the rays?

What to do: B. Set the globe of the tellurian so that the axis is inclined 23.5° away from the vertical and so that the north end of the axis leans *away from* the top heating ray.

What happens: 1. Where now do the rays act perpendicularly to the surface? 2. Where do they strike the earth on a slant?

3. What part of the earth receives the most slanting rays? 4. How does the rotation of the globe affect the direction of the rays on any part of the surface? Compare with position **A**.

What to do: C. Start with the globe in the position of *B* above, keep the axis pointed in the same direction and inclination, and move the globe counter-clockwise in a circular (really elliptical) path to position **C** where the axis becomes perpendicular to *the rays* turned in the direction of the earth. Rotate the earth. Compare with the result in *A*.

What to do: D. Move the globe so that the north end of the axis is inclined 23.5° away from the vertical and so that it leans *toward* the top heating ray, **D**. Rotate the globe. Compare your observations with those in *B*.

What happens: 1. Where now do the rays act perpendicularly to the surface? 2. Where do they strike the earth on a slant? 3. What part of the earth receives the most slanting rays? 4. How does the rotation of the globe affect the direction of the rays on any part of the surface?

Continue the swing counter-clockwise to position **A**, where again the axis is perpendicular to the rays. Rotate the globe. Compare these observations with those in *A*.

Repeat parts *A*, *B*, *C*, and *D*, keeping the axis always in a vertical position.

What happens: When the globe with its axis always pointing in the same direction is caused to revolve about a central point representing the location of the sun, what four results occur in the relation of the direction of the rays to the surface of the globe?

Note: Repeat each of the above again and again until you know exactly what happens in each case.

Conclusion: 1. How does the inclination of the earth's axis affect the amount of heat received by the northern and southern hemispheres?

2. How does the inclination affect the heat received at the equator?

3. How does the rotation of the earth affect the amount of heat received at any one location in its orbit?

4. How does the revolution of the earth affect the amount of heat received by the northern and southern hemispheres? 5. at the equator? 6. in different positions in the orbit?

Application: Why does the temperature fall at a given place on a clear day as the sun sets lower and lower?

The following brief statements of the relation between the variations in heat received by the earth and the seasons, and the meaning and importance of the orderly sequence should be easily understood by you, if you have understood the experiment.

When the earth is in position *B*, the northern hemisphere is inclined 23.5° away from the sun. The sun's heating rays, therefore, strike the northern hemisphere in a slanting direction, with the result that the northern hemisphere is receiving less heat than where the rays are more direct. (See diagram page 103.)

When the earth is in the opposite position in its orbit, the northern hemisphere is inclined toward the sun 23.5°. The northern hemisphere now receives more direct or perpendicular heating rays of the sun and is warmer than when it received the slanting rays.

When the northern hemisphere is slanted away from the sun, it is winter in the northern hemisphere and summer in the southern hemisphere. When the north end of the earth's axis slants toward the sun, it is summer in the northern hemisphere and winter in the southern. Between the two extreme positions the earth moves to positions resulting in spring and fall. The seasons follow one another gradually and with unfailing regularity.

58. The Earth's Gyrations. — Since the axis of the earth always points in the same direction, it follows that as the earth travels around the sun it reaches a position where the north end of the axis slants away from the sun. This position accounts for the cold of the winter season. (*B* in picture, page 103.) When in the opposite position with respect to the sun, the northern hemisphere receives its greatest heat, producing the summer season. (*D* in picture, page 103.)

Now as the earth swings from the first to the latter position it gradually moves to a place along its orbit where the north end of the axis slants neither away nor toward the sun. (*C* in picture, page 103.) In this midway position, when both ends of the axis are equidistant from the sun and both receive the same amount of heat, it is the spring season. There comes a day as spring advances, when, were it not for the bending of the sun's rays by the earth's atmosphere, day and night would be equal all over the earth. The date when this occurs is called the *spring* (*or vernal*) *equinox*.

As the earth swings from its summer position (northern hemisphere) on its journey back to winter position, it reaches a place midway in its orbit where again the poles are equidistant from the sun. (*A* in picture, page 103.) The time when this occurs is called the *autumnal equinox*. Because of the bending of the rays of light, day is about twenty minutes longer than night.

General Problem 4. How Do Plants, Animals, and Man Make Adaptations to the Seasons?

59. Plants. — Outwardly plants show the effects of changing seasons in various ways. With the oncoming winter, some wither and die after the fruiting season, others drop their leaves and prepare for a period of inactivity; still others die in the portions above the ground, leaving a bulbous root to carry on the species with the return of the growing season. Even in the tropics, where the seasonal changes are less extreme than in the North or South, plants must provide for resting periods.

Curiously enough, while plants do not have the power of locomotion, their seeds are distributed widely by means of winds, birds, and other animals. In this way plants may travel far. However, a plant once rooted

SIGNS OF AUTUMN

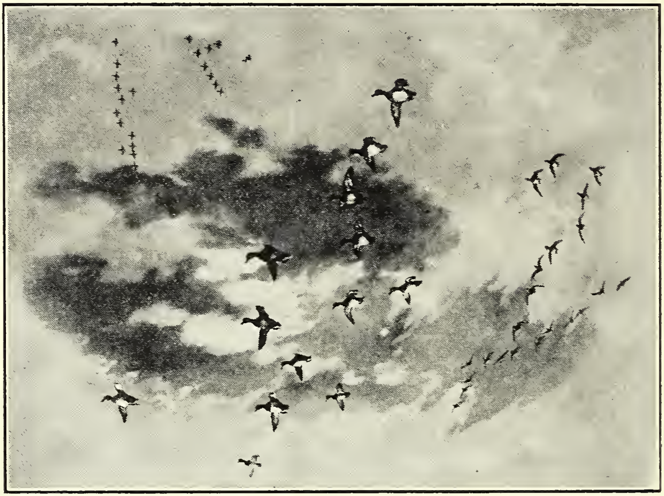
What happens to these corn stalks after the fruiting season?

must adapt itself to its environment or perish. Plants show wonderful powers of adaptation in this respect.

60. Animals. — Animals, too, prepare for the winter by laying up food and by growing heavier pelts. Some *hibernate* or rest during the cold season and waken for renewed activity with the spring.

While ground animals have the power of locomotion, they generally adapt their habits to a particular environment and are not likely to wander far. Many kinds of birds, on the other hand, migrate great distances to find an environment suited to their needs at nesting time.

Birds of the north lands migrate southward with the approach of winter to lands where food to their liking is available, and return the following spring to raise a



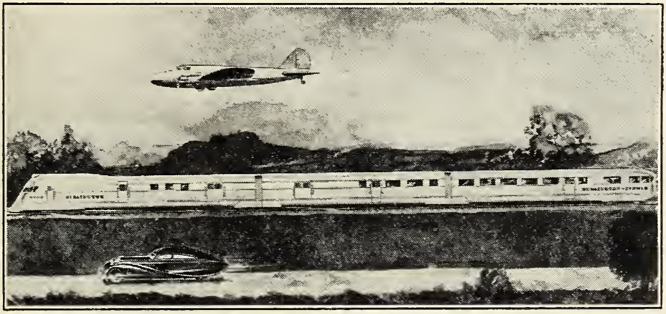
Courtesy Science Service

WINGING TO WARMER LANDS

family. By some it is thought that the migration of birds started as the continental glacier of North America advanced and receded. As the summer seasons changed to winter seasons, and the glacier steadily advanced, birds and animals alike were driven southward. With the birds, the habit formed then has never been broken.

Man is free to travel as he wills: by boat, train, automobile, and airplane. Man journeys from the torrid zone to the polar regions or flies across the seas. He can adapt his eating, clothing, and shelter to any climate and to any season.

Plants and animals, including man, prepare for the certainty and precision with which the seasons follow one another. Each group in its own way plans ahead



MAN TRAVELS AS HE WILLS

for the coming season with confidence that the laws of Nature will continue to operate in the future as in the past.

KEY WORDS

axis	galaxy	rotation
celestial	hemisphere	season
circle	migrate	spring
degree	orbit	tellurian
ellipse	plane	torrid zone
environment	polar regions	tropics
equidistant	rays	twilight
equinox	revolution	vernal

KEY STATEMENTS

1. The earth revolves about the sun from west to east.
2. The earth rotates on its axis from west to east.
3. The orbit of the earth about the sun is elliptical.

4. The axis of the earth is inclined 23.5° away from the vertical. It always points in the same direction (toward the North Star).

5. Day and night are caused by the rotation of the earth, and their lengths vary on account of the inclination of the earth's axis and its revolution about the sun.

6. The change of seasons is a result of varying amounts of heat received by the earth's surface.

7. Variations in the amount of heat received by the earth's surface from the sun are caused by the revolution about the sun of the earth with its axis inclined at 23.5°.

8. Rays of energy from the sun are parallel and heat more strongly when they act directly (perpendicularly) than when they act at an angle.

9. The motions of the earth are regular, hence the heat received by the earth varies in an orderly manner, which in turn results in an orderly sequence of the seasons.

10. Winter occurs in the northern hemisphere when the earth is in such a position that the north end of the axis is inclined away from the sun, at which time it is summer in the southern hemisphere. When the north end of the axis is inclined toward the sun, the seasons are reversed.

11. Spring and fall occur when the earth is in such a position that both the north and south poles are at the same distance from the sun.

12. Plants and animals including man adapt their habits to the changing seasons.

Thought Questions

1. The earth is farthest from the sun when it is summer in the northern hemisphere. Why, then, is it summer?

2. Why must the inclination of the earth's axis be considered when examining the cause of unequal days and nights?

3. How would the apparent motion of the sun, moon, and stars be affected if the earth turned from east to west on its axis?

4. What would be the effect on the variations in the lengths

of day and night if the axis of the earth inclined 47° away from the vertical? How would the seasons be affected?

5. What evidence can you give from personal observations that plants and animals anticipate the change of seasons?

Projects for Your Science Discovery Book

1. Draw a diagram to represent the sun and earth and use arrows to show the direction of the two motions of the earth.

2. Make a study of the migration of birds, finding out how far and how fast they fly, where they go, and why. Do any birds live the year round in the same environment, adapting themselves to the changing seasons?

3. Make a study of the shelters used by man in the tropics, the temperate zone, and above the Arctic circle. Compare them as to building materials, construction, and warmth.

4. Make a study of the diet of man in each of the three zones mentioned above.

5. Locate and record the points on the horizon of your locality where the sun rises and sets on the longest day, the shortest day of the year, and on the two days having equal lengths of day and night. Represent the horizon by a circle and mark the locations and date them. Stationary objects (to be labeled), such as trees, corner of buildings, fence posts, telegraph poles, and chimneys, may be used to mark the location on the horizon where the sun rises and sets. Two such objects should be discovered that are in a straight line with the positions of rising and setting.

SURVEY OF TOPIC V

If you want to find a particular house in a certain town, what do you do? You learn the name of the street the house is on, and its number on that street. Then you may hop into a taxi and tell the driver to take you there.

A navigator on the high seas and an aviator in the high heavens have no such easy means of locating their destinations. They have the sun, the stars, and the North Magnetic Pole to guide them. What can they do with those?

Just as towns are divided into real streets, so it has seemed wise to divide the surface of the earth into equal divisions by imaginary circles, called *meridians* (running north and south), and *parallels* (running east and west). These imaginary divisions are quite like streets, or avenues, for they have names; only their names are numbers, or degrees. And they help more than street names do, for they not only tell you where you are on the earth's surface, but they tell you what time it is as well.

Let us find out just how the sailor on the seas and the pilot in the air use these divisions to know exactly where they are at any time.

TOPIC V

EARTH MEASUREMENTS

I'll put a girdle round about the earth
In forty minutes.
— SHAKESPEARE

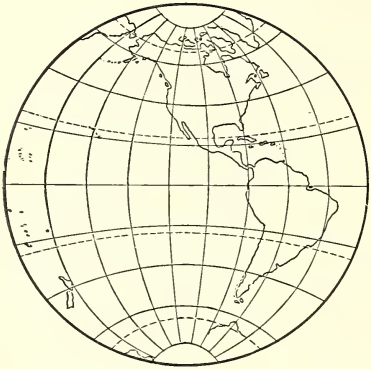
Do you know:

1. **The names of two important imaginary circles north of the equator and two south of the equator?**
2. **How many degrees there are in a circle?**
3. **How to describe the location of a place on the earth?**
4. **Why it becomes light in Boston before it does in Chicago?**
5. **Why a navigator uses a clock?**
6. **How daylight-saving time affects us?**

GENERAL PROBLEM 1. WHAT USE IS MADE OF IMAGINARY CIRCLES ABOUT THE EARTH?

61. Meridians and Parallels. — In order to be able to describe the location of places on the earth's surface, it is marked off by imaginary "great" circles (the diameter of a great circle of a sphere equals the diameter of the sphere) and small circles. One great circle is the equator. The plane of this equator circle is perpendicular to the earth's axis. Other great circles intersect the earth's axis at each pole. These great circles cross the equator circle at right angles. They are called *meridians*.

Small circles may be drawn north and south of the equator circle and parallel with it. These circles will become smaller and smaller toward the poles (the ends of the earth's axis). These parallel circles, like the equator circle, are crossed by the meridians at right angles. They are called *parallels*.



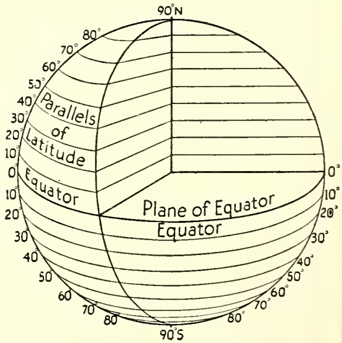
The Great Circles of the Western Hemisphere

Field Research:

Take an apple with a wire passing through the center to represent the earth and its axis, and with a wax pencil draw several great circles intersecting where the wire comes out of the apple. These circles will represent *meridians*.

Draw one great circle half way between the ends of the axis with its plane perpendicular to the axis. It will represent the earth's *equator*.

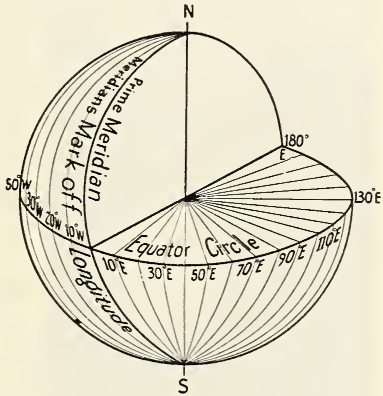
The meridians mark off the distances around the equator, and since a circle for convenience is divided into 360 degrees, let us say that the meridians mark off the equator into 360 equal lengths or arcs.



Parallels

The circles north and south of the equator and *parallel* with it, while smaller than the equator, are also divided into 360 parts or degrees. The equator circle and parallels are divided into degrees by the meridians, so the parallels may be spaced so as to divide each meridian into equal spaces. Since the parallels north and south start with the equator circle, they are spaced to mark off degrees north and degrees south of the equator. Therefore there would be 90 of them.

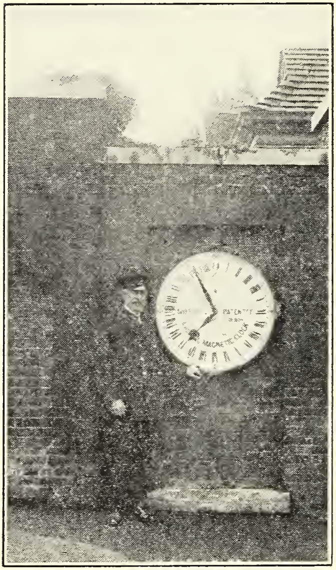
The length of the arc which measures a degree on the circle of the equator is longer than the length of one which measures a degree on any parallel, since the farther north or south one goes, the smaller such arcs become. In other words, the length of a degree in miles measured along the equator is greater than a degree measured along a parallel. It is evident, then, that the parallels mark off *equal distances* north and south of the equator as measured along the meridians, and that the meridians mark off equal distances on each parallel. Actually the length of a degree on a meridian is somewhat longer as one approaches the poles, due to the slight flattening of the earth's surface near the poles.



Meridians

General Problem 2. What Are Longitude and Latitude?

62. The Greenwich Prime Meridian. — In *Greenwich* (grĭn′ij), a city near London, England, there was erected long ago a great observatory with a fine telescope and other astronomical instruments. By 1884, the business of the world had grown so huge that the need for a standard *prime* (*first*) *meridian* was very great. A group of representatives from twenty-six nations met at Washington, D. C., to decide the question. The majority agreed that since the Greenwich Observatory was the center of investigation in such matters at that time, it would be fitting to name the meridian which passes through Greenwich, the *prime meridian*. For reckoning purposes, any other meridian would serve just as well as this one for a starting point, but to avoid confusion in the preparation of navigational and astronomical tables, it is necessary to have one generally-used prime meridian. All east or west astronomical calculations and earth measurements are, therefore, based on reference to the Greenwich Prime Meridian. Then of course there is only one equator circle, therefore north and south measurements and locations are recorded from the equator.



Courtesy Royal Observatory, Greenwich, England

AT THE GREENWICH OBSERVATORY

The master twenty-four-hour clock which provides Greenwich meridian time to the world.

63. Recording Locations. — The degrees east and west from a prime meridian are called degrees of *longitude*. The degrees north or south of the equator are called degrees of *latitude.* For convenience in reference, the meridians are numbered east and west from Greenwich, that is, from 0° to 180° each way; the parallels are numbered north and south from the equator, that is, from 0° to 90° each way. To secure accuracy, each degree is subdivided into 60 equal parts called *minutes;* and each minute, for still more accurate work, may be divided into 60 equal parts called *seconds.* Therefore, to give a very accurate location of any spot on the earth, all you need to say is that it is so many degrees (minutes, etc.) east or west longitude, and so many degrees (minutes, etc.) north or south latitude. These data mark the spot where the meridian and parallel cross each other.

General Problem 3. How Are Celestial Circles Used?

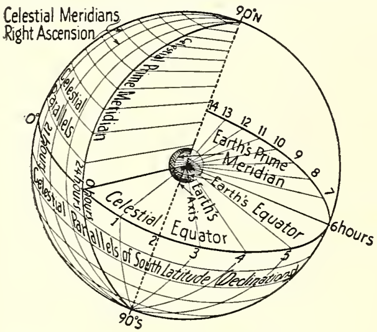
64. Locating Stars. — Just as the earth is marked off by intersecting meridians and parallels, so too the celestial sphere is marked off by similar but much greater meridians and parallels. By means of these celestial circles the location of a star is given by stating its position in degrees east or west of the *celestial prime meridian,* and north or south of the *celestial equator.*

Would the length of a celestial degree in miles be greater or less than on an earth circle?

These celestial circles may be thought of as imaginary lines traced out on the celestial sphere by the extended planes of the earth's equator and parallels, the prime meridian, and other great circles.

The north pole of the celestial sphere is the point in the sky where the axis of the earth points. It is marked by the North Star.

Distances in degrees north or south of the celestial equator are called *degrees of declination.* They correspond to the degrees of latitude on the earth. Degrees of declination are marked off by circles, parallel with the equator and corresponding to the parallels of the earth. They are called *declination circles.*



Celestial Circles

Degrees east or west of the celestial prime meridian are called *degrees of right ascension.* They correspond to degrees of longitude of the earth. The right ascension of a star is usually given *in hours instead of degrees.* The celestial prime meridian is the zero hour circle. The reason for this will be understood when you understand the relation between longitude and time.

Field Research:

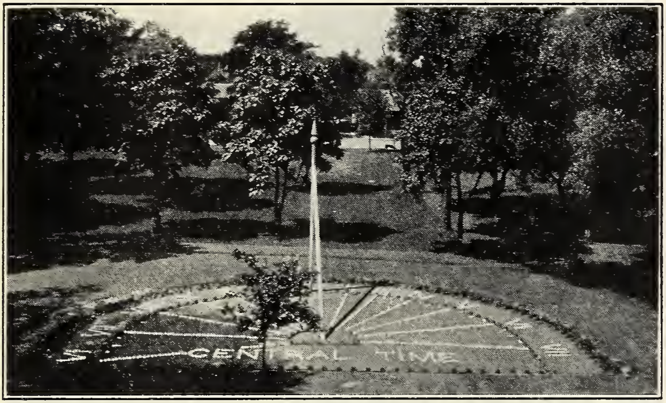
The celestial prime meridian passes midway between the two stars which form the inner edge of the bowl of the Big Dipper. With your eye trace a line through this point to the North Star. **See the diagram on page 19.**

The meridian reaches on through the North Star and passes very close to the nearer end star of the *W* of Cassiopeia. Name several other constellations that lie close to the celestial meridian.

General Problem 4. What Is Time and Place?

65. Telling Time by Longitude. — Not only are the degrees of latitude and longitude used to describe the position of a place on the surface of the earth and the location of a star in the heavens, but *longitude is directly related to time.*

When you recall that the earth makes one complete rotation on its axis in twenty-four hours, it must be



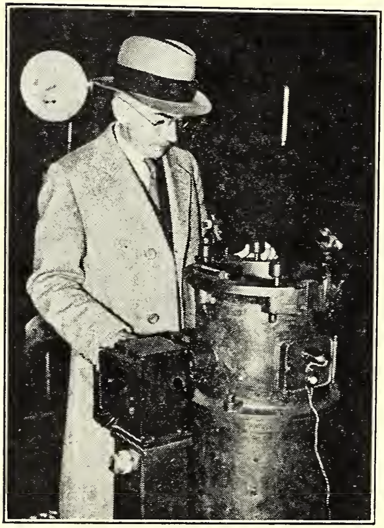
A Park Sundial

What is the sun time on the dial?

evident that a point on the earth will turn through an angle of 360° in twenty-four hours. In one hour the earth will rotate 15°, which is one twenty-fourth of 360°. Every 15° change in longitude is, therefore, equivalent to one hour's change in time.

If 15° change in longitude is equivalent to one hour's (60 min.) change in time, then one degree change in longitude is equivalent to four minutes' change of time (60 minutes divided by 15). On the basis of this relation of longitude and time, it is possible to calculate the difference in time between any two places, if we know the difference in longitude.

You know that a person to the east of you will see the sun before you do each morning. In other words, when you see the sunrise, people to the east of you have already seen it and perhaps have had their breakfast and gone to work. When it is six o'clock with you, it will be later than six o'clock with the people living east of you. Therefore, if you want to know what time it is by the sun in a place east, add to your sun time the difference in time indicated by the difference in longitude.



A CAMERA CLOCK WHICH CHECKS ITS TIME WITH THE STARS

This machine, at the United States Naval Observatory, determines time accurately by means of photographic recording of the stars. The element of error is reduced to .0087 of a second.

If the earth was flat, like a table, and the sun rose above the east end, everyone for the whole distance west would see the sun rise at the same instant. That this is not so is one proof that the earth is spherical.

66. Different Kinds of Days. — Do you know what the *zenith* is? It is the point in the heavens directly above your head. As you move, the zenith will be a correspondingly different point in the heavens. If you pointed a telescope toward a line which passes exactly north and south through the *zenith* of the heavens, and then noted the time when the same star crossed the line again the next night, exactly 23 hours, 56 minutes, 1 second would have elapsed. This star-measured day is called a *sidereal* (*sī-dē′re-al*) *day.* It is practically four minutes shorter than a mean solar day. Hence the stars rise four minutes earlier each night. The earth actually rotates 366 times in 365 mean solar days. Star time is told by a specially made instrument called a *sidereal clock.*

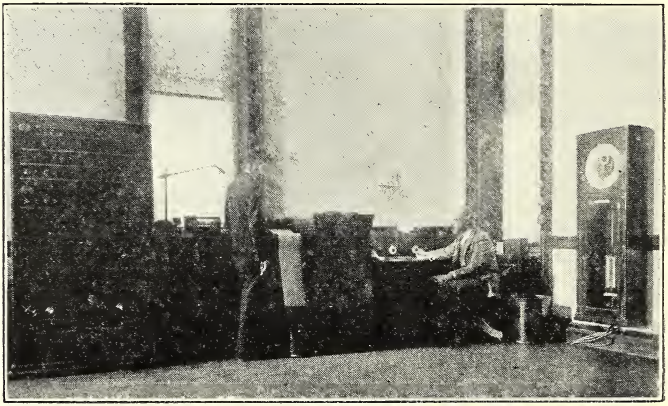
You know that the length of our days and nights varies, owing to the motion of the earth and to the inclination of its axis. But do you know that because of these facts and because the orbit is elliptical the total time from noon to noon, called a *solar day,* is nearly one minute longer on December 21–22 than on September 17–18? Since solar days vary even so slightly in length, the average of the 365 solar days, called a *mean solar day,* is used. The hours are counted from 0 to 24. It is the day used by astronomers and is sometimes called the *astronomical day.*

The ordinary day by which we run our business, our schools, and our pleasures is called the *civil day.* It is the same length as the astronomical day, but begins at midnight preceding the noon of a given astronomical day, and ends at the next midnight. The hours of this civil day run from 0 to 12 and repeat.

What is the meaning of the word *civil* as used here?

67. Standard Time. — Actual sun time is different for every point of longitude. A little thought will disclose that it would be extremely difficult to conduct the world's business if all our clocks were run on sun time. For example, suppose in your town the time of sunrise were called 7:00 o'clock and a train left your home at 7 A.M. going westward. You would then have to make a special time table for your train, showing the differences in longitude for all places between your town and the train's destination, if you wished to determine at what local time the train would arrive at its destination.

In order to escape the nuisance and confusion that would result, if all places went by sun time, *standard*



Courtesy U. S. Naval Observatory

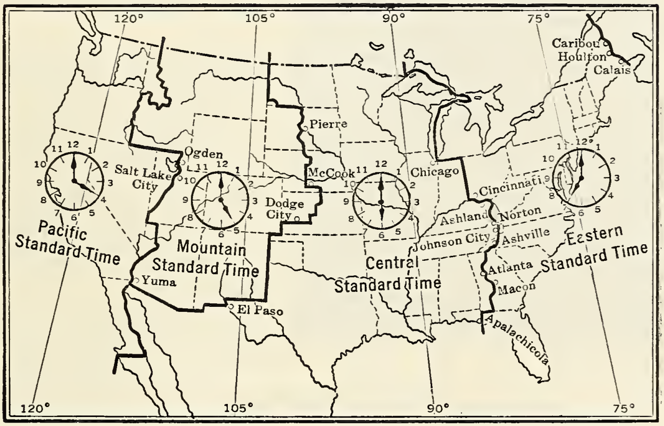
THE OFFICE OF "STANDARD TIME"

Transmitting time signals from Washington, D. C.

time has been adopted. Standard time is the exact sun time on the seventy-fifth meridian, which passes through Philadelphia. For all places north or south of Philadelphia and lying on this same meridian, sun time and standard time are the same.

If you live east of the Philadelphia meridian, a clock set for sun time will be some minutes ahead of a clock set for standard time. If you live west of the meridian, a clock set for sun time will be slow or behind standard time. To avoid such great differences between sun time and standard time, the whole country is divided into *standard time zones* — Eastern Standard Time, Central Time, Mountain Time, and Pacific Coast Time zones.

68. Time Zones. — A section of the United States, running north and south for a certain distance on either side of the Philadelphia meridian, uses the sun time of the Philadelphia meridian. The time for this section is known as Eastern Standard Time.



Standard Time Zones

A second strip, lying directly west of this section, is marked off as a Central Standard Time zone within which the time is one hour earlier than in the Eastern zone. When it is 7 o'clock in the Eastern zone, it will be 6 o'clock in the Central zone.

The third zone includes the mountain region of the west, where the time is called Mountain Time. West of the third zone lies the fourth zone, and here the time is called Pacific Time.

By this scheme of time zones any place in a given zone may keep its clocks on standard time and yet not be more than one half hour ahead or behind sun time.

Field Research:

Obtain time-tables of the principal transcontinental railroads and a map of the United States. From the time-tables determine the boundary cities of the time zones. Mark these places on your map. Connect the boundary cities by lines, and you will have approximately mapped the time zones.

Check the accuracy of your zone boundaries by the time zone map on page 123.

Mathematically exact time zones would have meridians as boundary lines, but for industrial reasons it is convenient to designate certain principal cities as fixing the boundary marks for the different zones. Railroads especially benefit by such an arrangement. It is not strange, then, that your study of the map has shown you that the boundary lines between the time zones do not coincide with the meridians.

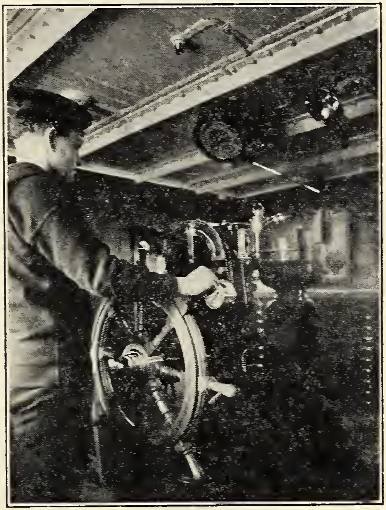
A general Standard Time has been adopted for all continents, and the prime meridian of Greenwich, England, is the meridian from which the standard time of the world is determined.

How many hours' difference in time is there between Greenwich time and Philadelphia time?

General Problem 5. How Can Navigators Follow the Water Trails and Air Courses?

69. How the Navigator Keeps His Course. — Navigators of ships and planes are often out of sight of land for considerable periods. They must, therefore, be able to determine their direction and exact position at any time, by other means than the observation of familiar landmarks.

The mariner and the pilot use special compasses to maintain sailing directions. However, direction alone does not tell position. For this reason each must know his exact latitude and longitude at given times in order to be sure that he is holding to his course. Knowing his location, the navigator can, with the aid of the sun, the stars, or direction-pointing compasses, continue on his course. He can determine his latitude from the stars on cloudless nights or from the sun on cloudless days.



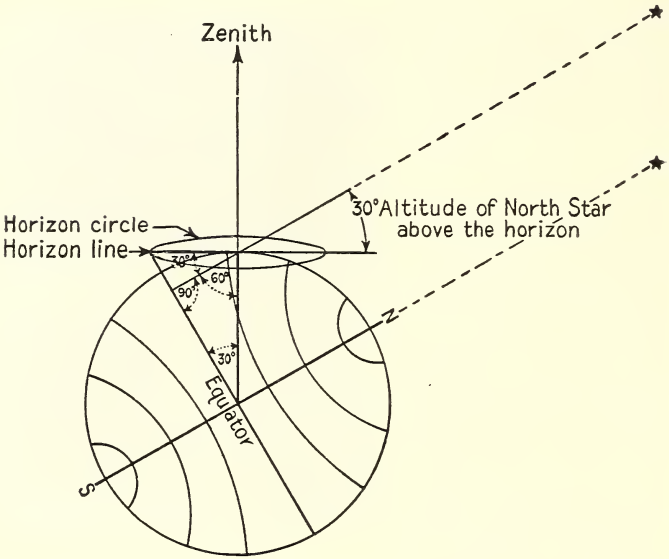
Ewing Galloway

STEERING BY COMPASS

By means of a gyro-compass this steamship is kept on its course.

70. The North Star, a Guiding Beacon. — The angle formed by a line from your eye to the North Star and your horizon line will equal any other angle formed in the same way anywhere on the same parallel. If you went north from your first position the angle would get larger. If you went south from your first position, toward the equator, the angle would get smaller.

You know that the position of a place on the earth is partly described by its distance in degrees north or south of the equator, that is, by its north or south *latitude.* Latitude is equal to the angle between a line to the earth's center drawn from the point where you stand and a line from the center of the earth to its equator, both lines being in the same plane. See the diagram below.



Determining Latitude from the Altitude of the North Star

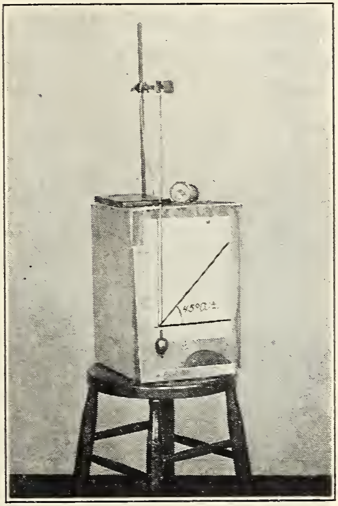
The star is so far away that its rays of light to the North Pole and to the position of the observer are practically parallel.

The north latitude of a place can be determined by measuring the angle of the North Star above the horizon as in the diagram above. It can also be determined by measuring the angle of the sun above the horizon at exact noon.

Experimental Problem 7. — *What is the latitude of your home?*

What to use: A plumb line and support; a box with a paper tacked to one side; a high stool; a carpenter's square; a protractor; and a flashlight.

What to do: On a clear night place the stool where there is a good view of the North Star. Set the box on the stool with the paper toward the east. Hang the plumb from the support so that it swings free. Adjust the box so that the paper side will be exactly in line with the plumb line and pointing toward the North Star. The plumb line should hang alongside of the paper on the box.



Experiment 7

With a pencil (using the flashlight for illumination) make a vertical mark on the paper to coincide with the line. Put the inner edge of the square against the plumb line and the flat side against the paper. Draw a pencil line on the paper at right angles to the plumb line. Take away the square, being very careful at all times not to move the box.

Now with your eye at the level of the angle made by the vertical and horizontal line, sight toward the North Star. With your pencil put a mark on the paper exactly in line with the angle and the North Star. With the straight edge of the square connect the angle and mark with a line.

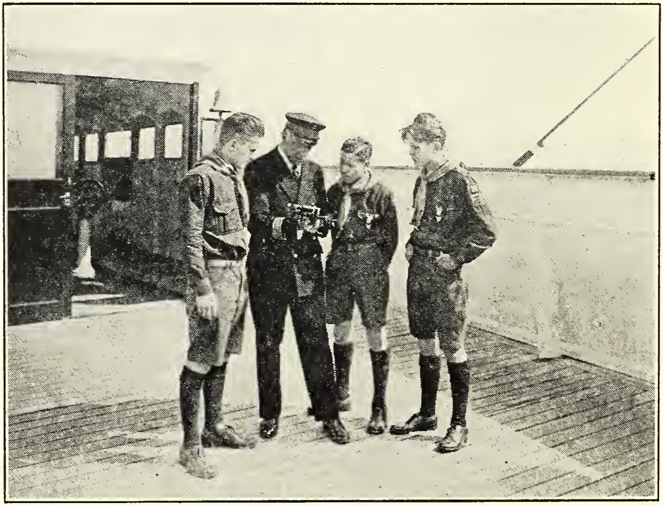
Lay the protractor against the horizontal line, with its center mark at the intersection of the vertical and horizontal lines. Then read the angle made by the star direction line and the horizontal line. This angle is the altitude of the North Star and is equal to the latitude of the place where the observation is made. For the sake of greater accuracy you should make the determination several times and take the average of the several angles for your result.

Conclusion: 1. What is your latitude? 2. Is it north or south?

Application: What is the length of the longest day and the shortest day at your latitude?

Note: Any other star may be used to determine latitude if its position in the heavens is known.

71. The Sun Helps, Too. — At exact noon (sun time) on any one day the sun is higher above the southern horizon than at any other instant. The approximate latitude of a place can be calculated by determining the altitude (angular distance above the horizon) of the sun at exact noon and subtracting that angle in degrees from ninety degrees.



Observing How the Sextant Works

Three boy scouts, on a hunting safari into Africa with Martin Johnson, are learning from Captain Blancart how to "shoot the sun."

Due to the inclination of the earth's axis and the revolution of the earth about the sun, the altitude of the sun at exact noon varies with the day of the year. Hence for accurate results by this method a correction is made by navigators.

The mariner uses an instrument called a *sextant* to determine the altitude of the sun at exact noon. When the sun shines he looks through the sextant to read the angle the sun makes with the horizon at the instant the sun reaches its highest point. Correcting for the angular distance of the sun north or south of the celestial equator on that date, he reckons his true altitude.

Field Research:

Try to determine the approximate latitude of your home by measuring the altitude of the sun.

Use the same material listed in Experimental Problem 7 and a magnetic compass. Follow the same procedure as in Experimental Problem 7. At exact noon the shadow of a plumb line on a horizontal surface (top of box leveled) will point north.

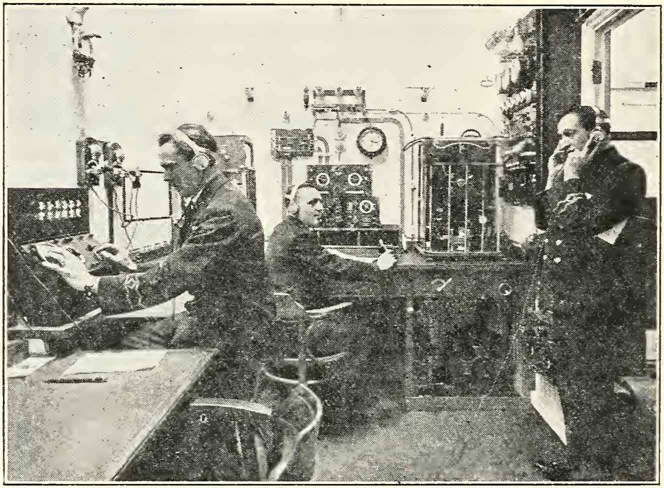
The compass should be laid on the box so that the shadow falling across it will tell you when it is approximate noon. At that instant you should mark the angle of the sun direction with the horizontal and vertical lines on your paper.

The angle in degrees subtracted from ninety is approximately your latitude. Compare the determination with the results obtained by use of the North Star method.

72. Mechanical Aids for the Navigator. — The navigator carries with him a ship's clock or *chronometer* set so that it agrees exactly with a master clock at Greenwich Observatory.

If the mariner sailing westward wants to know his longitude in time, he determines when it is exact noon, or, if at night, he may determine the time from the stars. From the difference between the time shown by his chronometer and the time by the sun or stars he can calculate his longitude, for he knows that for each hour's difference in time he has changed his position 15°.

Having determined the latitude by measuring the angle of the sun's direction at high noon, or by reference to the angular distance of the North Star or some other star (for which the data are known) above the horizon, and having determined the longitude by means of time calculations, the navigator can locate the position of his ship upon a map which he always carries with him.



Ewing Galloway

THE RADIO ROOM ON AN OCEAN LINER

Three operators control this "station," sending and receiving messages of all kinds. It is here that time signals are caught.

In these days of radio communication standard time signals are sent out many times during each twenty-four hours, and always at certain specified times. The radio standard time signal enables the navigator to check his chronometers. Thus his longitude determinations may be more accurate.

KEY WORDS

chronometer	equivalent	noon	sidereal day
compass	Greenwich	parallel	solar time
declination	latitude	prime meridian	standard time
diameter	longitude	right ascension	telescope
equator	meridian	sextant	zenith

Key Statements

1. Places may be located on the earth by stating their latitude and longitude. Latitude is the distance in degrees north or south of the equator. Longitude is the distance in degrees east or west of a prime meridian.

2. Stars may be located by giving their declination and right ascension. Declination corresponds to geographical latitude, and right ascension corresponds to geographical longitude.

3. Fifteen degrees of longitude is equivalent to one hour of time.

4. Standard time zones are established for convenience in comparing the times of different localities.

5. The latitude of a place equals the angular altitude of the North Star, and also equals the angular distance between the zenith and the angular altitudes of the sun at high (exact) noon, with allowances made for the position of the earth in its orbit.

6. Longitude is determined by the difference in time between standard time at Greenwich, England, and mean solar time at the place involved.

Thought Questions

1. Why is it helpful to be able to give the position of a place in terms of latitude and longitude? How else could one describe the location of a city? a ship at sea? an airplane in the air?

2. Why are fifteen degrees of longitude equivalent to one hour of time?

3. Why is it necessary to have a prime meridian?

4. Why is the plan of standard time zones better than that of having every place go by sun time?

5. Try to prove by mathematics that the angular altitude of the North Star measured from a certain place equals its latitude. Use the diagram on page 126.

6. Colonel Charles A. Lindbergh states in an article[1] that on his flight from New York to Paris he had only about five hours of darkness; while on his flight from Washington, D. C., to Mexico City he had over thirteen hours of darkness. He left

[1] *National Geographic Magazine*, May, 1928.

New York at 12 : 50 P.M., May 20, 1927, and flew approximately along a great circle. He reached Paris at 10:15 P.M., May 21, 1927.

On his trip from Washington, D. C., to Mexico City he left Washington a little after noon on December 13, 1927, and arrived at Mexico City 27¼ hours later.

Try to explain the difference in the hours of darkness on these two trips.

Projects for Your Science Discovery Book

1. From a map read the latitude and longitude of five places, based on the standard (Greenwich) prime meridian. Now on your map read the position of your home town in latitude and longitude, using the 75th meridian as your prime meridian. Record your results.

2. Make reports of news items that indicate the importance of the radio in navigation of the sea or air.

3. Read in "Skyward," page 191, what Commander Byrd says about the importance of chronometers and their accuracy in connection with his North Pole flight. Make a report of your reading.

4. If your community has daylight saving, discuss its advantages and disadvantages.

UNIT II. WEATHER

LOOKING AHEAD INTO UNIT II

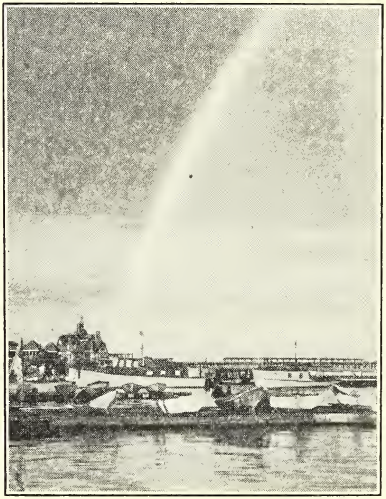
One of the most important things in this big country of ours is weather, for upon weather depends the health and comfort and much of the pleasure of all living things. Bad weather brings the cold or the drought that destroys crops; the floods that wash away bridges, river banks, and buildings; or the storms that destroy lives. Good weather brings the sunshine and the rain that make people well and happy, crops abundant, and life worth living.

In nearly every human endeavor weather plays a part. It affects the merchant and his sales; the doctor and the diseases he treats; the engineer and his building; the hotel man and his resort; the lawyer and his court proceedings; the gardener and his soil culture.

One of the most helpful things the government has done for us is to establish a weather bureau which foretells changes in weather conditions. Thus the farmer is warned of frost and freezing; the aviator is warned of fog and storm; forest-fire wardens are warned of impending droughts; fishermen are warned of storms at sea. Successful shipping, transportation, bridge building, and irrigation planning in this country depend greatly upon the United States Weather Bureau reports.

SURVEY OF TOPIC VI

Weather — a subject universally talked about; a phase of nature that is so seldom just right. For any number of reasons, every day of the year, children and grown-ups alike scan the heavens and ask the question, "Will it storm to-morrow?" or "Will it clear to-morrow?" How are they to tell? What controls these weather conditions that vary from blazing sunshine to stormy gales?



Once upon a time, when the majority of people lived more isolated lives than they now do, weather signs based upon a host of observations and superstitions were prevalent. Many of these superstitions were associated with the heavenly bodies. Even to-day, a ring around the moon, a red sunrise, or a rainbow are sure signs to many that rain or storm or a sunny day is due. We all know the thunder clouds that roll up on a sticky midsummer afternoon, heralding the thunderstorm that comes in their wake to clear the sultry air.

Let us observe some of these weather signs, old and new, and try to separate fact and fancy.

TOPIC VI

WEATHER SIGNS AND SUPERSTITIONS

Above the rest, the sun who never lies
Foretells the change of weather in the skies.

— VIRGIL

Do you know:

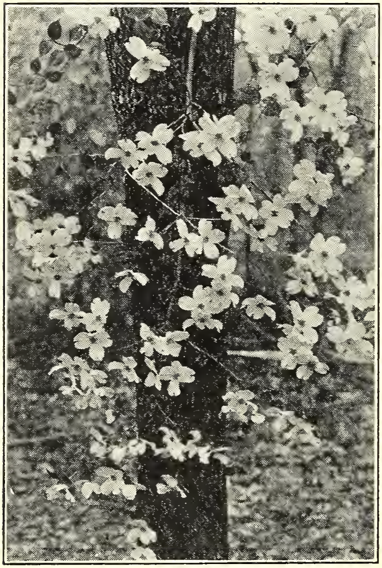
1. **A weather sign?**
2. **Whether or not the moon controls the weather?**
3. **Whether or not animals are good weather prophets?**
4. **How to make a rainbow?**
5. **The cloud family?**
6. **Any true weather signs?**

GENERAL PROBLEM 1. ARE SUPERSTITIONS BASED ON EVIDENCE?

73. A Definition of Weather. — As an introduction to our study of weather let us agree upon the following definition: *Weather is the condition of the air (hot, cold, dry, moist, heavy, light, active, or inactive) at any one time in any one place.*

74. Foretelling Weather by Animals. — Do animals with heavy fur or birds with heavy feathers in the fall indicate a cold winter? Do geese flying south foretell oncoming winter? Do crickets tell the temperature? Does the groundhog's shadow on February 2 have anything to do with the weather?

Science has shown that the coat of fur on animals and feathers on birds depend upon the supply of food available during the spring and summer, and not at all upon the animal's sense of coming weather changes. It is true that animals of all kinds make preparations for changes of seasons such as laying up food and preparing a den, but they do not know whether the season is to be normal or otherwise. Fur-bearing animals have heavier coats of fur during the winter, and shed most of the fur in the summer. Preparation for a change in season does not involve "knowledge" of an unusual season.



FLOWERING DOGWOOD
Weather folklore has it that a cold spell always accompanies its blooming.

Field Research:

Make observations of your own on the preparations birds and animals make for the winter and compare with what others report.

Geese and other birds which migrate southward stay in the nesting regions in the north until their young are strong and able to fly long distances. By the time this period is ended, the food supply has usually begun to dwindle, due to the freezing over of ponds and lakes.

Some birds, like geese, cruise leisurely southward, flying now one direction and now another, searching for food on their journey. Some fly by night and feed by day. Others fly great distances without stopping until they reach their destination. Possibly the birds were forced to acquire the habit of southward and northward movements by the advancing and retarding glacier front thousands of years ago.

The Fall Migration

Why are these birds alighting on the water?

Field Research:

Investigate the migration of birds to discover reasons for their movements other than that, as some people say, "they know cold weather is coming."

The robin's rain song, the restless leech, the dry fog, and low-curling smoke are but a few of the many weather signs which come to us out of the Nature-lore which generations of farmers, hunters, and other outdoor folk have built up. Our job is to learn to distinguish between those signs which are based on scientific sense and those that are not. Careful, prolonged observations of Nature and weather changes, joined with what we learn in the laboratory, will disprove many weather superstitions. You will get the scientific knack of searching out the facts and you will find fun in some of the foolish but still quite commonly accepted superstitions.

75. The Moon and the Weather. — There are many weather signs and superstitions relating to the moon. The weather is not influenced by the moon and, therefore, the moon cannot indicate the weather. Such sayings as: "When the crescent moon can hold water it will be dry"; "When the moon changes the weather will change"; "Fish bite best as the moon grows full"; and many similar statements are absurd.

You know from your study of the motions of the earth, moon, and sun that changes in the moon occur with great regularity due to the motions. The "changing" shapes of the moon, its phases, result from these motions. The tilt of the crescent varies, due to the inclination of the earth's axis and the season at which the moon is seen.

Statements relating to the moon and weather probably result from observed associations of the moon with certain kinds of weather. However, if the observations are continued long enough, the study shows that the moon has no influence upon the weather.

Field Research:

Talk with your friends to learn as many sayings as possible about the moon and weather. Give your reasons to show whether or not the sayings have any facts behind them.

General Problem 2. Are Weather Signs Scientific?

76. Rain, Rings, and Rainbows. — A ring around the moon or the sun may indicate the approach of a storm because the ring is produced by the action of light on ice crystals or water particles in the air. As the ice or moisture-laden air moves toward us, the ring often grows larger and hence there is some truth in the saying that "The bigger the ring, the nearer the storm." Sometimes a large ring of colors is observed about the sun. It is caused by the light shining through a layer-like cloud of ice particles, high above this earth. Such rings probably have little, if any, weather significance.

A colored ring close about the moon or sun is called a *corona*, while the larger rings are called *halos*. The first is usually caused by water particles and the latter by ice particles.

"Rainbow at morning, sailors take warning;
Rainbow at night, sailors delight."

There is some truth in this "sailor's warning." A rainbow is caused by the sun shining on particles of moisture in the air.

A rainbow in the morning is caused by the sun shining on rainclouds or moisture-laden air in the west. As the air moves easterly (the usual course of a storm because of the rotation of the earth) the weather condition moves with it. The rainbow at "night" indicates clear sky in the west, — a sign that the storm clouds have almost all passed through the area where the rainbow is visible. With their passing, of course, comes clear weather and so the old saying has some basis of fact.

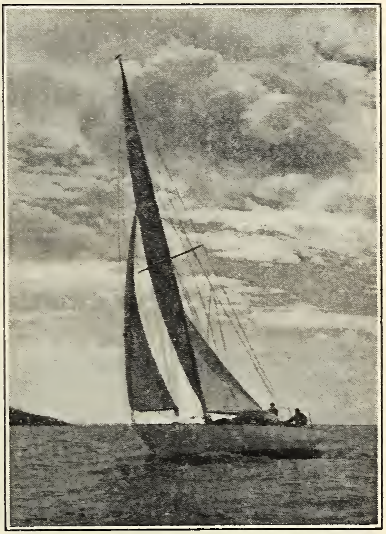
"Rain before seven, stop before eleven" is often true, not because "seven" rhymes with "eleven" but because the heat from the sun during the middle of the day acts to warm the clouds and causes their moisture to evaporate. Warm air, you know, can hold more moisture than cold air.

CUMULUS CLOUDS

Looking down through the cottony billows of storm-building clouds.

77. Clouds. — You know that there are fair-weather clouds and storm clouds. While observation and study of clouds alone will not give reliable weather forecasts, still a close observer of clouds is able to tell in advance some things about approaching changes in weather.

Some clouds are conspicuous as fair-weather clouds. You have seen them, the white billowy clouds looking like great piles of fluffy cotton with flat bases moving slowly along in the sky. These *cumulus* (hill-shaped) clouds, as they are called, float at a height of about a mile above the earth. They are fair-weather clouds when the air is dry, but when warm air filled with moisture rushes upward at such times, it expands and cools rapidly. This causes condensation of the moisture. The front edge of the cloud will assume a dark, threatening appearance. The peaceful cumulus cloud thus becomes the threatening thunder cloud.



RUNNING AHEAD OF THE STORM
Cumulo-nimbus clouds heralding a storm.

Contrasted with the cumulus clouds are the fleecy, feathery clouds that are often observed high in the sky. They are the highest of all clouds, sometimes floating five or six miles above the earth and usually not nearer than three or four miles. They are near the top of the *troposphere,* the cloud-bearing part of our atmosphere, above which is the *stratosphere,* a region without clouds. The upper troposphere is a region of very cold air and the clouds there consist of ice crystals. These *cirrus* clouds are always the advance guard of a storm. They travel with rapidly moving air currents, sometimes nearly 100 miles an hour.

As the heralded storm draws near, the shape of the cirrus clouds may change to low-lying *stratus* (layer) clouds. The stratus clouds become the *nimbus* (storm) clouds. The nimbus cloud is the rain cloud. It hangs low in the sky and is wide in extent. The stratus clouds are most often seen at sunrise or sunset, just above the horizon.

Each of the four common kinds of clouds mentioned often combines with others or changes into one of the other three forms, and frequently more than one kind of cloud can be observed in the sky at a time.

Field Research:

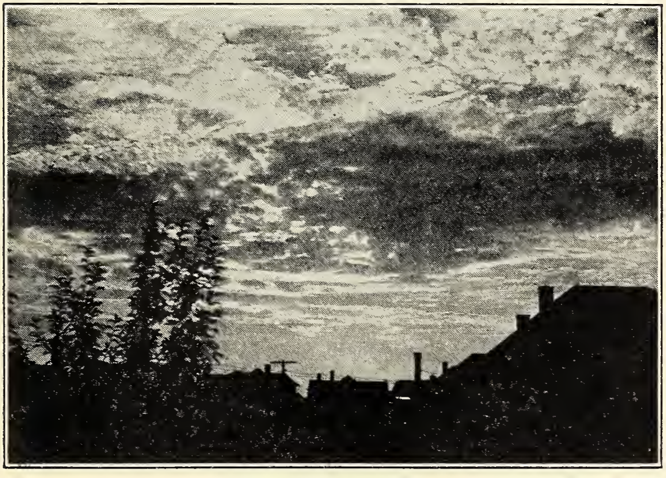
Learn to take pictures of clouds. Not only will you get some beautiful cloud pictures, but you will have pictures to mount in your Science Discovery Book to illustrate your discussions.

78. Facts *versus* Fancies. — Superstitions and misbeliefs are always indications of ignorance on the part of people who believe them. Such beliefs are evidence that the persons who accept them are not careful, accurate thinkers. In time, people of this sort become very narrow-minded and find it difficult to sympathize with the scientist's thorough search after facts. The results of the study of Nature by the scientific method have led to the disproving of many superstitions. Yet progress of this kind has always been opposed by the very people who are superstitious. Perhaps you know some such folk whom you can interest in your study of science and thus save them from the folly of superstition and misbeliefs.

You who are studying science should always have an open mind, ready to accept knowledge that is based upon facts. The true scientist is a seeker after truth.

Cirrus Clouds

This thin, whitish sheet of clouds gives the sky a milky appearance. How high may they occur?



Low-Lying Stratus Clouds

What kind of clouds are forming overhead?

The scientific forecasting of the weather requires a knowledge of the weather factors, their causes and effects. The next chapter deals with the science of weather changes.

Key Words

cirrus	facts	rainbow
cloud	foretell	reason
corona	halo	ring
crescent	migrate	stratus
cumulus	nimbus	superstition
evaporate		

Key Statements

1. The sun, our planet, and its motions are closely related to weather.
2. Superstitions are not founded on fact.
3. Only people who are ignorant of the facts are superstitious, and their superstitions tend to keep them ignorant.
4. One cannot foretell the weather by observations of animals.
5. The moon does not influence the weather.
6. Certain natural phenomena such as rings and rainbows do have some significance with regard to the weather.
7. Cloud formations indicate advancing weather conditions, to some extent.
8. Scientific weather forecasting depends upon exact knowledge of weather factors.

Thought Questions

1. How can you distinguish between a superstition and a reason?
2. Why is it that a ring around the moon may indicate certain weather conditions?
3. Explain why "sailors take warning" when they see a "rainbow in the morning."
4. Why is the rainbow method less satisfactory than information broadcast from a weather bureau?
5. How can one overcome a superstition?

Projects for Your Science Discovery Book

1. Keep a record of the changes of the moon and changes of the weather for a few months to discover whether or not there is any relation between them. How many sayings do you know about moon and weather?

2. Try to discover how some superstition about the weather started.

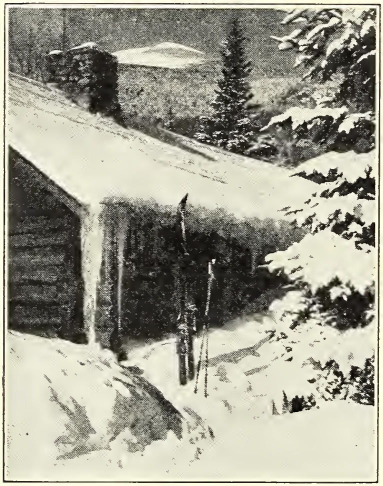
3. Experiment with a glass prism and sunlight to discover how rainbows are formed.

4. At what time of day would a rainbow show the largest curve? the smallest curve? Why does one never see a complete circular natural rainbow in the United States?

5. Report on what you can discover about the reasons for the migration of birds.

SURVEY OF TOPIC VII

On a day when snow crunches under foot and frost traces fantastic patterns on the window panes and the clear, biting cold makes faces glow, or when the beating sun softens the asphalt of the pavements and scorches the very leaves of the plants, people are very much interested in reading the thermometer to find out just how cold or hot it really is.



What happens to the mercury in the porch thermometer when it drops down to below zero or rises above 100° F.? What can affect the mercury in a little glass bulb to make the column in the stem vary day after day?

From the days of Galileo, who invented the thermometer, and Torricelli, who invented the barometer, to the present, our knowledge of air temperature and air pressures and their causes has increased step by step. Now we know for certain that air temperatures, air pressures, winds, humidity, and rainfall are all factors of our environment which produce weather. Let us see what scientific knowledge we can gain from research and experimentation of our own.

TOPIC VII

WEATHER FACTORS

When he uttereth his voice,
There is a multitude of waters in the heavens
And he causeth the vapors to ascend from the ends of the earth;
He maketh lightning with rain
And bringeth forth wind out of his treasures.

— Jeremiah

Do you know:

1. **How to read a thermometer?**
2. **The temperature at which water freezes and boils?**
3. **What air pressure is?**
4. **What a barometer is?**
5. **What causes winds?**
6. **How moisture gets into the air?**

General Problem 1. What Is Temperature?

79. Nature's Weather-Makers. — Nature's principal weather-makers are *air temperature, air pressure, air motions,* and *air moisture.* We shall consider them in detail as we continue our study of the weather. Each has its importance not only in making up the weather, but in its value in predicting weather. Your knowledge of each weather factor will help you to understand and appreciate these forces and conditions of Nature that have such important relations to your welfare, and to which you must adapt many of your activities.

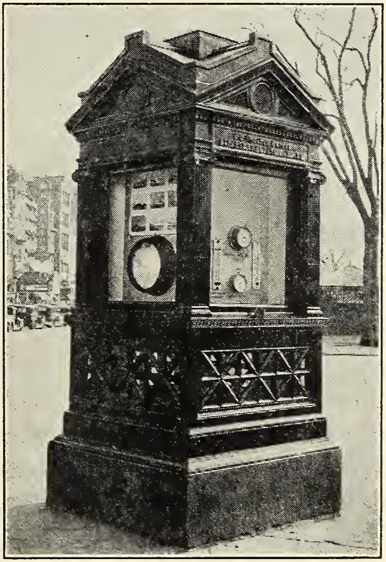
80. What Is Temperature? — Changes in heat and cold in our bodies, in the liquids we use, in the air about us, and in the fires which we build, make us very familiar with this weather factor, temperature. Every one of us knows what it is to feel hot or cold, but to be real scientists we need also to know exactly what temperature is. *Temperature is the intensity of heat energy in a body.* Or we may say more simply that temperature is the degree of heat of a body. Note carefully that temperature is not the amount of heat

Man-Made Temperature

Oil pots burning in an orchard in Oregon to prevent destruction by frost.

in a body, neither are heat and temperature the same thing. Heat (energy) is a cause of temperature. Energy, which causes a feeling of warmth in a body, tends to move from a body of higher temperature to one of lower temperature. One body is hotter than another, if it can give heat to the other. It is colder if it takes heat from the other. It is clear that if a glass of water and a boiler of water are heated to the same temperature, the boiler of water has more heat energy because it has more water, but it would not give off heat to the glass if they were side by side.

81. Determining the Temperature. — Now that we have considered the meaning of temperature, we are ready to turn to a consideration of its measurement. Not only can the temperature of objects on the earth be measured, but scientists have methods of measuring the temperature of the stars that may be millions of light years distant from the earth. You have noticed at times that when you enter a room, the air feels colder or warmer than it does at other times. This is often true in spite of the fact that the thermometer hanging on the wall will show that actually there has been no change in the temperature. Can you explain the apparent difference?



WEATHER RECORDING FOR THE PUBLIC

Here all who pass may read the weather news from various instruments on the four sides of the kiosk.

Field Research:

Place one hand in hot water and the other in cold water for two or three minutes, and then place both hands in lukewarm water. Explain your sensations.

Such experiences with air temperatures and hot and cold water prove that our sense of feeling is not a good measure of temperature. Therefore, scientists have devised certain instruments which will measure temperature accurately. These instruments are called *thermometers*. The word *thermometer* comes to us through the French from two Greek words meaning *heat* and *measure*, but we must not forget that thermometers can only measure the *intensity* (the degree) of heat; they cannot measure the *amount* of heat. There are several interesting kinds of thermometers in common use.

General Problem 2. How Are Temperatures Measured?

82. Metallic Thermometers. — One of the simplest thermometers is the so-called *metallic thermometer*, like those found in the front door of ovens and used in thermostats. It is made of two kinds of metal strips, curved and fastened together so that they cannot slip. When heat is applied, they expand, but being made of different metals one expands faster than the other. Thus, this double strip of metals curves (bends) still more or straightens out according to whether the heat affecting it is greater or less than the average temperature for which the instrument was designed. Let us see how this instrument acts in the presence of heat.

Experimental Problem 8. — *How can metals be used to show changes in temperature?*

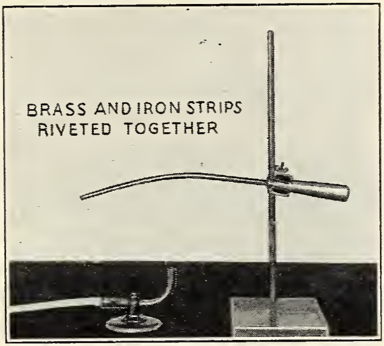
What to use: Two strips of metal, one brass and one iron, riveted together.

What to do: Heat the strip hot, and then cool it.

What happens: 1. Does the strip curve when you heat it? 2. Does it straighten out? 3. If it bends, which metal is on the outside of the curve?

Conclusion: 1. Can you think of an explanation of the bending? 2. When metals are heated, they expand. Suppose one of the metals expanded faster than the other. Does that help explain your observation?

Applications: Secure a discarded oven thermometer. Take it apart and find the two metal strips.



EXPERIMENT 8
Should the holes of the Bunsen burner be open or closed? Why?

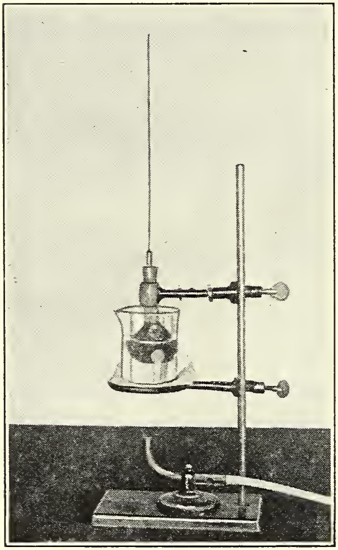
The balance wheel in a watch is really a metallic thermometer, only in this case it is used to govern the rate at which the watch spring unwinds in spite of the changes in temperature.

Field Research:

Go to a watch repair man and find out how the balance wheel helps to regulate a watch.

83. Thermometers Containing Liquids. — The common *house thermometer* consists of a glass *bulb* and *stem* nearly filled with a liquid metal, called *mercury*, or with red-colored alcohol or a similar liquid. Air is removed from the stem above the mercury or alcohol. The stem of the thermometer has a very fine *bore* (longitudinal hole) which is sealed at the top and broadens into the bulb at the bottom.

In order to understand how this kind of thermometer works you must understand that when a liquid like mercury, alcohol, or water is heated it expands, that is, it increases in volume. Mercury and alcohol expand uniformly. That is, they expand equal amounts with equal changes in temperatures, at least for ordinary changes. Their freezing and boiling points occur at convenient temperatures and so they make splendid indicators for thermometers. For example, if a liquid freezes at 20° F., it would be unsuitable for temperatures below 20° F. On the other hand, a liquid to be used in a thermometer must have a boiling point higher than the temperature it is to measure. Mercury (quicksilver) has a freezing point of −37° F. and a boiling point of 675° F., hence it can be used between those temperatures. Alcohol freezes at −179° F. and boils at 172° F. Therefore, alcohol cannot be used for temperatures above its boiling point, namely, 172° F.



EXPERIMENT 9

Why is the flask set in a beaker of water?

Experimental Problem 9. — *Do liquids expand when heated?*

What to use: A small (50 cc.) flask; a one-hole rubber stopper to fit the flask; a glass tube 12 inches long to fit the hole in the stopper; a large beaker or basin of water; a Bunsen burner; a clamp support for the flask; and a ring support for the beaker. For home experimenting a pickle bottle partly filled with water can be heated in a double boiler on the stove.

What to do: Fill the flask brim full and insert the stopper with the glass tube just sticking through it. Support the flask with the bulb immersed in cold water in the beaker. The beaker should be placed on the ring. Notice and mark the level of the water in the glass tube.

Heat the water in the beaker for a few minutes.

What happens: 1. When the stopper was inserted in the flask, did some water go up into the glass tube? 2. Why? 3. When you heated the water in the beaker, did the water in the flask get hot? 4. How? 5. Did the level of the water in the tube change as you heated the water in the beaker (up or down)? 6. How much did it change?

Conclusion: Why did the level of the water in the tube change?

Applications: Why do not hot water heaters have to be equipped with an expansion tank?

How does the liquid in a thermometer indicate higher temperatures?

When the bulb of a thermometer containing mercury or alcohol is heated, the liquid in the bulb expands or takes up more room. This causes the liquid in the stem to rise higher. If the liquid in the bulb of the thermometer is cooled, it contracts and the liquid in the stem lowers.

When water freezes does it contract or expand?

Experimental Problem 10. — *Do liquids contract when cooled?*

What to use: Use the same equipment as in Experimental Problem 9.

What to do: Place the bulb of the flask in cold water in the beaker, and add cracked ice. At home the bottle can be placed in the refrigerator.

What happens: Describe just what changes you observe.

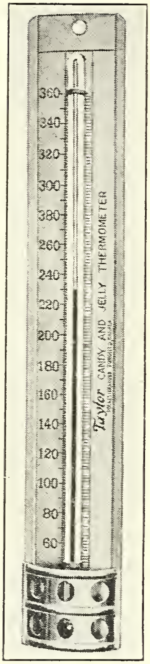
Conclusion: Do liquids contract when they are cooled?

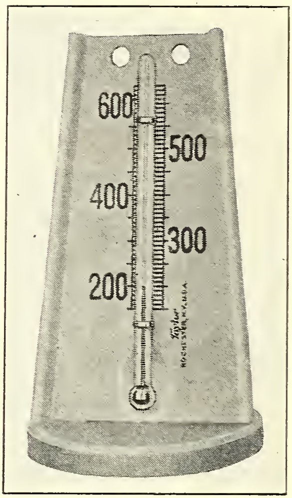
Applications: Why does the water in an automobile take up less room when it is cold than when it is hot? What happens if it freezes?

How does the liquid in a thermometer indicate lower temperatures?

84. Some Special Thermometers. — The doctor uses a small thermometer of special make to "take" (measure) the temperature of a sick person. The normal temperature of a healthy body is 98.6° F. A slight variation above or below normal is an indication of trouble.

The doctor's thermometer, called a *clinical* thermometer, has a short stem with a much





A B C D

THERMOMETERS

A is a candy thermometer. How does its scale differ from that of a house thermometer?

B is a clinical thermometer. Why is it made entirely of glass?

C is a chemical thermometer. Why does it have a long, slender bulb?

D is an oven thermometer. How many degrees are represented by each of its smaller divisions?

smaller bore than ordinary thermometers, so that a slight change in temperature will cause a considerable change in the level of the mercury in the stem.

The front part of the glass stem is shaped so as to act like a lens and hence magnifies the small thread of mercury in the bore so that it may be seen readily. The stem is *graduated* (marked off) in units of one fifth of a degree. Between the long slender bulb and the stem, the bore is constricted or made even smaller than the bore above or below (see the picture, **B**, on page 154). This keeps the mercury, once it gets above this point, from being drawn back into the bulb when the thermometer cools, as happens in an ordinary thermometer Such a device allows the doctor time to read the temperature accurately. You have seen him "shake" the mercury back into the bulb after he has read the temperature.

85. The Fahrenheit Scale. — One of the first thermometer scales was devised by a scientist named *Fahrenheit.*

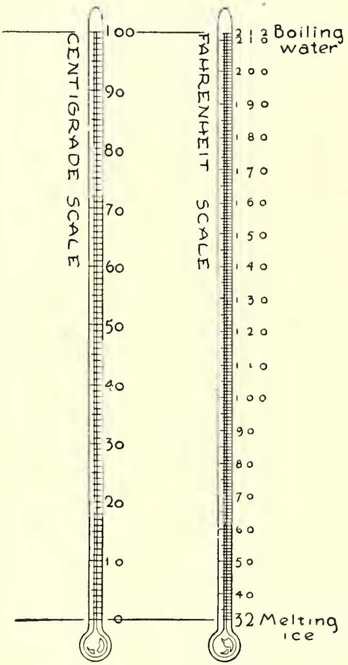
Field Research:

Consult your librarian for information about Fahrenheit. Find out how his first thermometer was marked and how the changes to the present markings happened to be made.

The common house thermometer has a Fahrenheit scale. When the bulb of a thermometer with a Fahrenheit scale is placed in melting snow or ice, the mercury or the alcohol will descend to a certain level in the stem and remain stationary. This point is marked 32°. If the bulb of a mercury thermometer is placed in boiling water or steam at standard air pressure, the liquid will rise to a level which is marked 212°.

Why does not an alcohol thermometer have temperatures marked as high as 212° F.?

The stem between the 32° mark and the 212° mark is marked off into 180 equal divisions, and each one of these divisions is called a *degree.* There are, then, on the Fahrenheit thermometer scale, two "fixed points," the 32° mark, which is the temperature at which ice melts or water freezes, and the 212° mark, which is the temperature at which water boils under standard air pressure.



A Comparison of Temperature Scales

The Centigrade reading multiplied by 1.8 plus 32 equals the corresponding Fahrenheit reading. Try it.

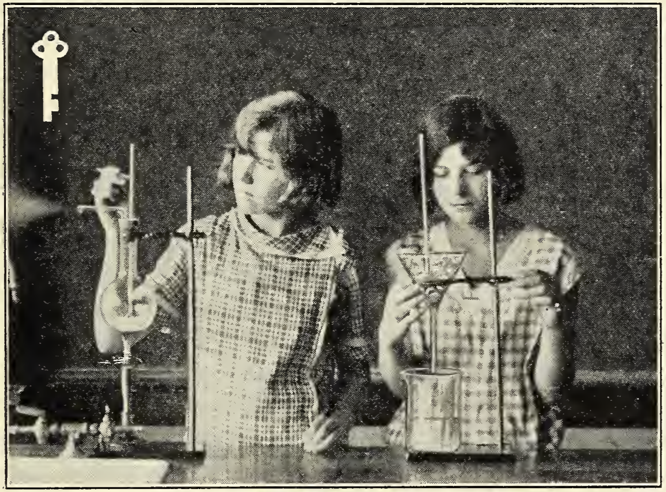
(Key) ***Experimental Problem 11: How may a thermometer be tested by its "fixed points" to determine its accuracy.***

What to use: A mercury thermometer; ice; a funnel; a beaker; a tripod; wire gauze; and a Bunsen burner.

What to do: Test the position of the 32° mark by placing the bulb in the funnel containing small pieces of ice. Catch the drip water in a beaker. (Melting ice is exactly 32° F. in temperature.) In the absence of a funnel use a cup filled with cracked ice, just covered with water. Leave the bulb in the ice until you are certain the mercury in the stem has come to a stationary position, showing that all the mercury in the bulb is at the same temperature as the melting ice.

Now carefully observe the 32° mark on the stem to determine whether it is exactly on a level with the mercury in the stem. If it is, the thermometer is accurate as to this fixed point. If it is not, make a note of the amount of disagreement, plus or minus.

To test the 212° mark on the thermometer, proceed as above except that you place the bulb in boiling water. It should be noted, however, that the boiling point of water is higher with increased air pressure and lower with low air pressure, so the results will not be as accurate as for the other test. If you wish to make corrections for air pressure, see the table in the Appendix. But since the small variation of pressure causes only



(KEY) EXPERIMENT 11

What is the girl at the left doing? What precaution is she taking?

slight variation in temperature, the test will be accurate enough for your purpose just now. (A thermometer with a wooden back should not be placed in boiling water, for the hot water will injure the finish on the wood.)

Conclusion: State how accurate you found the thermometer.

Applications: Commercial thermometers are calibrated (marked for reading) by placing them in constant temperature baths and marking the mercury (or liquid) level for each temperature. Then with a dividing machine the stem is marked off into equal spaces with these marks as starting places. Or the spacing of the marks is transferred to the metal back.

Use a tested thermometer to check one that may be inaccurate.

86. The Centigrade Scale. — The *Centigrade* thermometer scale differs from the Fahrenheit scale in divisions and "fixed points." On the Centigrade thermometer, the point at which the liquid in the stem should stand when the bulb is in melting ice is marked 0° C. The level for boiling water is marked 100° C. The space between 0° C. and 100° C. is divided into 100 divisions, hence the name *centi* (hundred) *grade* (marks). A thermometer with a Centigrade scale may be tested in the same manner as the Fahrenheit.

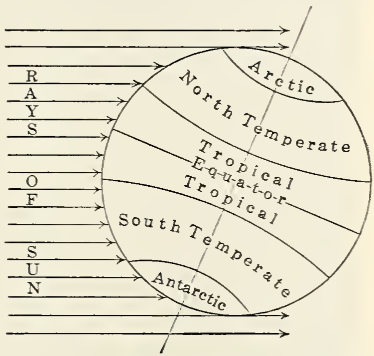
General Problem 3. What Causes Differences in Air Temperatures?

87. Variations in Air Temperature. — In the Temperate Zone the air temperatures range from 60° F. below zero to 110° F. above zero. The five heat zones of the earth — tropical, north and south temperate, and north and south frigid zones — result from the fact that the earth's axis is inclined $23\frac{1}{2}$° away from the vertical. Because of this, as you have learned already (see page 100), portions of the earth receive more direct rays from the sun than others, and the direction of the rays changes from season to season.

While the zones are marked off on a map by lines parallel with the equator, the limits of the zones are by no means as regular. Altitude, nearness to large bodies of water, ocean currents, and wind direction all act to cause a variation of the line between zones.

The temperature of the air of a place is affected by the direction of *winds*. Wind coming from the north is usually a current of cold air and consequently the temperature of a place in its path will drop. Also, air moving over a body of cold water is cooled and will cool the succeeding localities over which it passes.

The temperature of the air is affected by the direction of the rays of the sun. Slanting rays of the sun, as you have learned, do not heat the earth as much as the more direct rays. Consequently the air over a certain portion of the earth will be warmer during the season when that particular region receives the more direct rays of the sun. Of course you know that heat energy absorbed by the earth from the sun heats the air above it.



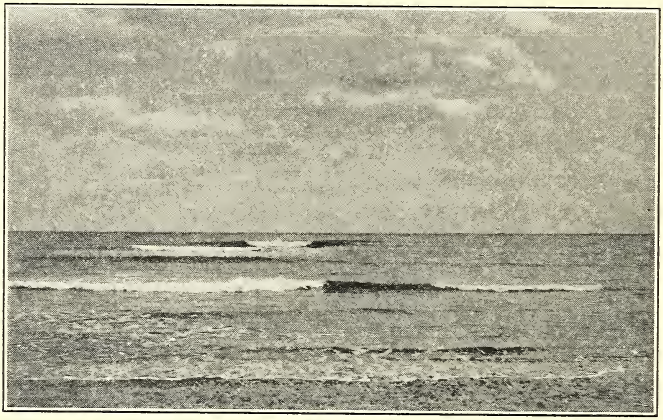
TEMPERATURE ZONES

Altitude above sea level has a marked influence on air temperature. Notwithstanding the fact that the top of a mountain is nearer the sun, it is cooler there than at its base. Air temperatures decrease with altitude up to about 6 or 7 miles, which is the top of the troposphere. Above the troposphere and in the stratosphere the temperature remains rather constant at 60° to 75° F. below zero.

From what you have studied about the relation of the sun's heat on the moon and the earth (page 48), try to explain the cause of decreasing temperatures as one rises towards the sun.

The temperature of the air of a locality is affected by the nearness or remoteness of large bodies of water. A large lake (or ocean) makes the summer temperature of near-by land cooler than it would be otherwise and the winter temperature warmer.

The temperature of the air of certain places near the ocean is affected by the great ocean currents. These currents are like huge rivers flowing in the ocean itself.



A Regulator of Temperature
What effect has this body of water on the near-by land?

If the current comes from the Tropical Zone, its waters are warm and will heat the air of places near it. On the other hand, if the current comes from the north, its waters are cold and will make the air of near-by places colder.

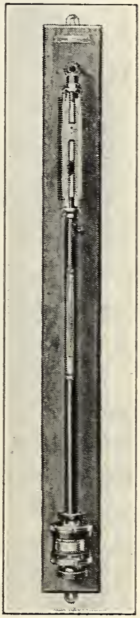
Field Research:

Ocean currents owe their motion partly to the fact that cold water is heavier than warm water. The direction of ocean currents is influenced by the rotation of the earth. Follow up these hints by further reading to determine why a particular ocean current takes the course it does.

General Problem 4. How Can Air Pressure Be Measured?

88. What Is Air Pressure? — The earth is covered with an ocean of air called its *atmosphere*. There is really no "top" or upper surface of the atmosphere, as there is to the water ocean. The air merely *rarefies* (thins off) into space.

In your science study last year, perhaps you experimented and found that air is composed of oxygen, nitrogen, carbon dioxide, moisture, and rare gases. Can you recall how you tested for three of these substances? The air has about the same composition up to an altitude of sixty miles, except for ozone, although without special aids to breathing man cannot live long above three and one half to four and one half miles from the earth on account of low air pressure. We know almost nothing of its composition above that height. It is likely that above 100 miles the atmosphere contains slowly decreasing amounts of oxygen but no hydrogen. Nitrogen is the principal gas at all heights.



A Mercurial Barometer

We know that air is matter and that all matter has weight. *The weight of the air is called air pressure.* A column of air one square inch in area, and as high as the air extends upward, weighs 14.7 pounds at sea level under normal conditions. Since there is a similar column of air over every square inch of ground or water, we may say that the atmospheric pressure on the earth is 14.7 pounds to the square inch. This is called *one atmosphere of pressure.*

To help you understand about air pressure, think of a large pile of loose straw. It would be more pressed together or compact at the bottom than at the top, for the straw at the bottom would bear the weight of all the straw above it. The same is true of air. The lower portion of the atmosphere is the most compact or *dense*. As one goes up from the earth, the air becomes more rarefied (less dense). Therefore, the air pressure decreases very rapidly as one ascends from the earth. At a height of about three and a half miles, approximately half of the weight of the air is below one. That is, at that altitude the pressure is approximately 7.3 pounds per square inch.

89. Measuring Air Pressure. — Air pressure is measured by instruments called *barometers*. There are two types of barometers in general use, *mercurial* (or *liquid*) and *aneroid* barometers. Here is the story of the invention of the mercurial barometer.

Galileo, knowing that water would not rise in a pump higher than about 33 feet, reasoned that the fact had something to do with the pressure of the atmosphere. He asked one of his pupils to solve the problem. The pupil, *Torricelli* (tŏr′rē-chĕl′lē), proved that Galileo's idea was correct by his now famous experiment.

Torricelli filled a tube about a yard long, and closed at one end, with mercury. Placing a finger over the open end, he inverted it, putting the open end in a dish of mercury. On removing his finger, by which he had held the mercury in the tube while inverting it, he noticed that not all the mercury came out of the tube. It settled down part way and came to rest with the top of the mercury in the tube about 30 inches above the surface of the mercury in the dish.

Torricelli reasoned that since there was no air in the tube above the mercury (the tube had been filled with mercury and no air was allowed to enter), the column

Would You Believe!

Would you believe that the fact that engineers, in the time of Galileo, could not raise water in a suction pipe higher than 33 feet, could lead to the invention of the barometer? Here is the answer:

Evangelista Torricelli became a pupil of Galileo a short time before Galileo's death in 1641. After Galileo's death, Torricelli was considered to have the master mind of his time. He was appointed Professor of Mathematics and Physics in the University of Padua, a position formerly held by Galileo.

Torricelli studied the flow of liquids and became interested in finding a reason why water would rise only 33 feet in a suction pipe.

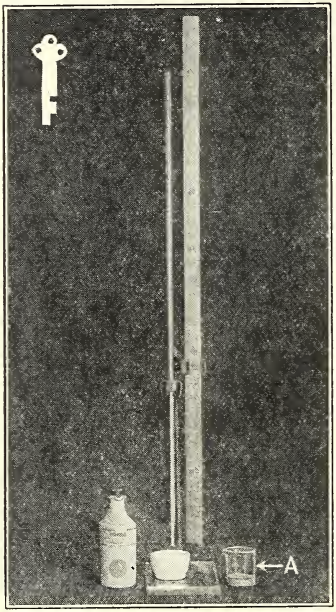
The text tells how he experimented with a tube and mercury. He discovered that the mercury, held up in the tube, weighed the same as the column of water (same diameter) standing in the suction pipe. He proved that the water and the mercury, respectively, were held up by atmospheric pressure.

The first barometer to measure changes in air pressure was constructed in 1643 by Torricelli and a friend.

of mercury must be held up or balanced by the pressure of the air on the surface of the mercury in the dish.

Field Research:

Suppose you try Torricelli's experiment to find what results you get. If you fasten the tube upright, you can measure the height of the column of mercury from day to day to observe any changes that take place. (See (Key) Experimental Problem 12.)



(Key) Experiment 12

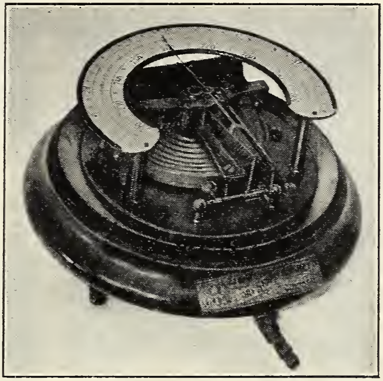
A column of mercury 30 inches high and one square inch in area weighs 14.7 pounds. Since it is the air that holds the mercury up in the tube, it follows that the pressure of the air per square inch is 14.7 pounds.

Pascal, another famous scientist, thought that if Torricelli's explanation of the action of a barometer was true, then the height of the column of mercury ought to be less on top of a mountain than at the foot. In 1643 Pascal had an inverted tube filled with mercury carried to the top of a mountain and by this means proved his theory to be a fact.

(Key) ***Experimental Problem 12: How does atmospheric pressure affect a barometer?***

What to use: A glass tube 34 inches long, with a bore of $\frac{1}{4}$ inch and sealed at one end; mercury; a ring stand and a clamp; a yardstick; and a small, flat-bottomed dish.

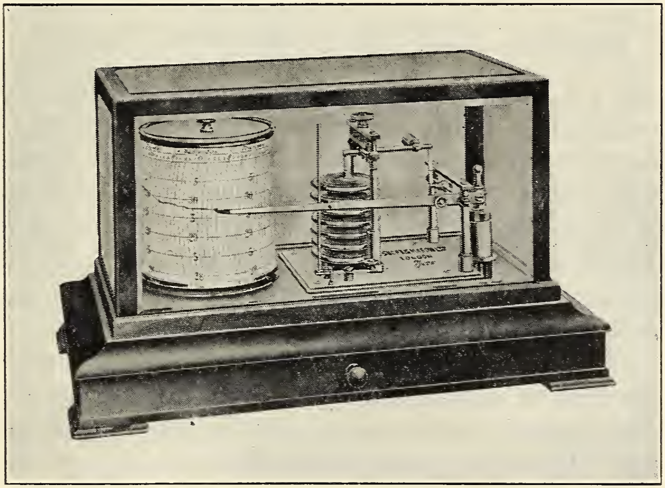
What to do: Set up the barometer as Torricelli did and fasten it in an upright position on the ring stand. At a certain time each day for one week measure the distance from the surface of the mercury in the dish to the top of the mercury in the tube. Record your readings in a table.



A Demonstration Aneroid Barometer

How does this differ from a household barometer?

What happens: 1. Did the mercury stay in the tube with a level of about 30 inches in height? 2. What kept it from flowing entirely out of the tube into the dish? 3. Did the height of the column of mercury vary from day to day? 4. How much?



A Recording Aneroid Barometer

Was the air pressure increasing or decreasing when the picture was taken?

Conclusions: What is the effect of atmospheric pressure on the mercury column of a barometer?

Applications: Keep a record of the air pressure and air temperatures for a few days. Note differences or similarities in their readings.

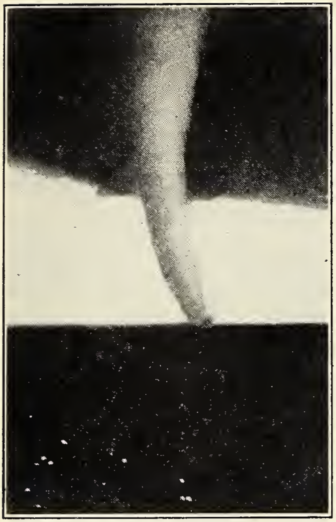
The aneroid barometer is more convenient for general use than the mercurial barometer. It can be made small and light. It contains no liquid to spill and so is readily portable.

The part affected by changes in air pressure is a flat metal box with flexible top and bottom. It contains no air. Increasing pressures squeeze the top and bottom together and decreasing pressures let them spring back again. Their movements are transmitted to a pointer on the face of the aneroid by little levers and chains. Another important advantage of the aneroid is that its readings can be recorded automatically.

General Problem 5. What Is Wind?

90. Air Motions. — On a hot summer day you may be enjoying a gentle breeze while in other sections of the country a wind may be blowing with such terrific velocity that it tears down buildings, pulls up trees, and devastates everything in its path. A wind like the latter is called a *tornado*. The velocity of a tornado may reach 200 or 300 miles per hour. Wind of ordinary velocity moves from 3 to 15 miles per hour. *Wind is air in motion.*

In order to understand the cause of this moving air, called "wind," let us consider some common observations. Almost everybody knows that hot air rises. Do you know why? Perhaps you can get an answer by experimenting at home.



TORNADO CLOUD
The white spots in the foreground are hailstones.

Courtesy Science Service

IN THE PATH OF A TORNADO
The violence of tornado storms causes destruction like this.

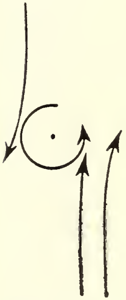
Field Research:

If you have a hot-air furnace in operation, place a tuft of cotton or a feather over the hot-air register. Does the cotton move up or down? Which way does it show that the air is moving? If you have no furnace but have a stove, make a little smoke near the stove pipe. Does the smoke go up along the hot stove pipe? Which way is the air moving, up or down?

Or open a window a bit at top and bottom, when it is rather cold outdoors and there is no wind blowing. Test the air movement. Does the air come in through the open window at top or bottom? Does it go up or down after it gets in?

From your experiments you should discover that warm air rises because cool air settles and displaces it. You conclude that if air is heated unequally, that is, heated more in some places than others, the air will move, because cold air is heavier than warm air and therefore settles and pushes the warm air out of its way. For this reason air will move from a colder region to a warmer region.

In our imagination let us travel down near the equator in Central America. Here we shall find that the land receives the maximum amount of heat energy from the sun. We shall soon observe that the air touching the heated earth becomes warmer than the air a little farther to the north or to the south. Consequently, the warm, light air is pushed up out of the way by cold air coming in from the north and south.



SHIFTING AIR CURRENTS

Another interesting fact is that, because of the rapid rotation of the earth about its axis, the air currents pushing in from the north and south do not meet head-on, so to speak. The current from the north shifts to the right and the current from the south also shifts to its right. This movement of winds north of the equator causes the rising air to whirl *counter-clockwise.*

Field Research:

One result of this whirling movement of air currents can be illustrated by whirling water in a glass. The water will whirl with the glass but will pile up at the sides of the glass and will be shallow in the center. Try it.

A whirling mass of air acts in a similar way to whirling water. The center portion of the whirling mass is shallow and has a low air pressure. A whirling mass of air may be many miles across and move in a northerly direction up through Mexico and in a curved northeasterly path over the United States toward the St. Lawrence River. Sometimes these whirling formations of air form in the Pacific Ocean and pass over the United States in a curved path from the state of Washington and out the St. Lawrence River region. These large whirls of air moving across the United States are called *cyclones.* A cyclone should not be confused with a tornado.

91. On the Wings of the Wind. — An ability to estimate the velocity of the wind will bring you worth-while and interesting experiences. A study of the following table and a little practice will make it possible for you to use this ability with considerable accuracy.

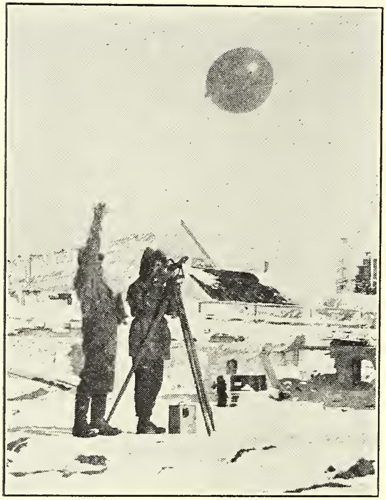
Air Condition	Velocity Mi. per Hr.	Distinctive Characteristics
Calm	0	Flags limp, leaves unmoved. Smoke goes straight up.
Breeze	1–5	Leaves of trees barely move. Smoke drifts.
Fresh	5–15	Moves small branches of trees, blows up dust. Flags blow out.
Brisk to Strong	15–25	Sways branches of trees, makes whitecaps, much dust and sand.
High	25–35	Sways trees, moves twigs on ground.
Gale	35–75	Breaks branches of trees, dangerous for sailing.
Hurricane	75–100	Destroys houses, uproots trees.

Winds are named from the point of the compass from which they come. Hence a weather vane, a flag on a pole, or smoke from a chimney will determine wind direction.

Experimental Problem 13. — *How can the direction and velocity of the wind be determined?*

What to use: A weather vane (or a magnetic compass); a flag on a pole; and smoke from a chimney.

What to do: Determine the points of the compass, — North, East, South, West, and equidistant points between, — eight in all. Observe and record the direction of the wind as indicated by the weather vane, flag, or smoke, using arrows flying with the wind as indicators.



MEASURING THE VELOCITY AND DETERMINING THE DIRECTION OF WIND

By reference to the preceding table of velocities estimate the velocity of the wind at each observation.

What happens: Record your observations.

Conclusion: Tell how you determined the direction and velocity of the wind.

Applications: Keep a record of the wind direction and velocity for a few days to discover if there is any relation between a high wind and direction.

92. Wind Pressure. — You know that it is difficult to walk against a strong wind. This characteristic of the wind is called *wind pressure.* Wind pressure varies or increases in proportion to the square of its velocity. For example, if a wind of 5 miles per hour increases to 10 miles per hour, the wind pressure becomes four times as great. That is, the pressure at 10 miles per hour is as much greater than that at 5 miles per hour as 100 (10×10) is to 25 (5×5).

Field Research:

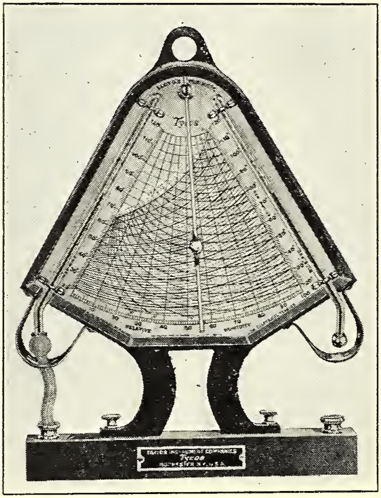
A wind blowing 10 miles per hour exerts pressure of about 0.27 pounds per square foot. Calculate the total pressure (approximately) that it would exert against your body. (Height and width $\times$ 0.27 pound.) What would be the total pressure on a window of your school or house?

THE STEAMING MOISTURE OF THE JUNGLE

GENERAL PROBLEM 6. WHAT IS THE HUMIDITY OF THE AIR?

93. Moisture in the Air. — You have learned that the moisture in the air is really water. Usually it is in the form of an *invisible* gas and is referred to as the *humidity* of the air. Because it is invisible it is difficult to understand. The invisible moisture is the gaseous state of water. You have, however, *seen* fogs, clouds, and rains, and so have had first-hand evidence of the presence of those forms of moisture in air. The amount of gaseous moisture in the air varies from time to time. The air very rarely, if ever, contains all the gaseous moisture it can hold. The actual amount of invisible moisture required to saturate the air depends upon the temperature of the air.

Warm air can absorb more moisture than cold air. The amount of moisture in the air at any one time is always relative to the amount which the air would hold if completely saturated at the same temperature. The first amount is always stated as a per cent of the latter and is known as the *relative humidity*. For example, if the air contains three fourths as much moisture as it could possibly hold at a given temperature, the relative humidity is 75%.

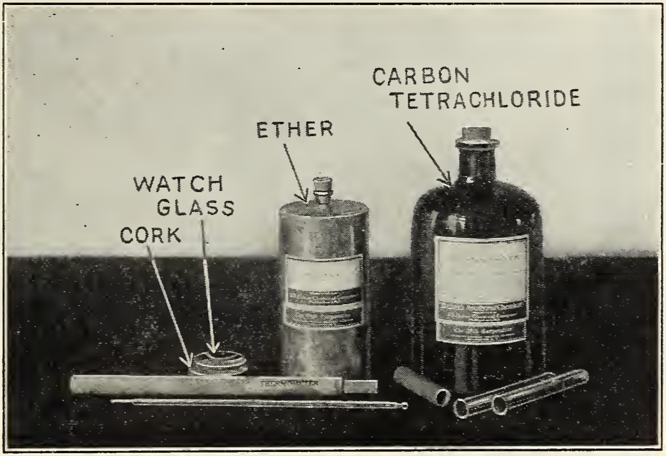


A HYGROMETER

Why is a wick on one bulb only?

A *hygrometer* is used to measure the relative amount of moisture in the air. It usually consists of two thermometers with the bulb of one thermometer covered with a silk wick which dips into water. The other bulb is left dry. Water creeps up the wick due to *capillary action* and wets the bulb with the silk wick. Capillary action is the lifting of liquids by means of tubes or tube-like air spaces of fine bore. The liquid water changes into gaseous water (evaporates) and escapes.

As the water on the bulb changes from the liquid state to the gas state, it absorbs heat from the mercury or alcohol in the bulb, causing the liquid in the bulb to contract. The other thermometer bulb which is kept dry indicates the real air temperature.



EXPERIMENT 14

What other examples can you give to show that evaporation causes a cooling effect?

Experimental Problem 14. — *Does an evaporating liquid absorb heat?*

What to use: Alcohol; gasoline or carbon tetrachloride; ether; a large, flat cork; and a small watch glass.

(**Caution:** Do not have any flame about.)

What to do: Put a few drops of gasoline on the back of your hand and let it evaporate. Repeat, using a few drops of carbon tetrachloride, ether, or alcohol.

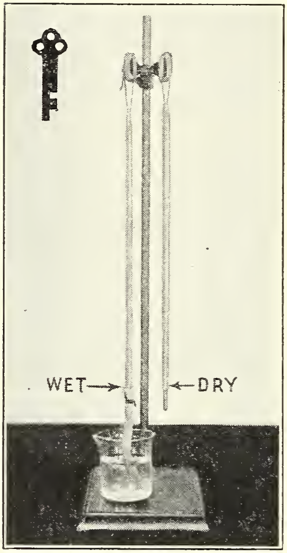
Place a few drops of water on the cork. Set the watch glass in the water and fill it with ether. Fan the ether briskly.

What happens: 1. Did the liquids on your hand dry up (evaporate)? 2. Did this make your skin feel cold? 3. Did the ether in the watch glass evaporate? 4. Did fanning make it evaporate faster? 5. What happened to the water under the glass?

Conclusion: Do liquids absorb heat when they evaporate? Explain.

Applications: Why does fanning yourself make you feel cooler? Why is it colder in a wind than out of the wind?

A Law: When any liquid evaporates (turns to the gas state), it takes in or absorbs heat.



(Key) Experiment 15

What is in the beaker? Would the effect be the same if ether were used? Explain.

(Key) ***Experimental Problem 15: What is the relative humidity of the air?***

What to use: A hygrometer or two thermometers; a support; a silk wick; and a beaker.

What to do: Fill the water pan of the hygrometer, or place the wick on one of the thermometers, supported so that the wick will hang in the beaker of water.

The second thermometer is hung alongside of the first, as in the picture.

Allow the apparatus to stand a few minutes and then read and record the temperature of the air from the dry-bulb thermometer and the wet-bulb temperature.

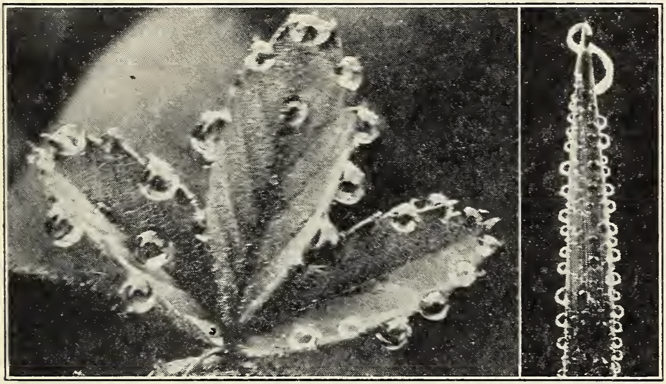
What happens: 1. Does the wet-bulb thermometer read lower than the dry bulb? 2. What causes the difference?

Use the table of relative humidity in the Appendix to calculate the relative humidity.

Conclusion: 1. What did you find the relative humidity to be? 2. What principle or law is involved in the determination?

Applications: What is the relation between health and relative humidity? between relative humidity and wet things drying?

The drier the air, the greater will be the difference in readings between the wet bulb and the dry bulb because, in the drier air, the water on the wet bulb will evaporate faster and therefore absorb heat faster from the mercury. If the air could be saturated with moisture, no water could evaporate from the wet bulb. (Why?)



Dewdrops

Like drops of clear crystal spangling leaves and grasses.

General Problem 7. What Causes Precipitation?

94. Dew and Frost. — As the sun drops below the horizon, the land begins to cool rapidly. Consequently, when the air touches the cold earth, it too becomes cooler. The water vapor which the air contains is then condensed to little particles of water on cold objects such as sticks, leaves of plants, and blades of grass. This *condensed moisture* on the cold objects is called *dew.* You may have shown by experiment in earlier science work how moisture will condense. Warm air holds a larger mixture of invisible water than cold air, hence some moisture must separate from the warm air and become visible, if it becomes cold enough. When water separates from air and falls as rain, snow, sleet, hail, dew, or frost, the process is called *precipitation.*

Experimental Problem 16. — *How does dew form?*

What to use: A tin cup; ice; and a thermometer.

What to do: Partly fill the cup with water at air temperature. Add ice, a little at a time, stirring constantly. The thermometer bulb should be in the water, but do not stir with it. Why?

Experiment 16

Why use a tin cup instead of a thick earthenware cup? Why use a glass-stemmed thermometer?

Watch the outside of the tin to note the first appearance of a film of moisture on the tin surface. At that instant read the temperature of the water.

Repeat the experiment three times.

What happens: 1. Did the ice melt? 2. Did the temperature of the water become lower? 3. What caused it to get colder? 4. Did moisture form on the outside of the dish? 5. At what average temperature for the three experiments? 6. Where did the moisture come from? 7. What was the temperature of the layer of air touching the tin dish when its moisture condensed?

Conclusion: The air temperature at which its moisture condenses is its *dew point.* What was the dew point of the air during your experiment?

Application: What makes the cold water pipe or water pitcher "sweat" some days in summer more than on other days?

If, during the night, the temperature of the earth and the air touching it drops down to 32° F. or below, the moisture freezes as fast as it separates and the result is called *frost.*

Why is dew less likely to form on a cloudy night than on a clear night? (See page 140.)

95. The Birth of a Raindrop. — It will help you to understand clouds, rain, and snow better if you can find out what causes the small particles of the clouds to become large enough to fall.

It is strange but true that water vapor will not readily change from a gas to a liquid unless it has something to condense "on," such as a cold dish, window, or leaf as in the formation of dew. In the air it seems that tiny dust particles serve that purpose in making rain. They act as *nuclei* (centers) on which the moisture of the cooled air can condense. It is thought by some scientists that particles of electricity in the air, called electrons, also may act as nuclei for condensation.

Clouds consist of millions of such tiny drops of water, so light that they are held up by the air. Once the water particles are formed from vapor, they may grow larger by the condensation of still more water on their surfaces and hence may become large enough to fall. A raindrop may be half a million times larger than a cloud particle. The sizes of raindrops vary from one

Photograph by Captain D. Wilson-Barker

FEELING HER WAY THROUGH THE FOG

The most ticklish job that weather imposes upon the navigator.

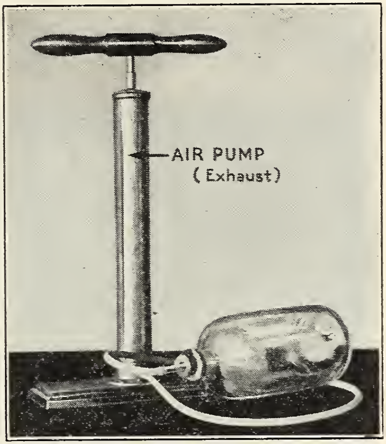
Photograph by Captain C. J. P. Cave

A MORNING MIST IN ENGLAND

Light fog creeping over the South Downs. What causes such a fog?

twentieth of an inch to one fifth of an inch. One inch of rainfall deposits over 100 tons of water per acre.

The formation of fog illustrates the need for particles on which moisture can condense.



How to Make a Fog

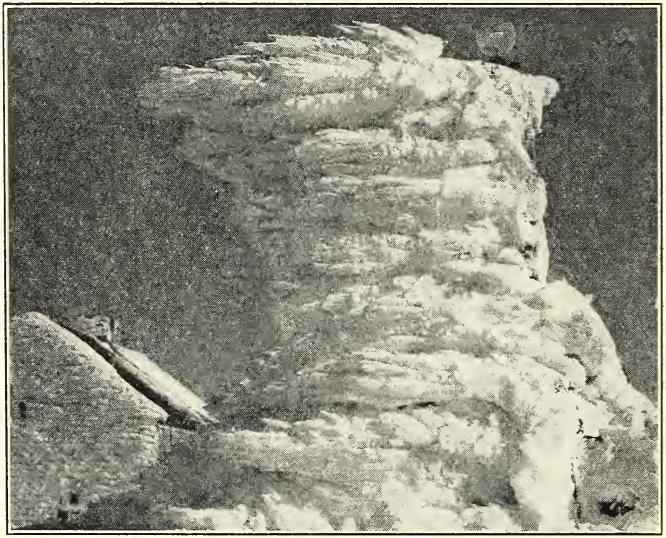
Field Research:

With the aid of a large glass bottle with a one-hole rubber stopper, a glass exit tube, an exhaust air pump, a heavy walled rubber tube and some chalk dust, try forming a fog. The air in the bottle may be cooled by forcing in more air and then allowing it to expand quickly, or by quickly taking out air by means of the exhaust pump, which causes rapid expansion of the air left in the bottle. If the air in the bottle contains dust when the air is suddenly cooled as above, a fog will form. If there is no dust, put in some chalk dust and exhaust again.

96. Why the Air in the Sky Cools. — In order to complete our knowledge of how it rains, we must discover what makes the air of the sky become cooler. You know that there is a general cooling at certain seasons due to the motions of the earth and the direction of the sun's rays. However, it is a local cooling that causes rain, snow, or hail. What causes this local cooling?

A simple law of gases (air is a mixture of gases) will answer our question. Do you know what happens when you compress air into a tire with a tire pump?

The pump gets hot but not from friction. It gets hot because in forcing air into the tire, the air becomes hot. When a gas is forcibly compressed into a smaller space, it gets hot. Also when a gas expands, it gets cooler. (Refer to your fog experiment.) Remember, then,



Frost Feathers

The velocity of the wind on Mt. Washington, New Hampshire, has blown these frost crystals into a fantastic shape like some massive figurehead.

that gases become heated when they are compressed, and cooler when they expand. This explains the cooling of air.

Warm air expands as it rises above the earth and therefore cools. If the rising current of warm air contains considerable moisture, the cooling, due to expansion, may cause the moisture to condense and form a cloud. That is just what causes cumulus (page 140) clouds. If the expansion is great enough, the cooling may form large drops of water that will fall in spite of the rising current which is able to keep the smaller cloud drops dancing in the air. When a gentle drizzle takes place, it shows that the rising current of air is slow so that even tiny drops can break away from their clouds and fall down through the air.

97. Snow and Sleet. — Who has not made a snow man or a snow fort? How differently snow packs —

Snow Crystals

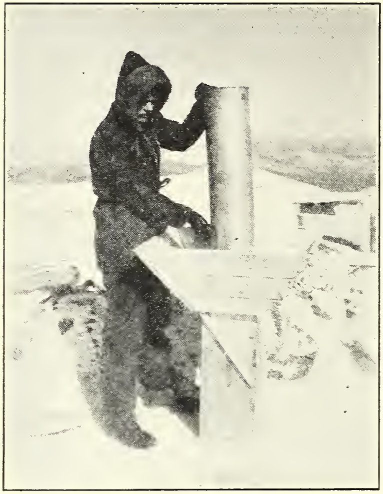
Can you observe any similarities? Explain.

sometimes it is so dry it will not pack at all and then again, it is so wet it makes the best of snowballs. Of course, a blanket of snow is made up of snowflakes just as rain is made up of raindrops.

Field Research:

On a cold, crisp day examine snowflakes with a magnifier. You will marvel at their beauty. It was said by Mr. Wilson A. Bently of Jericho, Vt., who, during his life, photographed thousands of snowflakes, that there are no two alike.

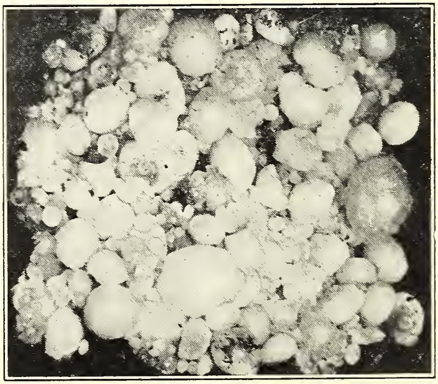
Whenever the air is cooled to a temperature of 32° F., or somewhat lower, its moisture will freeze into tiny crystals. More crystals form on the first and so a snowflake is built up.



Measuring the Depth of Snowfall

Snow is measured by finding its average depth, but as "precipitation" it is reported in inches of water obtained when it is melted. Some snow is heavier than other snow because it contains less air; in other words, it is more packed. It ordinarily takes about twelve inches of snow to make one inch of water.

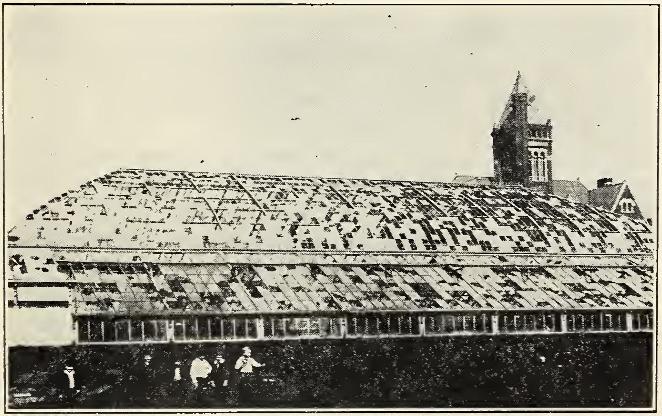
Some people think that snow consists of frozen raindrops. That is not the case. Frozen raindrops form what is known as *sleet.* Sleet is also formed when snowflakes melt in the air and become frozen again. While sleet consists of little ice particles, these ice particles differ from hail in their structure and manner of formation.



Hailstones

What are they? Can they occur at any time of year? Explain.

98. How Hail Is Formed. — While snow and sleet occur in the winter, hail almost always occurs in warm weather. Hail is a feature of thunderstorms and is formed by raindrops being tossed high into the air by the upward currents of air to an altitude where the air temperature is below freezing. There they change to globules of ice. If the hail drops, it may melt before it reaches the earth, or it may become covered with an additional layer of water



THE EFFECT OF A HAILSTORM

condensed on its surface and be hurled up again, causing a new layer of ice to form. In this way a hailstone is made up of layers of ice. When it gets too heavy for the rising currents to keep it up, it falls to earth.

With your knowledge of weather factors you are now ready to investigate and understand the occurrence and formation of storm areas and the prediction of the weather.

KEY WORDS

air pressure	atmosphere	clinical
altitude	capillary action	clouds
aneroid	Centigrade	contract

cyclone	humidity	sleet
dew	hygrometer	snow
evaporate	mercury	temperature
Fahrenheit	Pascal	thermometer
"fixed points"	precipitation	tornado
fog	rain	Torricelli
frost	relative humidity	velocity
hail	saturated	wind

Key Statements

1. The senses are poor indicators of temperature.
2. Metals expand at different rates.
3. Mercury and alcohol are used in thermometers because they expand uniformly and because their freezing points and boiling points occur at convenient temperatures.
4. Most solids (including metals), liquids, and gases expand when heated and contract when cooled.
5. The Fahrenheit thermometer scale has 32° for the temperature of freezing water (or melting ice) and 212° for the boiling point of water at sea-level air pressure.
6. The Centigrade thermometer scale has 0° for the temperature of freezing water (or melting ice) and 100° for the boiling point of water at sea-level air pressure.
7. Air pressure (atmospheric pressure) is due to the weight of the air.
8. The air pressure decreases as the altitude increases.
9. Air pressure can be measured with a barometer.
10. Wind is caused by the unequal heating of the air.
11. Due to the rotation of the earth, air currents are deflected to the right in the northern hemisphere and to the left in the southern hemisphere.
12. Air moves in great whirls called cyclones.
13. The pressure of the wind increases as the square of its velocity.
14. Relative humidity is the ratio of the amount of moisture in the air to the amount that would be needed to saturate the air at a given temperature.
15. Evaporating liquids absorb heat.

16. Dew forms by condensation of the moisture of the air, when the air is sufficiently cooled by contact with cold objects. Frost occurs, if the cold object is below freezing.

17. Rain results from the condensation of the cloud water particles on dust or electric charges.

18. Rising air currents expand and become cooler.

19. Snow is composed of ice crystals formed by the freezing of the moisture of the air.

20. Sleet forms from the freezing of rain or the melting of snowflakes and the freezing of the drop of water which results.

21. Hail is made of globules of ice in layers.

Thought Questions

1. Why are the freezing point and the boiling point of water taken as "fixed" points on thermometers?

2. If air pressure acting on the surface of the mercury in the dish holds the mercury up in the tube of a barometer, why does it not push more mercury into the tube since the area of the mercury surface in the dish is so much greater than in the tube?

3. How can a barometer be used to determine altitudes?

4. Why must the top of a barometer tube be sealed?

5. Why is it necessary to remove the air from the box of an aneroid barometer?

6. Why does the wind blow?

7. Why will sprinkling a street with water cool the air?

Projects for Your Science Discovery Book

1. List all the uses of thermometers you can discover.

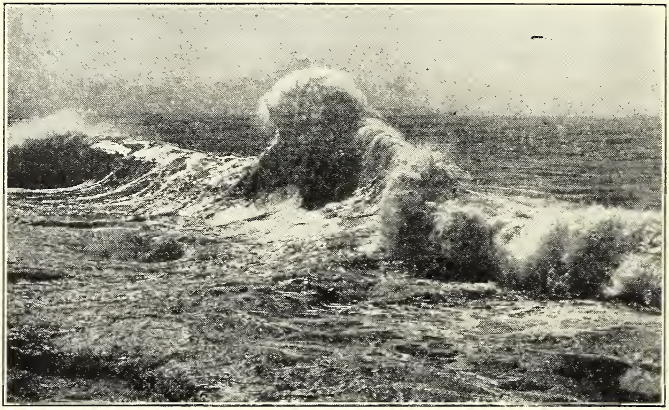
2. Record the extreme temperatures for your town. Do you believe that summers are cooler and winters warmer than they used to be? Investigate by means of weather bureau reports to find the facts.

3. Keep a daily weather record for two weeks. Make observations at the same time each day. Include reports of wind direction and velocity, temperature, precipitation, and cloudiness.

4. Keep a special record of wind direction for one month to determine the prevailing wind direction of your locality.

5. Make a report on the direction and effects of ocean currents.

SURVEY OF TOPIC VIII



Have you ever watched a summer's storm ride across the sky? Sometimes near the shore, the heavy storm clouds will gather toward the west, rush across the sky, spilling rain as they ride, and disappear over the ocean's edge, all in one short hour. Out to sea sheets of rain may still be falling, when overhead, once more, the sun shines.

Have you ever watched the raindrops chase each other down the window pane; seen the curtain of rain falling endlessly from leaden clouds; and wondered how long this downpour would last?

And have you seen the breakers crash along the shore — have you listened to their roar as they fell over each other in their mad eagerness to run back into the deeps? Some storm, far out to sea, is closing in over the surface of the waters, and the waves rise high, curl over, rush forward, and rise again in response to the wind's wild calling.

These various storms do not just happen; they are due to very definite causes and they move in well-defined areas. Because of these facts we can study them and their importance in predicting weather.

TOPIC VIII

STORM AREAS

The winds grow high;
Impending tempests charge the sky;
The lightning flies, the thunder roars;
And big waves lash the frightened shores.

— PRIOR

Do you know:

1. How large an area a rain storm covers at one time?

2. Whether lightning strikes twice in the same place?

3. What makes the thunder?

4. What high and low pressure areas are?

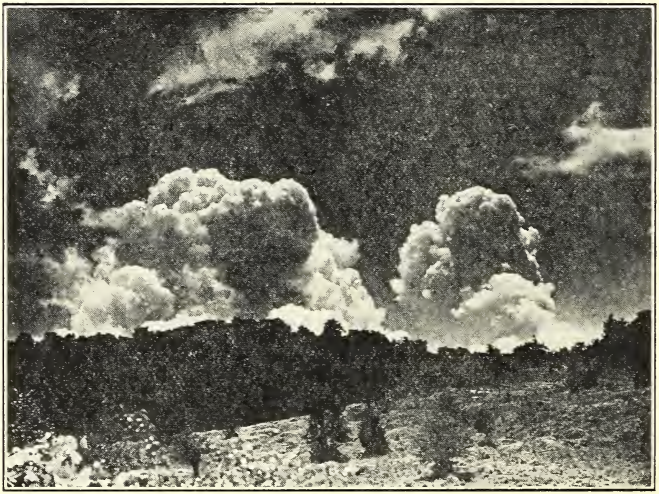
5. The paths taken by great storm areas across the United States?

GENERAL PROBLEM 1. WHAT ARE LOCAL STORMS?

99. Local Disturbances. — Local storm areas include thunder (electric) storms, windstorms, hail, and some snowstorms. Local storms are generally caused by sudden local disturbances of the air, such as excessive heating or cooling over a small area.

100. Thundershowers. — One of the most interesting and at the same time terrifying of local storms is the thunderstorm. You will recall how cold the rain is which falls during a thundershower. In fact sometimes hail occurs in such a storm. This tells us that a thundershower is caused by a very sudden and severe cooling of the air above the earth.

Overheating of very moist air in a locality starts a sudden and rapidly rising current of air. You have learned that when air rises rapidly, it cools rapidly. This cooling changes the fair-weather cumulus cloud into a thunderhead.



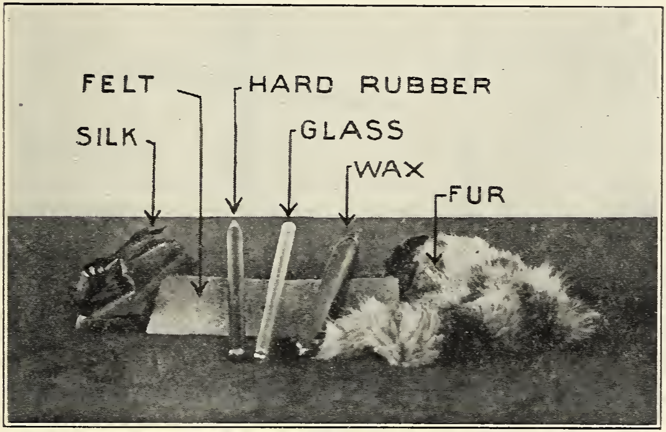
A Thunderhead

Explain the picture, telling at what height such clouds travel.

A thundershower freshens the air because the warm moist air before the storm is replaced by cool air. The latter pushes its way in because the warm moist air was lighter than the surrounding cooler air. It is one of Nature's ways of cooling the air and removing excess moisture from it. The thundershower is so named because of the noise caused by lightning. It is also called an electric storm because of the electric discharges it produces. Benjamin Franklin, if you remember, discovered the relationship of lightning and electricity by means of the famous kite experiment.

Read an account of Franklin's experiment to refresh your memory.

101. What Makes Lightning? — The cause of the electrical discharge of a thunderstorm is rather difficult to explain without some knowledge of electricity and its action. The following demonstrations will help us to know something about electricity and what it does.



Experiment 17
Why are there three kinds of rods?

Experimental Problem 17. — *How are electric sparks made?*

What to use: Pieces of fur, flannel, and silk; a glass rod; a hard rubber rod; and a stick of sealing wax.

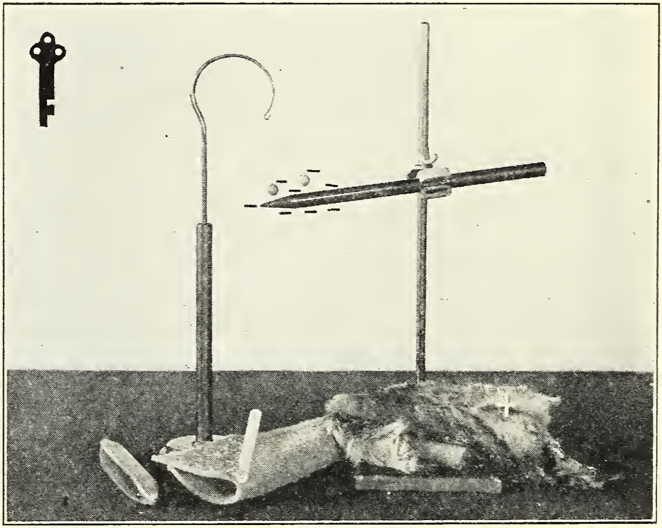
What to do: Rub the fur briskly on each of the rods for a moment. As soon as you stop rubbing hold the rubbed end of the rod near your finger. Repeat the test, using in turn flannel and silk with each rod.

Again rub each rod with the fur, flannel, or silk, and try to pick up small bits of paper.

What happens: 1. Did you hear a slight crackling as you rubbed the rods? 2. Did you see a spark occur when you held each of the charged rods near your finger? 3. Was there a noise when the spark occurred? 4. Did the rubber rod attract the bits of paper?

Conclusion: 1. Did you make electricity by rubbing two substances together? 2. Did the electricity form on the rods?

Application: Briskly rub a cat's or dog's fur with both hands. If you feel an electric discharge explain why.



(KEY) EXPERIMENT 18
What causes the pith balls to stand apart?

(Key) ***Experimental Problem 18: Are there two kinds of electricity?***

What to use: A piece of fur; a piece of silk; a glass rod; a hard rubber rod; two pith balls, — one on each end of a short thread; and a support for the thread.

What to do: Hang the pith balls with the thread over the support so that the balls touch each other.

Rub the fur on the glass rod and at once hold the rubbed end of the rod near the balls but without touching them.

Repeat, only touch each ball with the glass rod (this is called charging the balls) and then keep the rod near the balls. Now bring the fur near the balls but without touching them.

Again charge the balls with the glass rod rubbed with fur, and then bring the hard rubber rod, which has been rubbed with the silk, near the balls. Now bring the silk near the balls.

What happens: 1. Were the balls attracted to the glass rod at first? 2. After the balls were touched (charged) with the glass rod, were they still attracted to the rod? 3. Did the fur attract them? 4. Did they fly away from each other? 5. When the balls were charged from the glass rod rubbed with fur, were they attracted or repelled by the hard rubber rod rubbed with silk? 6. by the silk?

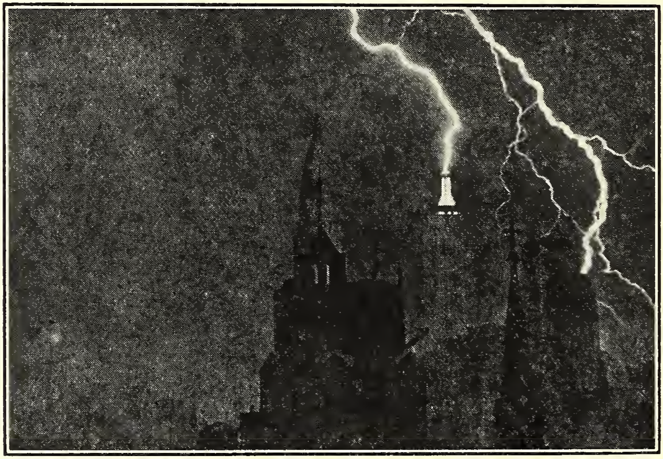
Conclusion: 1. How many kinds of electricity have you made? 2. How do they act toward each other? 3. When electricity formed on a rod, did different kinds form on the fur and on the silk?

Application: Rub a comb with silk or fur. Hold it near tiny bits of paper to attract them, then if they jump away after a second or two explain what happens.

Field Research:

Secure a bar magnet and a magnetic compass. Try to discover the similarities of attraction and repulsion between like and unlike electric charges and like and unlike magnetic poles. What direction does the dark end of the compass needle point when left free? Place the bar magnet on a block of wood, floating in water. Does it swing about to any fixed position? What direction does it point? Now bring the north-pointing end of the compass needle near the north-pointing end of the bar magnet. Do they attract or repel each other? What causes a compass needle to swing in a particular direction?

A thundercloud is a dense mass made up of many small electrified particles. It is believed that sometimes raindrops get so big that rising currents of air split them into two unequal drops. When this happens, it is thought that the larger drop loses electrons (particles of negative electricity) and so becomes positively charged with an excess of protons. The other gains the extra electrons and so is negatively charged. Positive charges of electricity always tend to attract unlike charges to them. If a large number of such drops

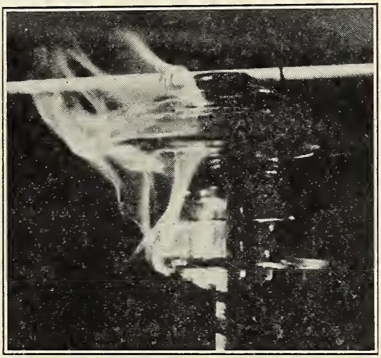


A Thunderstorm over New York City

The tall buildings attract the lightning because of their height. Their steel construction makes them good and safe conductors of the electric current.

become split and then separated into two clouds by the air currents, the electric charge may jump across from one cloud group to the other. This discharge is lightning.

If the cloud of larger, positively charged raindrops gets near enough to the earth, the discharge may take place between the cloud and the earth instead of between two clouds. Chain lightning, which you have seen, occurs when the flash or discharge is from cloud to cloud and the flash may be several miles long. *Electric* *potential is the tendency of unlike (positive and negative) electric charges to come together* and it is measured in *volts*. It requires a charge of a thousand volts to jump one twenty-fifth of an inch through the air. Can you imagine, then, the enormous number of volts represented by lightning when you know that the distance between clouds or between a cloud and the earth may be a mile or more?



Courtesy Science Service

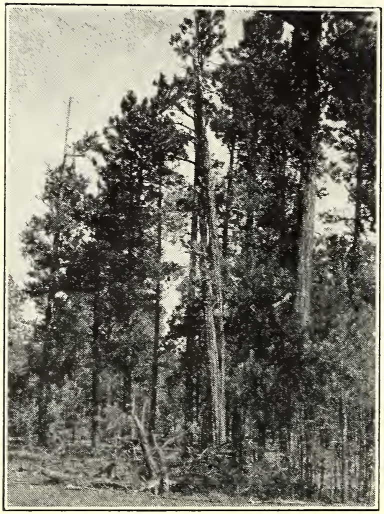
Glass Insulator

A pyrex glass insulator flashing over after withstanding a potential of 125,000 volts.

102. Why Does It Thunder? — When the electric discharge passes through the air, it heats that air very hot. That is why you see the flash. The hot streak of air is very much expanded, and as it cools rapidly it contracts and forms an area of very low pressure. The cooler air rushes together to equalize the pressure and in so doing makes a noise. The noise is produced in much the same way as that of an explosion. The rumbling roar of thunder has an explanation which you can think out for yourself. Give your answer to the class.

103. Is Lightning Dangerous? — If lightning strikes something, it is quite likely to damage it, though comparatively few people are injured or killed by it. The greatest damage from lightning is due to fires, especially in forests. This is one of the very few non-preventable causes of forest fires and of fires in general.

Sometimes lightning hits a building and splits it open, knocks down the chimney, or performs other queer tricks. Some places seem more likely to be struck by lightning than others. For example, a barn filled with straw or hay is more likely to be struck than a house; a tree or a person in an open field, more likely than a tree or person in a woods. Certain kinds of trees are struck more often than others. Hills, being nearer cloud masses, are more likely to be struck than hollows.

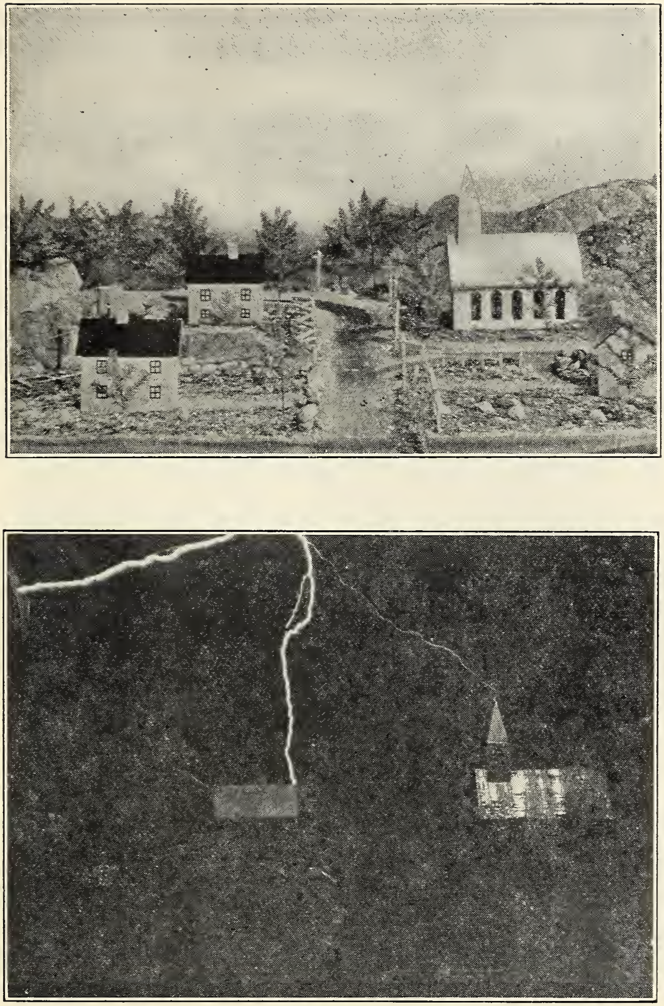


U. S. Forest Service

A YELLOW PINE TREE SHATTERED BY LIGHTNING

Certain it is that if you see the electric flash, you need have no fear, for that particular flash has done its work and is gone. Then, too, if you will count the number of seconds that elapse between the time of the flash and the sound of the thunder, you can estimate roughly the distance of the storm.

While the light of the flash reaches the eye almost instantly (light travels 186,000 miles a second), the resulting sound travels only about one fifth of a mile a second. By slowly counting one thousand one, one thousand two, one thousand three, etc., you can mark off approximately as many seconds as you continue to count. Therefore, by counting in this manner, you can

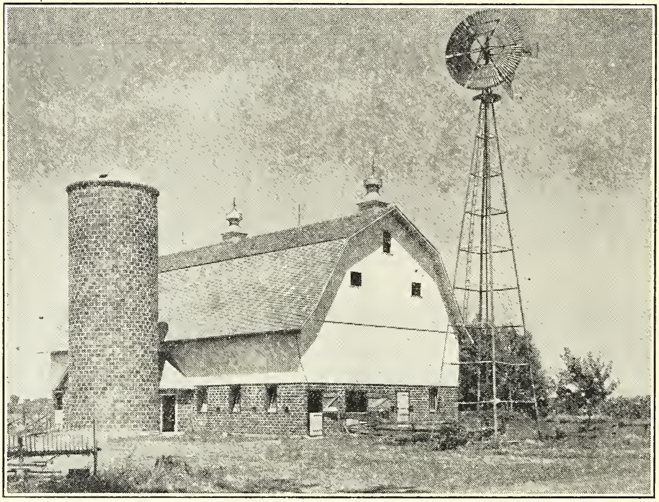


Lightning in the Laboratory

The upper picture represents a model village used to study lightning and its effects. In the lower picture artificial lightning strikes the little village. Why do you think it struck the church?

determine the number of seconds between the flashes and the thunder. This will tell you how many fifths of a mile away the storm is.

All sorts of devices and schemes have been originated for protection against lightning. Lightning rods properly installed with good ground connections are a real



Ewing Galloway

PROTECTED AGAINST LIGHTNING

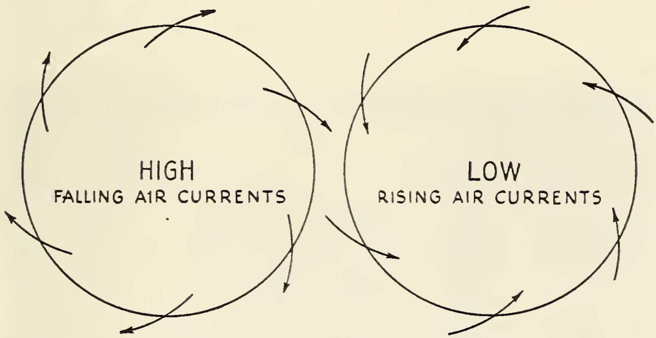
How are these rods a protection?

protection to buildings. They make an easy passageway for the electricity from the cloud to the earth. If a discharge is about to take place near a building equipped with lightning rods, it will be likely to pass through the rods to the earth without damaging the building. It is a law of electricity that an electric current will follow the easiest path — in other words, the best *conductor*. Rods also act as *discharge points* and, so, often prevent an accumulation of the electric charge sufficient to form a flash; that is, they prevent the building up of a voltage high enough to make the flash.

General Problem 2. What Are General Storm Areas?

104. Cyclones and Anticyclones. — Although many storms are purely local, the factors which cause them are closely related to a surrounding general storm area and to the weather conditions in different portions of the larger area.

General storm and fair weather areas, known as cyclones and anticyclones, are the result of unequally heated areas of land. In the warm areas, the air

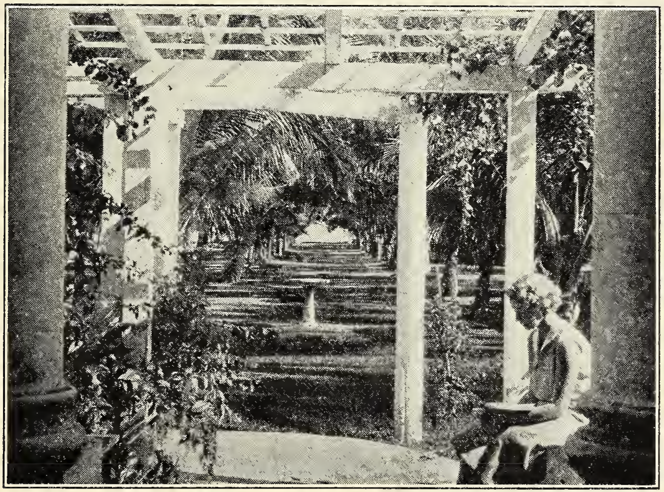


pressure is *low* because of the rapidly rising warm air. Cool air rushes in from all sides to push up this expanding warm air which carries much moisture up with it. These centers of low pressure we know are the cyclones. The anticyclones are the result of the expanding and cooling air which flows up, out, and down, maybe at a considerable distance, from the low center area. In these outer areas of the anticyclones, the air pressure is *high*, the sky is clear, and the winds are dry and cool.

You have already learned how the air over a large area is set whirling counter-clockwise in the northern hemisphere and clockwise in the southern. You have found also that these cyclonic areas move from west to east across the United States. A study, then, of the weather conditions of one of these areas will help to solve the weather problems of a particular place.

105. High and Low Pressure Areas. — Usually high pressure areas are of much greater extent than the low pressure areas. Since air moves from a high pressure area to a low pressure area, the *wind direction* in a low pressure area will be toward the center as well as counter-clockwise. In a high pressure area the wind direction is outward. Knowledge of these air movements and their causes assists in predicting the weather for a locality in the path of the approaching cyclone.

106. Hot and Cold Waves. — Sometimes in summer the "high" that should follow a "low" gets out of place and spreads out so as to cover the southern and eastern states, while the low pressure area moves slowly across the northern states. This condition may result in a current of hot air moving northerly bringing with it the heat from the southern states. Such a hot wave or spell lingers for three or four days. In local places the moisture sometimes becomes oppressive until, finally, cooling thunderstorms result. A cold wave is often produced in winter by just the reverse condition of displaced areas of pressure. Low pressure areas in the southern and eastern states with high pressure areas in the north allow the cold air of Alberta and Ontario, Canada, to push down over the United States. Occasionally such cold waves may pass down even into the southern states.



North and South

How is living in Eskimo land different from living in Florida?

107. Climate. — It is natural for us to think of climate whenever we speak in terms of the weather. As in the case of weather, we all know what climate is, but for working purposes we need to agree upon a definition of it. *Climate is the average of weather conditions for a particular area over a long period of time.* The climate of a certain region may be dry, hot, wet, cold, windy, equable (mild), changeable, and so on.

Right climatic conditions are required to produce the various kinds of life. Tropical climates produce abundant plant and animal life; the Arctic regions a scarcity of both. Man, of all living things, seems to be the only one who can adapt himself and his living to any of the various climates on the earth.

Our pleasures, crops, industries, and our health, all are closely related to weather conditions. Understanding the weather, its causes and effects, gives man the information to help him plan and adjust his living to Nature's laws. Accurate predictions of weather give man an added advantage in his adaptations to life.

Key Words

anticyclone	electric charge	lightning	potential
climate	electron	local	proton
cold wave	general	"low"	storm area
conductor	"high"	negative	storm paths
cyclone	hot wave	positive	thunder

Key Statements

1. Local storms include electric (thunder) storms, rain, sleet, snow, hail, and windstorms.

2. A general storm area includes the air conditions over a large extent of territory. General storm areas move along rather definite paths across the country.

3. Weather conditions in a general storm area or cyclone are rather constant as the storm moves along.

4. Thundershowers (electric storms) are caused by sudden and rapidly rising currents of warm, moist air. Expansion, due to rising, causes sudden cooling of the air, condensation, and precipitation of the air moisture.

5. Lightning is an electrical discharge between adjacent clouds or between a cloud and the earth.

6. Properly installed lightning rods on buildings are a protection against lightning.

7. In a cyclone area the air moves counter-clockwise in the northern hemisphere and clockwise in the southern.

8. A hot wave in the northern section of the country occurs in summer when the corresponding "high" separates from its "low" and spreads over the southern portion. This causes the "low" to move slowly across the northern part.

9. A cold wave occurs in winter when conditions of the hot wave are reversed.

10. Climate is the average of weather conditions for a particular area over a long period of time.

Thought Questions

1. Why do hailstones often form during a thunderstorm?
2. What kind of cloud form becomes a thundercloud?
3. How big is a raindrop?
4. Why is a person more likely to be struck by lightning when standing in an open field than when standing in the woods?
5. What does the phrase "best conductor of electricity" mean?
6. Tall objects in exposed situations are more likely to be struck by lightning than are short objects. Why?

Projects for Your Science Discovery Book

1. From a study of the U. S. Weather Maps over a period of two weeks report on the path taken by cyclone movements across the country.

2. Make a labeled drawing of the formation of a thundercloud, studied from observation.

3. If possible, take air temperatures and relative humidity before and after a thundershower.

SURVEY OF TOPIC IX

Eight o'clock in the morning, and over the radio comes the weather report for the day! Each morning and evening newspaper carries the weather predictions for the next twenty-four hours. Sometime during the evening the radio will again forecast the local and general weather conditions. We listen, and we read these reports with little thought as to how they were obtained; only muttering and blaming the weather-man if the predictions prove to be wrong.

Just where do these reports come from, and how can they possibly be nearly eighty-five per cent correct?

As a matter of fact, the government maintains a great eye, or several great eyes, called the weather bureau, which foresees weather changes all over the country. It is this master weather prophet's job, with the aid of proper instruments, to observe the sky, classify the clouds, read the thermometer and barometer, discover the velocity and direction of the wind, measure the amount of rainfall and calculate the amount of moisture in various parts of the country, draw a correct conclusion, and report that conclusion to people like you and me.

Let us learn something about this business of weather prediction.

TOPIC IX

PREDICTING THE WEATHER

The sun that brief December day
Rose cheerless over hills of gray,
And, darkly circled, gave at noon
A sadder light than waning moon.

. . . .

A portent seeming less than threat,
It sank from sight before it set.

— WHITTIER

Do you know:

1. Why people take vacations near the water?

2. How the newspapers get their information about the weather?

3. How to read a weather map?

4. How your health is related to the weather?

5. Whether a lake or its surrounding land heats up the faster?

GENERAL PROBLEM 1. WHAT ARE SOME LOCAL WEATHER INDICATIONS?

108. Do You Believe in Signs? — In a given locality an observing person soon learns that a certain wind direction indicates good or bad weather. Some clouds are dark with moisture and indicate rain, or, if the temperature is low, snow. Other clouds indicate fair weather. A changing air pressure shown by the barometer tells us that the weather is changing. The flight of birds and habits of insects and small animals are believed by some to indicate changes in the weather to one who is very observing. However, weather signs are not, for the most part, very accurate means of foretelling the weather.

Read the following lines, "Signs of Rain," written long ago and learned by school children a hundred years ago, to help them "foretell" the weather. Do you think there are any points in the poem that are true? Compare this method of forecasting the weather with the scientific method.

Signs of Rain[1]

The hollow winds begin to blow,
The clouds look black,
The glass is low.
Hark how the chairs and table crack!
Old Betty's joints are on the rack.
How restless are the snorting swine!
The busy flies disturb the kine.
Puss, on the hearth, with velvet paws,
Sits wiping o'er her whiskered jaws.
My dog, so altered in his taste,
Quits mutton bones on grass to feast.
And see yon rooks — how odd their flight!
They imitate the gliding kite
And, headlong, downward seem to fall
As if they felt the piercing ball.
'Twill surely rain. I see with sorrow
Our jaunt must be put off tomorrow.

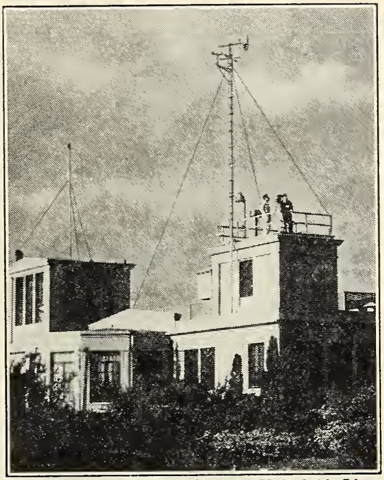
109. Newspaper Reports. — Many newspapers print weather reports furnished by the Government Weather Bureau. The predictions for a day in advance are based on a knowledge of the weather conditions all over the country and exact knowledge of how general storm

[1] Part of a collection of weather doggerel usually attributed to Dr. Edward Jenner, and written from memory by a pupil of 1850.

areas travel across the country. The prediction is made for a rather large territory and, therefore, is sometimes incorrect for a particular locality.

Field Research:

Study a newspaper weather report and discover the accuracy of the prediction. What weather factors are included in the report?



Courtesy United Air Lines

AIRWAY WEATHER REPORTING STATION

Observers are checking conditions for reporting to pilots in flight.

110. Radio Reports. — The radio is an important means by which weather conditions can be made known to everyone interested. Forewarning of the probability of violent wind-storms, and of the likelihood of killing frosts, is important to mariners and to shippers and gardeners. Airplane pilots are kept constantly informed about weather conditions ahead and whether to proceed to their destination or make for the nearest landing field. Radio makes possible more timely, more frequent, and farther reaching weather information than is possible through newspapers.

111. The Work of a Weather Prophet. — *Temperature, air pressure, air moisture, wind direction, and wind velocity* are factors to be considered in forecasting the weather both of the small local areas and the larger, general areas. To foretell successfully the local weather changes these factors must be accurately determined, and the observer must know how local conditions are related to the more general weather conditions.

General Problem 2. What Are Some General Weather Observations?

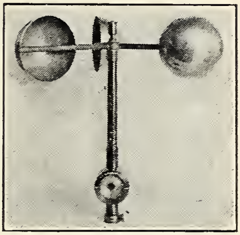
112. Official Weather Reports. — The main office of the United States Weather Bureau is located at Washington, D. C. Local weather observation stations are located in many cities and towns of the United States, including Alaska and other possessions. At each station, weather observers determine all the weather factors at 8 A.M. and 8 P.M., Eastern Standard Time. The direction and velocity of the wind, hours of sunshine, air pressure, temperature, and precipitation are recorded constantly by instruments. These data are telegraphed to the main office.

Courtesy United Air Lines

Weather Reporting via Radio

A ground station operator is conversing with a pilot in the air. Notice the weather map the operator is studying.

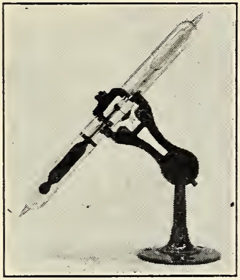
At the main office in Washington the data received are marked on the master map for each weather station. This map then presents a picture of the weather conditions all over the country at the time stated. Lines called *isobars,* drawn on the map to connect areas having the same air pressures, mark out the "lows" and "highs" which you have studied. Other lines, called *isotherms,* connect places having the same air temperatures. By symbols on the map, other weather factors for each observation station are indicated.



U. S. Weather Bureau

A Recording Anemometer

Examine the weather map, page 209, and locate: a "low," a "high," isotherms of lowest and highest temperatures, areas of precipitation (shown by shading), areas of fair weather, pressure at center of low and at outer edge of low, and general wind direction in each quarter of the low (northeast, northwest, southwest, and southeast). Recall or review what you have learned about high and low pressure areas and storm paths across the United States.

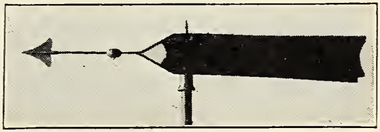


U. S. Weather Bureau

A Sunshine Recorder

Field Research:

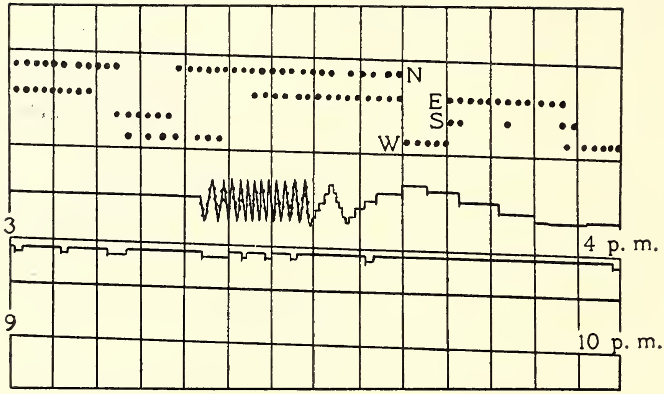
Secure a current weather map from your daily paper. Locate your home town and note weather factors as shown by the map at the time the map data were prepared. Look at the weather map again and, supposing the conditions shown should move toward the east, note what changes might occur at your locality in the next twenty-four hours. Bring your prediction to class for discussion.

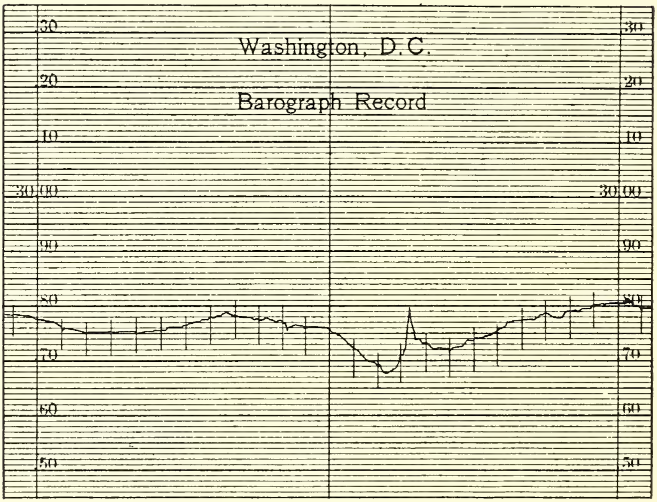


U. S. Weather Bureau

A Recording Wind Vane

Washington, D. C.
Wind, Rain, and Sunshine Record

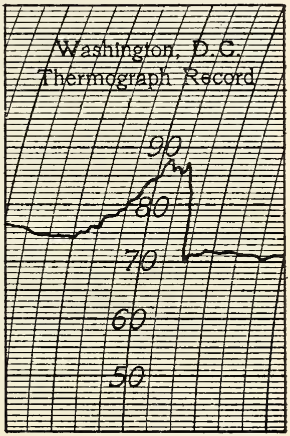




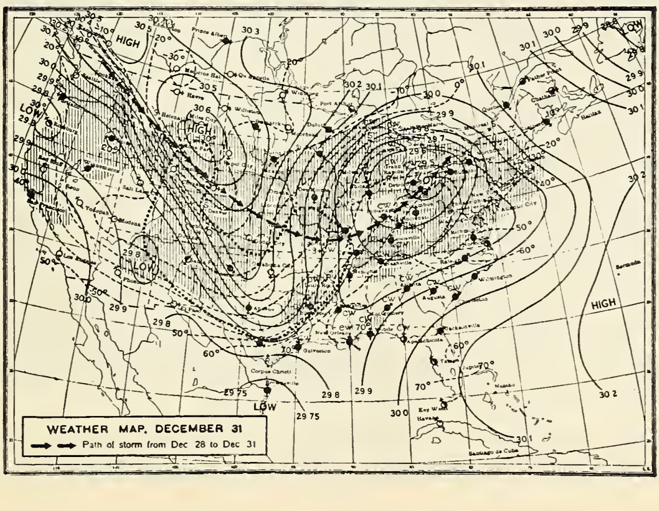
Weather Factor Records of a Thunderstorm

Compare the records on this page and in the upper chart of the next page to determine the relations of the several weather factors recorded. All three are for the same day.

113. The Master Weather Prophet. — Many people do not realize that the United States Weather Bureau predictions save millions of dollars annually. For example, if food is shipped in cars which are not frostproof, a sudden fall of temperature below the freezing point may spoil a whole trainload of perishable foods. The Weather Bureau publishes the lowest temperatures likely to be encountered for a period of a few days. Hence shippers by following these reports know what care to take of perishable material.



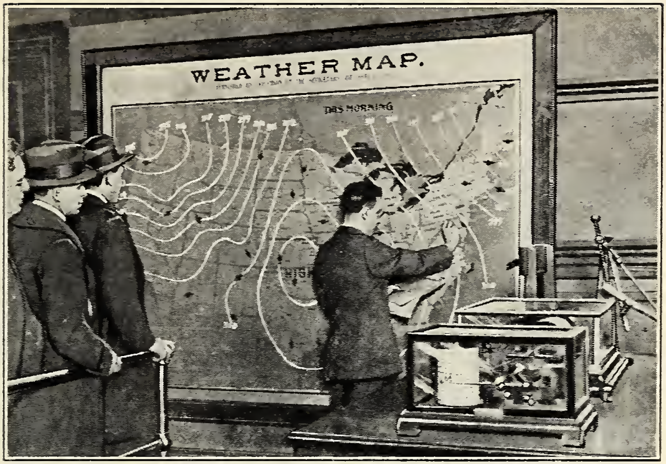
The shipping and fishing industries receive advance warning of great storms at sea. By "laying by" in



some good harbor untold shipping losses are prevented. Advance information is often given in the tornado section of the approach of a tornado and people are able to protect themselves. Fruit growers and agriculturists, in general, profit enormously by taking advantage of advance information concerning frosts. Many individuals actually call up the "Weather Man" and ask concerning the probable weather "to-morrow" or "next day" in order to complete plans for outings, celebrations, and so on.

Every day the United States Weather Bureau publishes a weather map which shows the weather conditions all over the country. Copies of these maps are distributed throughout the larger towns and cities of the United States. The weather maps may be had for a small charge by any citizen who will write to the nearest weather bureau and ask that his name be placed on the mailing list. Thousands of postcards stating the probable weather conditions and possible occurrence of frosts and storms are sent out every day all over this great country.

These methods of distributing information are supplemented by the radio. The study of the air and general weather conditions made by the United States Weather Bureau has resulted in a vast amount of scientific information available for the use of men who are studying and improving aviation. Without this information the airplane could not have advanced and become such a factor in the day's doings as it is. The success of Lindbergh's and Byrd's transatlantic flights was dependent to a great extent upon weather advice from the Bureau. Knowledge of weather factors and prediction were important aids to Admiral Byrd's suc-



Making the Weather Map

What are the white lines?

Office of the Weather Bureau, Washington

Electrically recording instruments are connected with apparatus on the roof and give continuous record of weather conditions.

cessful flight over the South Pole. Studies made during his second Antarctic Expedition are expected to contribute still greater knowledge of world weather.

© *New York Times*

BYRD IN ANTARCTICA

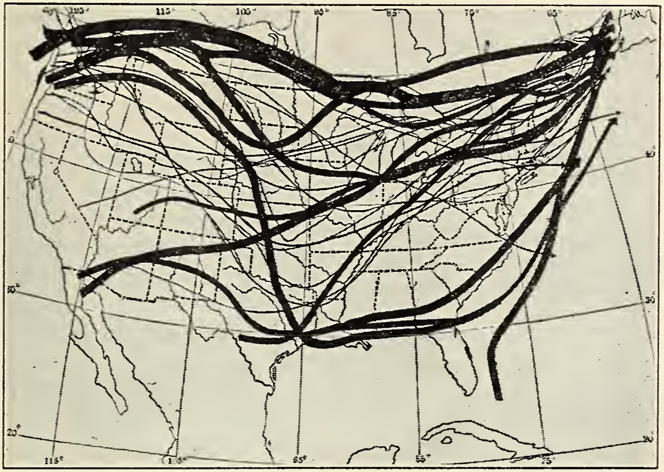
Studies are being made of weather conditions which will add to the knowledge of world weather.

The Bureau studies and makes reports relative to weather and rain insurance, the influence of weather on public highways, and other matters of interest and importance. In the summer and fall, special weather forecasts are sent to forest-fire wardens, who are thereby helped greatly in preparing for a possible fire and its control.

114. Weather Forecasting as a Science. — In order that you may forecast the weather for twenty-four to thirty-six hours in advance, with considerable accuracy, you should have in mind the following rules:

1. The storm areas (cyclones) proceed across the United States from west to east, usually passing over the St. Lawrence River region, sometimes to the southeast, or the path goes from the southwest to the northeast and out the St. Lawrence River regions. (The drawing on the next page shows the average paths.)

2. The direction of the wind in the storm area (low) is somewhat circular and, on the map, opposite to the motion of the hands of a clock. The general direction is along the isobars, crossing them slightly toward the center.



Storm Paths

What general direction do most of the storm paths take?

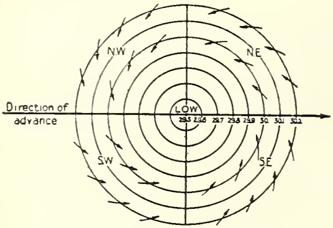
3. Facing the wind, the right hand stretched out at the side will indicate roughly the direction of the storm center.

4. The direction of the wind, together with the position of the storm center, will determine in which of the four quadrants of the cyclone the observer is located. The weather conditions of each of the four quadrants of a storm area are somewhat constant.

5. The barometer reading will indicate the nearness or remoteness of the storm center, if the observer refers to the isobars on the weather map.

6. A changing air pressure indicates the approach or passing of a storm area. [For example, if your town happens to be in the southeast quarter and the storm is moving so as to bring the northwest quarter to you (draw this on your paper), you can predict weather conditions similar to those prevailing in the north-

west quarter. If the storm center has not reached you, you should be able to predict whether the storm center will pass north or south of you and hence what weather you will have. If you know by study of the map how fast the storm is moving, you can predict when it will reach you.]



Weather Quadrants

What help does mathematics give in studying this diagram?

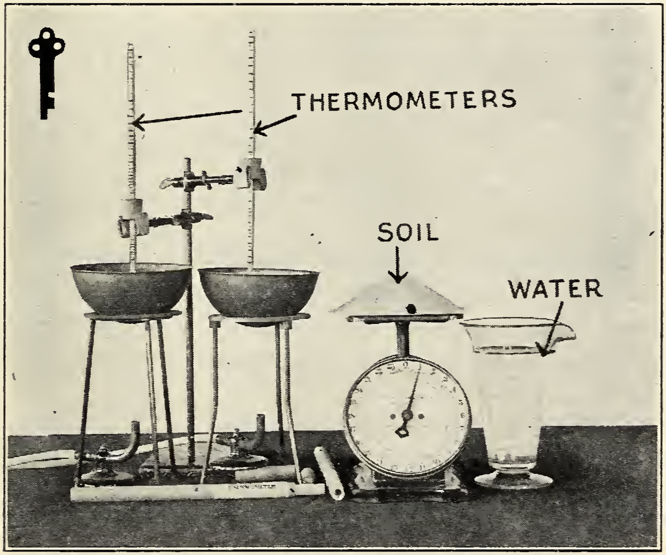
7. A very slowly falling pressure indicates warmer temperatures. A very slowly rising pressure indicates cooler temperatures.

8. Weather map pressures are sea-level pressures, therefore the barometer reading of a given locality should be converted to sea-level reading to compare with the weather map data. Since the pressure decreases as the altitude increases, something must be added to convert a local pressure to sea-level pressure. Practically 1 inch should be added for each 900 feet altitude or fraction or multiple thereof.

General Problem 3. What Relation Does Water Have to Climate?

115. Weather and Water. — Water and heat are so closely associated as factors in weather making that a student of weather conditions must take them into account when he considers the problems of weather forecasting. When heat is added to water, the temperature of the water rises. The more water there is, the greater amount of heat required to cause the same rise in temperature. If enough heat is added to water, boiling takes place, during which there is no further rise in temperature as long as any water remains. At boiling temperature the liquid water changes to water vapor.

In Nature, the energy from the sun is the source of heat for water and for the land. A given soil has a certain capacity for absorbing water, a fact that every successful gardener well understands. You can see examples of this yourself, any spring or summer day after a shower. In about the same way land, water, and all other substances have certain capacities for



(Key) Experiment 19

What volume of water weighs one pound?

absorbing heat. In this respect, water has a greater capacity than any other common substance; that is, it takes more heat units to raise a pound of water to a certain temperature than is required by the same weight of any other common substance. The rate at which a given weight of a substance heats indicates its heat-absorbing capacity. The slower it heats, the greater its heat capacity.

(Key) ***Experimental Problem 19: Does water have a greater or less heat capacity than sand?***

What to use: A pound of water; a pound of dry soil; two iron or tin dishes; two thermometers; two tripods; two Bunsen burners; and two supports.

What to do: Place the pound of water in one dish and the soil in the other. Set each dish on a tripod. Support the thermometers so that the bulb of one is in the water and the bulb of the other is in the soil. Using the same size flames, heat both dishes for three minutes.

What happens: 1. Did each material receive the same amount of heat? 2. Which material heated up the faster? 3. Which was hotter at the end of the three minutes?

Conclusion: Which material has the greater heat capacity? Explain.

Application: Why is water used in automobile radiators?

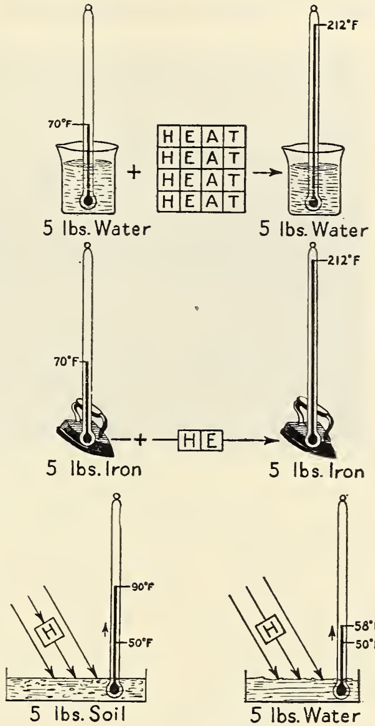
A pound of iron, a pound of brass, a pound of soil, a pound of air, or any other substance will heat faster than a pound of water if the same size of flame is used.

Field Research:

Which do you think would stay warm longer, a bag with two pounds of hot water or a bag with two pounds of sand, if they are both at the same temperature at the start? Try to prove your opinion. Use the apparatus of the preceding Experiment.

116. The Heating and Cooling of Land and Water. — Applying your knowledge of the heat capacity of water and other substances, you can explain why land and water heat up and cool off at different rates. When the heat (energy) of the sun strikes the land, the land heats up (becomes warm) more rapidly than near-by water; that is, the temperature of the land becomes higher than that of the water. When the sun goes down, the land cools off (loses heat) faster than the water.

These facts about the unequal heating and cooling of land and water are true not only from day to night, but from season to season. As spring advances, the land away from a large body of water becomes a little warmer each day than the body of water. If the body of water is large enough, the summer may be far advanced before the water becomes as warm as the land some distance away.

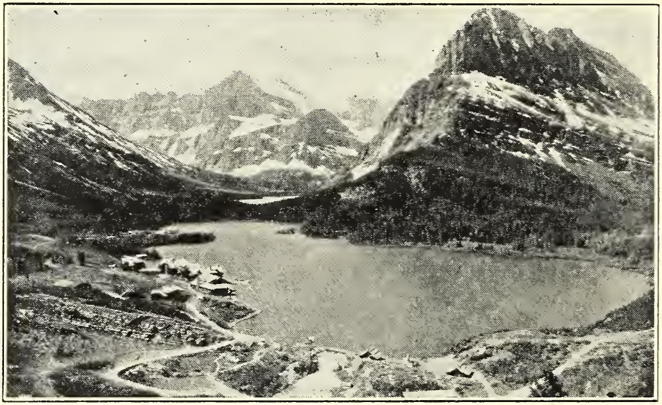


Heat Capacity

Study the diagrams to determine which substance has the smallest heat capacity. Which has the greatest capacity for absorbing heat?

The air is not heated directly by the energy from the sun but must get its heat from land and water which it touches. For this reason changes in air temperatures over the land and the water correspond to changes in the temperature of land and water. As the summer advances, the water of lake and sea gradually absorbs more and more heat. As fall comes on, the land away from water quickly loses its heat and the air over it becomes cooler, while the heat stored in water is given off very slowly, keeping the air warmer.

117. Land and Sea Breezes. — The unequal heating and cooling of land and water causes interesting and useful air movements between neighboring land and water. You have learned that air currents move from



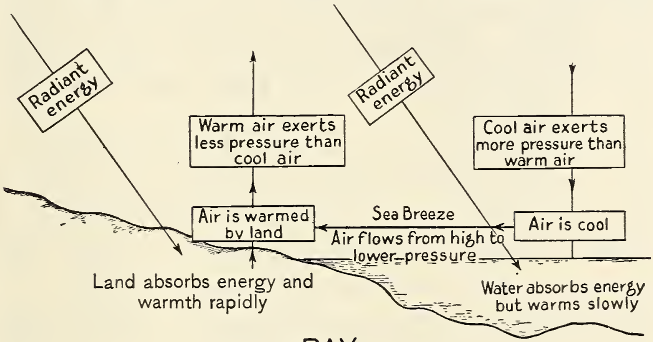
Courtesy Burlington Railroad

Glacier National Park

Why has this spot become a summer playground?

places of high pressure to places of low pressure. Warm air is lighter and therefore exerts less pressure than the same volume of cold air. Another fact to consider is that air has a very low heat capacity, and therefore heats up rapidly and cools off rapidly. With these facts in mind and remembering also that the air gets its heat from the land or the water, you are ready to explain the occurrence of land and sea breezes.

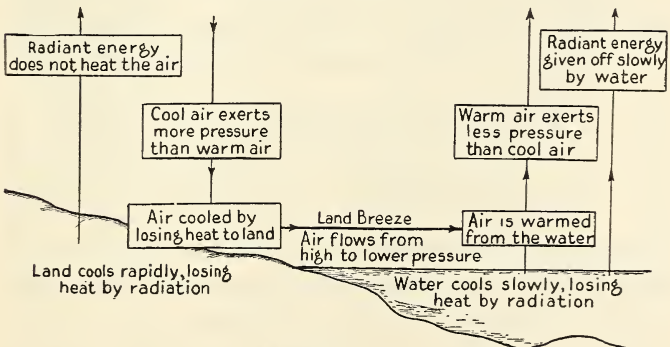
As the land heats up rapidly the air touching it heats up even more rapidly and becomes lighter because it expands, while the air over the cooler water continues cool and hence heavier than the warm, lighter air over the land. Therefore, the cool, heavier air moves from the water surface to the land and pushes the warm, lighter air up out of the way. The cool air, in turn, becomes warm and is pushed up by more cool air from the sea. The air current thus set up is called a *sea breeze.*



DAY

Explain the diagram.

At night the land becomes cool more rapidly than the water, hence the air over the land becomes cooler than the air over the water. In other words, the air pressure is now greater over the land than over the water and an air current moves from land to the water. This kind of air current is called a *land breeze.*



NIGHT

Explain the diagram.

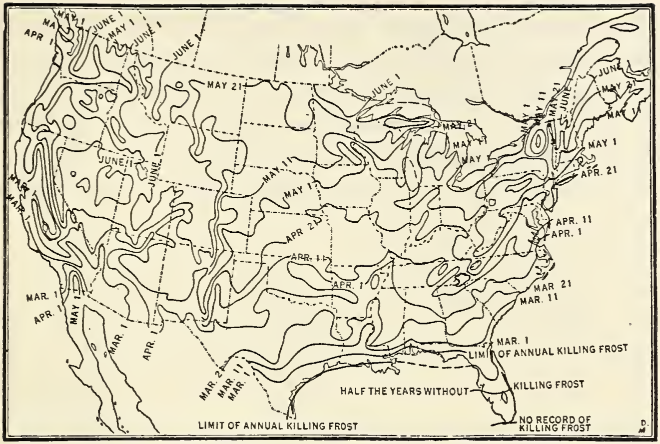
118. The Growing Season. — The length of a plant-growing season is often determined by the number of days between the last killing frost of spring and the first killing frost of fall. Crops that require longer time to mature than the time between these two dates are better grown farther to the south where the growing season is longer.

It is important for a farmer or gardener to know the length of the growing season where he lives and the crops adapted to it. As students of science it is a valuable study for us to determine what causes affect the length of a growing season in a given locality.

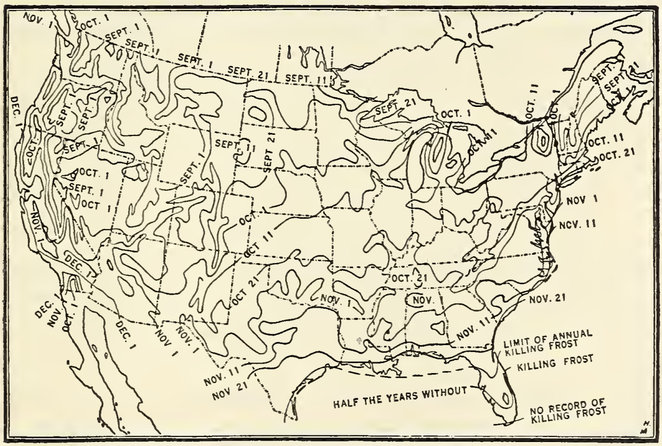
119. Crops and Related Industries. — Since profitable growing of certain crops requires not only special soils but a sufficiently long growing season, canning and preserving industries are naturally developed near-by, in case the crops are perishable. Likewise, raising of cattle, pigs, and other livestock will develop to take advantage of products that would otherwise be wasted or shipped away.

General Problem 4. What Adaptations Are Made to Weather and Climate?

120. Weather and Industries. — The weather of western New York, during the spring, summer, and fall of 1915, was responsible for making many crops an almost total failure. During the planting time in the spring so much rain fell that potatoes and other seeds rotted in the ground before they sprouted. They were virtually drowned. Weather conditions all over the country during those growing and harvesting seasons made the food shortage a serious problem in its relation

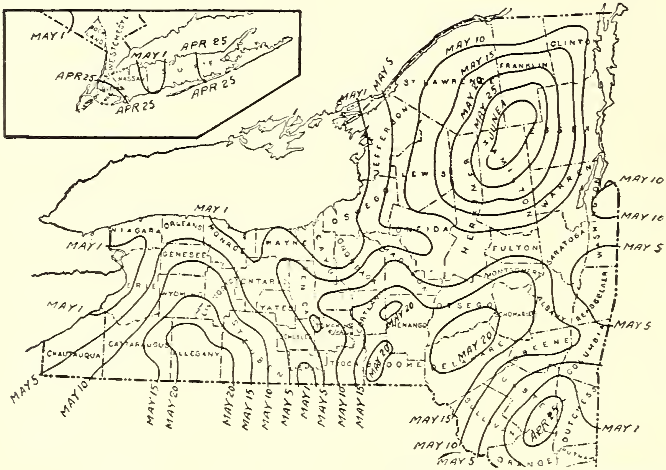


Latest Killing Frosts of Spring



Earliest Killing Frosts of Fall

to the great European war. Early in the spring of 1916 a gigantic effort was made throughout the nation to insure an enormous crop of food staples to make up the loss of the previous year. Home gardens sprang up everywhere and people, generally, became more interested in weather conditions than ever before.



New York State College of Agriculture

LATEST KILLING FROSTS OF SPRING IN NEW YORK STATE

What is the effect of the two large lakes in the time of frosts? In what portions of the state can the earliest plantings be made?

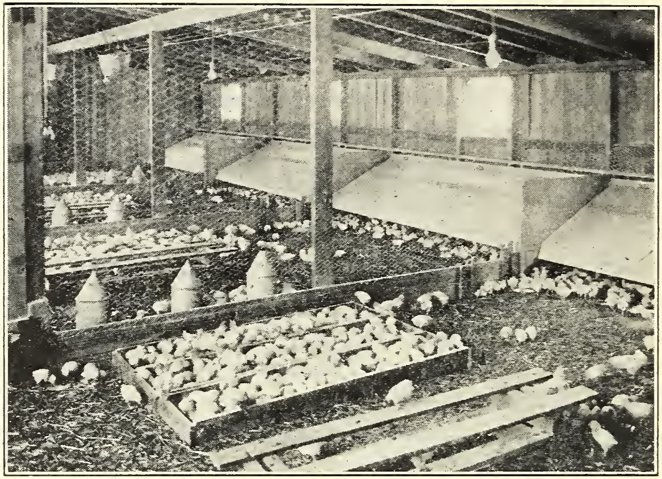
Every year agricultural industries are very largely dependent upon weather conditions and every individual is concerned because this industry furnishes our food.

Industries of many kinds are dependent, to a greater or less extent, for their success upon certain weather conditions. The *canning industry*, for example, will fail unless conditions are such as to produce an abundance of *fruits* and *vegetables*. The *milling industry* will fail unless there is a sufficient amount of *wheat, corn,* and other *grains.* Also, a second class of industries not directly related to the food supply of the nation is often, to a larger extent, dependent for its raw materials upon the growth of plants and animals. These, too, are affected by weather conditions.

Scientific farming has resulted to some extent in localizing crops to meet the weather factors. For example, crops requiring a longer period to mature than the time between the early and late frosts of the North are grown by the southern planter, although sometimes a northern gardener grows a southern crop under glass where he can maintain indoor weather conditions to suit his needs.

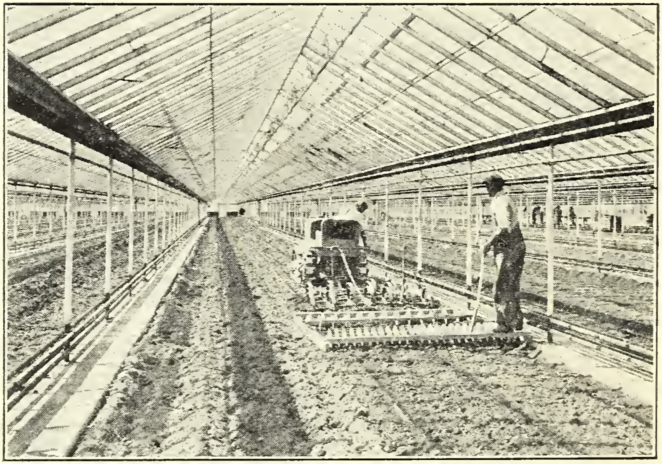
In other cases, as for example with wheat, some varieties are developed that will withstand more rigorous climatic conditions than other varieties. Certain kinds of vegetables, such as corn, peas, and beans, have been developed to mature in a shorter growing season than other varieties. These are examples to show how man with increasing knowledge is able to make adaptations to natural conditions which he cannot change.

Practically all industries make some adaptation to weather and climate. Houses and factories are differently constructed in the North than in the South. Stores provide clothing adapted to the climate and season. Ways are discovered to make building easier during the winter months when work is scarce. For example, the chemist has found what to add to mortar and cement to enable it to set and harden without freezing. Roads are built to withstand extremes of temperatures.



Electricity in the Poultry House

How is this an adaptation to climate?



Preparing for Planting under Glass

How are weather conditions controlled by planting under glass?

121. Climate and Health. — People with some forms of disease are able to live more comfortably and oftentimes longer in one climate than in another. On the other hand, people who are blessed with good health are able to adapt themselves to almost any kind of climate. Men accustomed to the South can, by wearing suitable clothing and eating the right kinds of food,

A Snow Block House

Stefansson's men are adapting themselves to life in the far North.

live and work in the far North. The healthy Eskimo can adapt himself to the southern clime. However, keeping well in localities where the weather is changeable is somewhat more difficult than adapting oneself to extremes of climate.

The body with ordinary exercise loses about 400 heat units every hour. (Unit refers to the British Thermal Unit, which is the amount of heat necessary to raise the temperature of a pound of water one degree Fahrenheit.) This is about the amount of heat given off in one hour by the burning of one cubic foot of cooking gas.

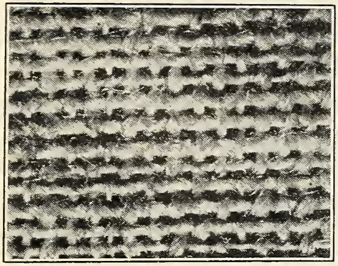
Adapting ourselves to changes of climate or weather as a means of protecting our health is aided by a knowledge of how the body loses heat and how the heat may be conserved when the air is cold and how its loss may be promoted when the body is in very warm air.

Some heat is lost from the body by *radiation* just as any hot body loses heat. It also loses heat by *conduction* when colder objects touch it and take heat away. When cold air touches the body, it absorbs heat and, if its motion is not hindered, the warmed air is pushed away because more colder air pushes in for its share of the heat. This way of taking heat away from anything by a moving or circulating gas or liquid is called *convection*. So the body all of the time loses heat by these three methods: radiation, conduction, and convection.

You have already learned that when liquids evaporate, they absorb heat from objects which they touch. Therefore, when the sweat of the body, which is mostly water, evaporates, it absorbs heat from the body. The water vapor thus formed mixes with the air and is carried away by the moving air currents. This explains why you feel colder standing in a wind than in a sheltered place on a cold day.

Conserving body heat or promoting its loss, as the need may be, by proper use of clothing depends upon our knowledge of how the body loses heat. Winter clothing should prevent, to some extent, the loss of heat from the body. Wool and silk fabrics are poor conductors of heat. A wool garment contains many air spaces among its fibers, therefore it retards the loss of heat because the fibers prevent the circulation of air and so convection losses are prevented. Wool also absorbs moisture and retains it near the skin and so prevents rapid evaporation of sweat.

Summer clothing needs to transmit heat from the body and to reflect heat rays from the sun. Light




Courtesy Bausch & Lomb

LINEN AND VELVET

Which cloth makes better clothing for winter, and why?

colors on smooth fabrics of cotton, linen, and silk will reflect the sun's rays. They also contain less air spaces than the coarser wool fabric and so allow freer air circulation, which removes heat from the body. Cotton is a better conductor of heat and so allows heat to escape by that method. Cotton, linen, and silk absorb moisture readily and allow it to evaporate quickly, hence promote the loss of heat from the body by evaporation of sweat.

Field Research:

Using a hand magnifier, examine samples of wool, silk, linen, and cotton fabrics to discover differences in weave and air spaces.

122. Alcohol and the Weather. — Correct clothing, food, rest, and exercise are all necessary to enable a body to adapt itself to ever-changing weather conditions at home and different climatic conditions when traveling. The use of alcoholic beverages is a great handicap to successful adaptation. While it may be true that small amounts of alcohol are oxidized in the body, producing slight amounts of energy, it is also true that alcohol causes dilation of the blood capillaries of the skin, allowing an extra amount of blood to enter. Thus, heat loss from the body is increased, which more than offsets any energy obtained from the alcohol.

The fact that alcohol injures many body cells results in a lowering of general body efficiency, and so it is more likely to be affected by diseases related to weather changes, such as colds and pneumonia. Alcohol is a habit-forming, narcotic drug and like other narcotic drugs should be used only when prescribed by a competent doctor.

Key Words

adaptations	frosts	pressure
cause and effect	heat capacity	radio
climate	isobars	sea breeze
crops	isotherms	weather
forecast	land breeze	Weather Bureau

Key Statements

1. Scientific prediction of weather depends upon the collection of accurate data or facts, and a knowledge of the cause and effect relations.

2. Weather predictions based upon weather signs are not likely to be accurate.

3. Weather forecasting involves a knowledge of the weather factors all over the country.

4. Weather forecasts sent out by the United States Weather Bureau are of great money value to industries of all kinds.

5. Substances differ in their capacity to absorb heat. Water has the greatest heat-absorbing capacity of any common substance.

6. Land, because it has a smaller heat capacity than water, warms faster and cools faster than water.

7. A land breeze (blowing from the land) occurs when the air pressure over the water is less than over the land.

8. A sea breeze occurs when the air pressure is less over the land than over the water.

9. The difference in air pressure over adjacent land and water is due to the unequal heating of the air over each.

10. Because of the heat-storing capacity of water, regions near large bodies of water have a longer growing season than regions farther away.

Thought Questions

1. If water has eight times the heat-absorbing capacity of iron, how many pounds of iron would be required to contain as much heat, at a given temperature, as one pound of water?

2. Which would keep a person's feet warm longer, a hot brick or an equal weight of water at the same temperature?

3. Explain how the unequal heating of land and water results from their different heat capacities.

4. Why are official weather observations made at a given hour?

5. Why can one not make an accurate weather prediction using only a barometer?

6. How can a frost prediction be made? What factors must be known?

Projects for Your Science Discovery Book

1. List all the ways you can determine in which weather reports by radio are useful.

2. Practice making weather predictions until you become proficient. Keep careful records of the weather factors, your prediction, and the final outcome.

3. Explain why it may be warm and uncomfortable at the sea shore in the evening after a warm day over the land. Is the land breeze or the sea breeze likely to be cooler and more refreshing?

4. Discuss the relation between relative humidity and atmospheric pressure.

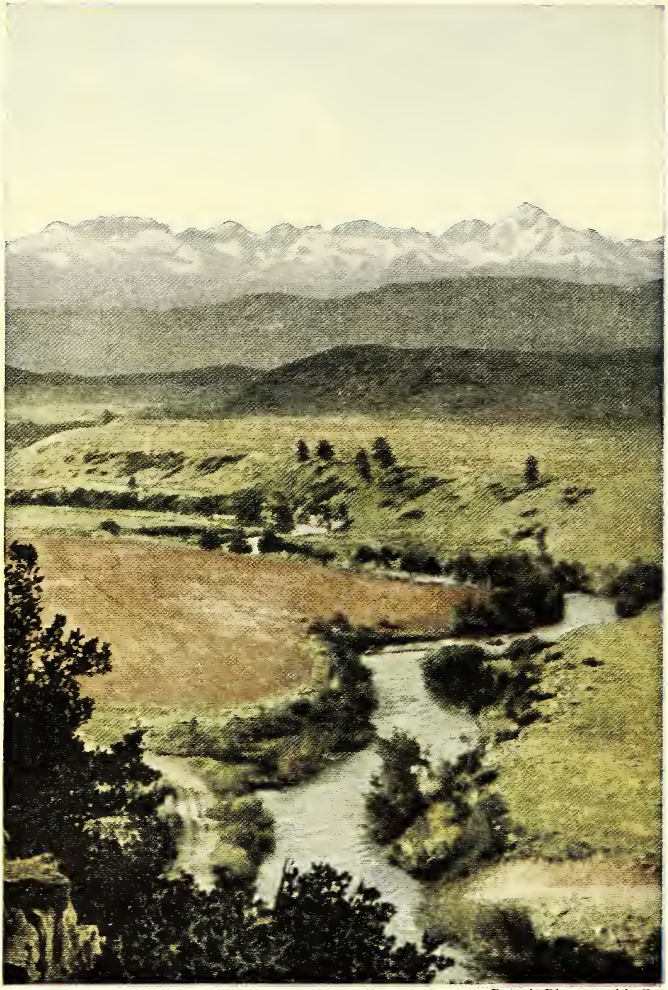
5. Select a locality near a great lake and from Weather Bureau reports determine the latest average date of killing frosts in the spring and earliest average date of killing frost in the fall, within two miles of the lake shore and 25 miles to 30 miles from the shore. What is the average length of the growing season in each location? How is this related to land and sea breezes? Record all your findings.

6. Make a list of the important crops of your vicinity and the industries related to them. Explain the relationships.

7. Discuss the ways in which unusual weather conditions, such as late frosts in spring and too much or too little rain, may determine the abundance or scarcity of food.

8. List the principal occupations in your community and tell how each is related to the weather conditions and what adaptations are made to meet these conditions.

9. List the weather hazards to health in your community and tell how you can adapt yourself to these conditions so as to keep well.



Detroit Photographic Co.

THE WORK OF WATER

I have flooded the sands and washed them down,
I have cut through gneiss and granite.
No toiler of earth has wrought as I,
Since God's first breath began it.

— RICE.

UNIT III. WATER

LOOKING AHEAD INTO UNIT III

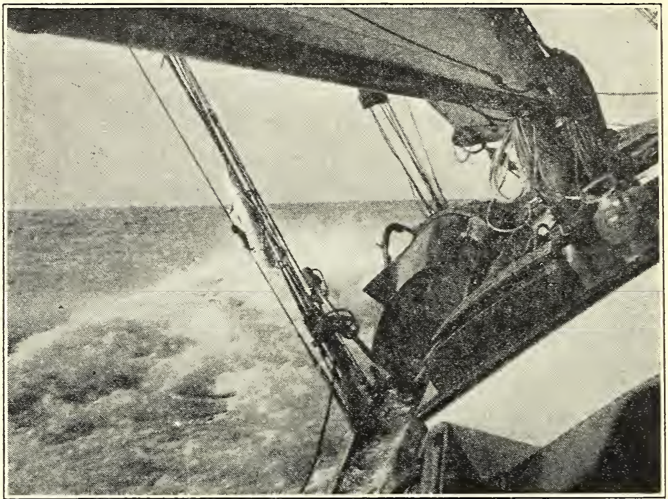
You are all familiar with water — that clear, colorless liquid that is everywhere about you. You know it in its many forms; as rain, as clouds, as snow and ice, and as steam.

The very word *water* conjures up many pleasant pictures: a garden pool, on whose mirrored surface pond lilies float; a bubbling brook; a foaming waterfall; a sheet of silver ice and the ring of skates; snow-covered fields and trees.

Water is carried many miles from snow-capped mountains to desert spots to make gardens bloom; it is carried from huge reservoirs, in far-away places, through a network of pipes to millions of city homes to make human living clean and healthy.

It is fortunate that water is so abundant, for our uses of water are so many. Water is indeed a friend to man.

SURVEY OF TOPIC X



Have you ever stopped to think what this world would be like without water? No lakes, no ponds, no rivers, no brooks; no ice or snow or rain; no clouds; no ocean. A world where there was no skating or sliding in winter; no swimming or boating in summer; a gardenless, treeless waste.

Three quarters of the earth is covered with water. Wherever we go we will find water in some form or other — from the ice and snow of the Arctic regions to the steamy moisture of the tropical jungles.

From sunrise to sunrise, every day of our lives, water plays a leading rôle in our work, in our play, and in our habits of living. Everywhere, water has its use, — from the little mill stream, leaf-strewn in autumn, to the translucent blue depths of southern oceans, where iridescent angel fish lazily swim over beds of coral.

TOPIC X

CHARACTERISTICS AND USES OF WATER

Time writes no wrinkle on thine azure brow, —
Such as creation's dawn beheld, thou rollest now.
Thou glorious mirror, where the Almighty's form
Glasses itself in tempests.

— Byron

Do you know:

1. What is the most abundant substance on the surface of the earth?

2. How much of your body is water?

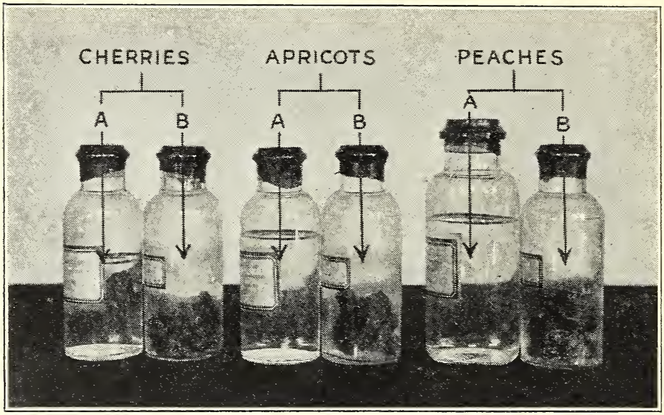
3. How to tell water from other liquids?

4. What the three states of matter are?

5. The most important use of water?

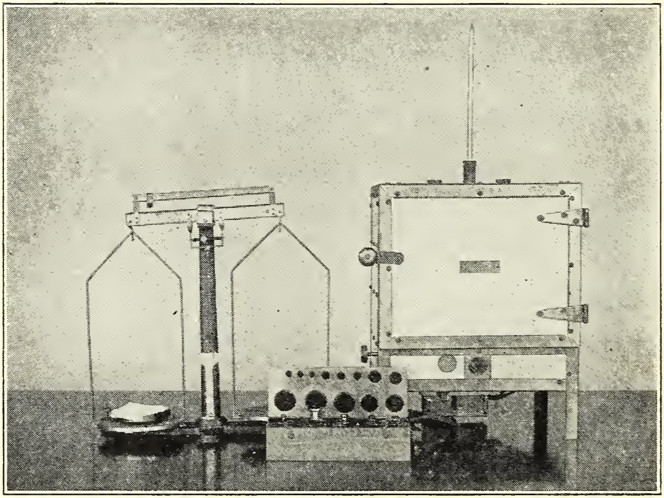
General Problem 1. Where Is Water Found?

123. The Abundance of Water. — Water is the most abundant compound on the surface of the earth. A *compound* is a substance that can be separated into simple substances called *elements*. The abundance of water is very evident if you consider the oceans (averaging four or five miles deep), the rivers and lakes, the great quantities of water held in the atmosphere, all the ice (solid water) of the polar regions, and the water bound up in nearly all organic matter. Nearly all food materials contain a large percentage of water. Your body is about two thirds water.



Water from Fruits

Which fruit contained the most water? Why would one bottle have to be larger than the others?



Experiment 20

Field Research:

From tables in a cooking text or health book, find the percentage of water in fish, beef, tomatoes, bread, and other foods and report your findings to the class.

Experimental Problem 20. — *What percentage of water does bread contain?*

What to use: A drying oven; a thermometer; a slice of bread; a balance and metric weights; and a large watch glass.

What to do: Heat the oven to 220° F. Accurately weigh the watch glass, and then the watch glass and bread together. Record both weights.

Place the watch glass and bread in the oven and keep the temperature at 220° F. for thirty minutes. Remove, cool, and weigh the watch glass and bread again. Record this weight.

Replace the glass and bread in the oven for fifteen minutes, maintaining the same temperature. Take out and weigh again. Repeat this heating and weighing until the bread no longer loses weight. Use the last weight for your calculations.

What happened: 1. Did the bread become dry? 2. Did it look burned? If so, it was heated too hot and your data will be incorrect. Record data as follows:

Before heating:		
Weight of watch glass	———	
Weight of glass and bread	———	
Weight of bread		———
After heating:		
First weight, glass and bread	———	
Second weight, glass and bread	———	
Final weight, glass and bread	———	
Weight of bread alone after heating		———
Weight of water lost		———
Percentage of water lost		———

$$\left(\frac{\text{weight of water lost}}{\text{weight of bread}} = \text{percentage of water}\right)$$

Conclusion: 1. What evidence have you that heating the bread drove off water? 2. What percentage of water did the bread contain?

Note: Some other food might be substituted for the bread. Also satisfactory, but less accurate, results can be obtained by drying a piece of bread in the oven at home (not toasting). If the weights before and after drying are known, the percentage of water can be calculated.

Application: What evidence can you give that plants must have water?

General Problem 2. What Are the Properties of Water?

124. What Are Properties? — You know what water is like, for you have observed and used it all of your life. But can you describe water exactly, using scientific words? All substances are described or recognized by means of their characteristics or *properties.* By a property of water is meant a characteristic that is present in every sample of water. A property of any substance is a characteristic which helps us to distinguish that particular substance from other substances. For example, sulfur is yellow. The yellow color is a property of the sulfur and helps us to distinguish between sulfur and a piece of coal, which is black.

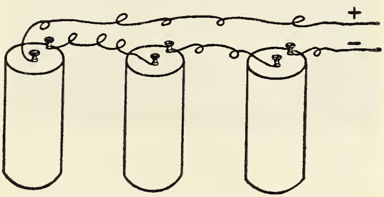
In science work you frequently have need to examine a substance and tell its properties: color, taste, odor, boiling point, freezing point, whether it is hard or soft, whether or not it will dissolve in water, whether it will burn, and so on. Knowledge of these and other facts about a substance enable you to describe it accurately.

The properties of water which you have studied so far are called *physical properties* because we can recognize them by the use of our senses. They are: Water if pure is odorless, colorless (in small quantities), tasteless, boils at 212° F. and freezes at 32° F. There are other properties of water, however, which are revealed only by a study of its elements (page 223) as they unite with other elements. Such properties are called *chemical properties.*

It is interesting to prove by experiment that water is composed of two elements, the gases, hydrogen and oxygen.

Experimental Problem 21. — *Is water composed of two gases, hydrogen and oxygen?*

What to use: Several dry cells or a radio battery charger; test tubes; a large dish; platinum terminals; wood splints; a support; and dilute sulfuric acid.



CELLS CONNECTED IN SERIES

What to do: Fill the dish with water to which a very little of the sulfuric acid has been added.

Connect the dry cells in series (positive to negative, etc.), and run a wire from the end positive pole into the water.

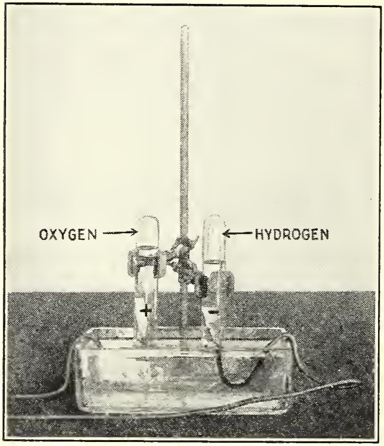
Run another wire from the end negative pole into the water. If a charger is used, connect it to a lighting socket and place one battery terminal in the water at one side of the dish and one at the other. Do not let them touch either in or out of water. **Caution: Do not handle both battery terminals at the same time while the current is turned on.** The ends of the wires placed in the water should be equipped with platinum terminals. Do bubbles form at the platinum ends of the wires in the water?

Fill two test tubes with water and invert each under the water in the dish and put one test tube over one wire end (terminal), and the other over the other wire end.

If gases form and rise into the tubes, do they form at the same rate in both tubes?

Note the proportion of gases in the two tubes. Mark the wire where the gas forms most rapidly with a negative sign, and the other with a positive sign.

When the tubes are partly full of gas, take each one out and test the gas in it with a glowing splint. Collect more gas in each tube and test with a flaming splint.



EXPERIMENT 21

When not collecting gas, disconnect the battery or charger.

What happens: 1. Were gases formed at each wire terminal? 2. What color were they? Describe each test made with the gas formed at each terminal, and indicate whether the terminal was negative or positive. 3. In what proportion did the gases form?

Conclusion: 1. Judging from the properties of the gases formed, what do you think they were? 2. What was the proportion? 3. Does this suggest a reason why the chemist represents water as H_2O?

Application: Explain why a gas oven is filled with moisture when the gas is first lighted?

125. Water as a Solvent. — Pure water, as you know, is odorless, tasteless, and colorless. The color of water appears to vary in lakes and the ocean from blue to green, and even black when very deep and black clouds are overhead.

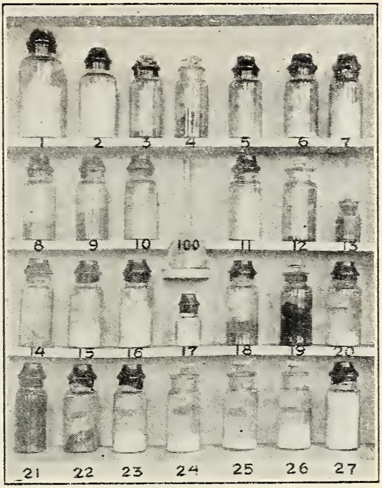
That water *dissolves* oxygen from the air and minerals from the soil is also common knowledge to pupils studying science. But do you know that the ability of water to dissolve substances is a property on which all life depends?

Field Research:

Test various common substances that you know are practically insoluble in water as follows: Grind each to a fine powder and

place a very small amount in half a test tube of water. Shake thoroughly. Does it disappear? If not, heat the tube of water. Does it now apparently dissolve?

Now make a list of ten substances which you know to be readily soluble in water. Make your selection, so far as possible, from materials used by the housekeeper.

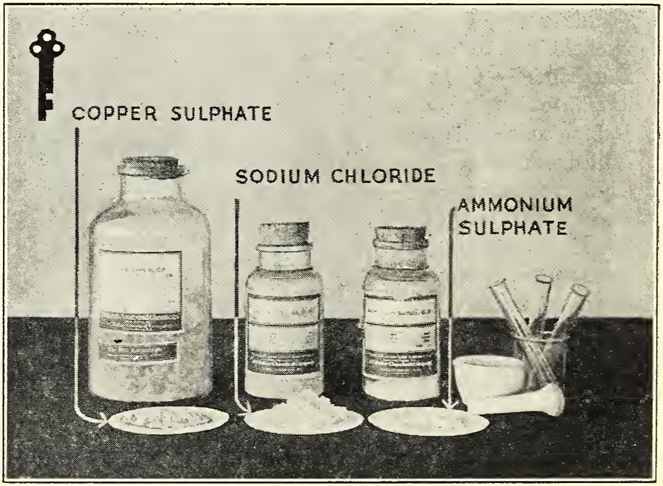


SOLUBILITY

Each bottle contains just enough of the substance to make a saturated solution with 100 c.c. of water. Select three familiar substances from the list and arrange their names in order of their solubility.

1. *Cane sugar* — Sucrose
2. Calcium chloride
3. Ammonium chromium sulfate
4. Nickel chloride
5. *Blue vitriol* — Copper sulfate
6. *Baking soda* — Sodium bicarbonate
7. Chili saltpeter — Sodium nitrate
8. Cobalt nitrate
9. Sodium dichromate
10. Uranium nitrate
11. Ferrous sulfate
12. Potassium permanganate
13. Picric acid
14. Iron alum — Ferric ammonium sulfate
15. *Washing soda* — Sodium carbonate
16. *Sal ammoniac* — Ammonium chloride
17. *Cream of tartar*
18. Nickel nitrate
19. Ferric chloride
20. Sodium pyrophosphate
21. Chromium trioxide
22. Potassium chromate
23. Disodium phosphate
24. *Common salt* — Sodium chloride
25. *Trisodium phosphate*
26. *Epsom salts* — Magnesium sulfate
27. *Glucose* — Dextrose

A solution is a clear, even mixture of a solid and water (or any liquid). The mixture will not change if allowed to stand, nor can the solid be separated from the water by *filtering*. In a similar manner, gases and liquids may be used to form solutions with water. The dissolving liquid is known as the *solvent* and the substance dissolved is the *solute*. Substances vary in their solubility in water. Those which cannot be dissolved are called *insoluble*.



(KEY) EXPERIMENT 22

How do the results of this experiment compare with the evidence of solubility in the illustration on page 239.

(Key) ***Experimental Problem 22: Are some substances more soluble in water than others?***

What to use: Table salt; copper sulfate (blue vitriol); ammonium sulfate; test tubes; and a mortar and pestle.

What to do: Grind to a fine powder samples of each substance. Put equal amounts of each material (about one half inch in depth) into three test tubes respectively. Add to each test tube an equal amount of water. Shake the contents of each tube for two minutes and allow to settle.

Observe closely whatever happens.

What happens: 1. Did all of each substance dissolve? 2. Did the temperature of any of the tubes change? Make labeled diagrams to illustrate each tube and contents before and after shaking.

Conclusion: Do substances differ in solubility? State the evidence proving your statement.

Application: Why does ocean water contain more salt than lime in solution?

Not only do substances vary in their solubility in water, but the solubility of a given substance varies with the temperature of the water. Generally, solids are more soluble in hot than in cold water, while gases are less soluble in hot than in cold water. Does this latter statement explain why cold water from a faucet, after standing until clear, gradually becomes filled with air bubbles if it becomes warm? Try it.

EXPERIMENT 23
Why is the burner needed?

Experimental Problem 23. — *Are certain solids more soluble in hot water than in cold water?*

What to use: A Bunsen burner; test tubes and holder; water; and Epsom salts.

What to do: To half a test tube of cold water add very small amounts of the salts and shake thoroughly after each addition until no more will dissolve.

Now heat the solution nearly to boiling temperature and add more of the salts, a very small amount at a time, as long as the salts continue to dissolve. Pour off some of the hot clear solution into another test tube and cool it rapidly.

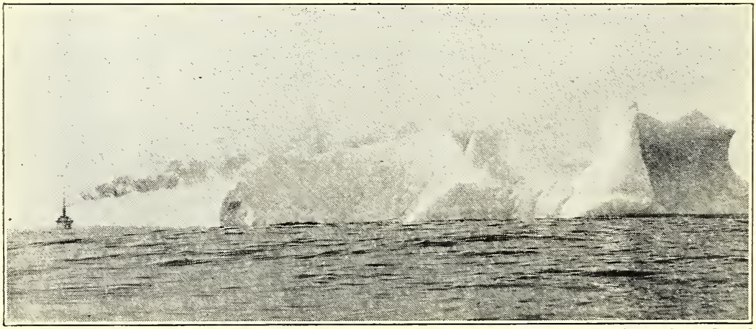
What happens: 1. Did the cold water dissolve some of the Epsom salts? 2. Did the cold water dissolve a limited amount only? 3. Did the hot water dissolve more than the cold water? 4. Was there a limit to the amount the hot water would dissolve? 5. Did crystals separate from the water when the hot solution became cold?

Conclusions: Were the Epsom salts more soluble in hot or cold water? Give proof for your decision.

Note: Water that, at a certain temperature, has dissolved as much of a substance as it can dissolve is called a *saturated* solution. Did you make a saturated solution in your experiment? Explain.

If you wish, you could try the above experiment, using Glauber's salts (sodium sulfate) or powdered blue vitriol (copper sulfate) instead of Epsom salts (magnesium sulfate). Table salt (sodium chloride) is just about as soluble in cold as it is in hot water. It is an exception to the rule.

Application: Explain the formation of deposits of hot springs.

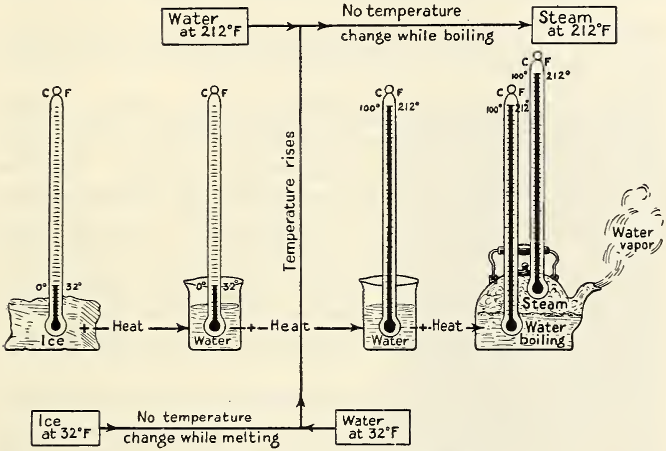


Courtesy United States Coast Guard

ON THE TRAIL OF ICEBERGS

Danger lurks in northern waters when great icebergs break loose from glacier streams and float off to sea. Coast guard vessels keep ships informed about the location of these bergs.

126. Forms of Water. — Water may exist as a solid (ice), a liquid (water), or a gas (steam). Water can be changed from a solid to a liquid and then to a gas by adding heat. Moreover, by taking heat away (cooling) the gas can be changed first back to the liquid, and then to the solid. The temperature at which solid



Changes of State in Water

What happens when heat is added and no temperature change occurs?

water (ice) changes to liquid is called the *melting point* (melting temperature) of ice. The temperature at which water changes most rapidly to steam is called its boiling point. No two substances have the same melting and boiling points. These are physical properties that help to identify a substance, if it is pure, because a pure substance has a fixed boiling point and freezing point.

Look up the melting and boiling points of iron, tin, zinc, lead, paraffin, sugar, chocolate, and butter in the tables to be found in the Appendix.

We know that when a gas like steam is changed to a liquid by cooling, the process is called *condensation*, and when the liquid is changed to a solid (ice) by further cooling, the process is called *freezing* (solidification). The freezing temperature of water, 32° F. (0° C.), is the same as its melting temperature.

Laboratory Research:

To find out whether the atmospheric pressure in your science room is standard.

Suspend an accurate all-glass thermometer so that the bulb is just immersed in a beaker nearly full of water. The beaker should be placed on a wire gauze on an iron tripod. Heat the water to brisk boiling, and observe and record the temperature of the water as indicated by the thermometer. Let the water cool a few minutes and heat again to boiling. Observe and record the boiling temperature again. If the two determinations agree very nearly, take the average as the boiling temperature. If they do not agree, make a third and fourth determination, if necessary.

From the table of boiling temperature and pressures in the Appendix, find the pressure corresponding to the boiling temperature just recorded. Standard atmospheric pressure (page 164) is 30 inches (760 mm.). What should the boiling temperature be at this pressure?

What is your altitude? How does altitude affect atmospheric pressure, and how does this affect the boiling temperature of water? What other factors might be responsible for the boiling temperature determined? Try to state a relation between the boiling point of water and altitude, and explain why the relation exists.

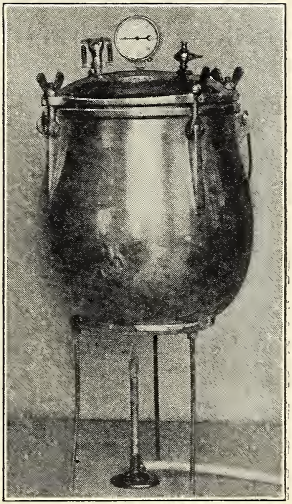
The boiling and freezing points already given are for pure water at standard pressure. Water containing substances like sugar, salt, alcohol, or glycerine in solution has a different boiling and freezing temperature from that of pure water.

Laboratory Research:

Secure an accurate all-glass thermometer, a Bunsen burner, a beaker or glass, a tripod, wire gauze, and some salt or sugar.

Determine the boiling point of water taken from the tap. Next add and dissolve about $\frac{1}{4}$ as much sugar or salt as you have water. Now determine the boiling point of the solution. Is it the same or higher or lower than that of the water alone?

People living at high altitudes find that the boiling temperature of the water is too low to cook some foods quickly. One way to overcome this difficulty is to use a boiler with a cover that fastens on tightly. This causes steam pressure to increase in the boiler, and therefore the temperature is raised. Can you suggest another way of raising the boiling temperature in case you do not possess a "pressure cooker"?



A Pressure Cooker

If you live where winters are severe, you know that alcohol, glycerine, or other substances are often mixed in the water in the automobile radiator to prevent the water from freezing. You can test out that scheme by the following experiment:

Laboratory Research:

Make a freezing mixture of equal parts of coarse salt and finely scraped ice. Place the mixture in a tight wooden box such as a crayon box, and set the box in a pan to catch any water that may leak out.

Secure five accurate all-glass (chemical) thermometers, five test tubes, some salt, and some denatured alcohol. In one test tube put water from the tap; in the second, water plus $\frac{1}{8}$ as much salt; in the third, put water and twice as much salt as in

the second. Prepare the fourth and fifth tubes as the second and third, but use alcohol in place of the salt.

Place a thermometer in each tube, and set the tube in the freezing mixture. Shake each tube occasionally. Record the temperature at which the contents of each tube begins to form ice crystals, that is, begins to freeze.

Tell what you did, and the freezing temperature of each solution if it froze. Explain.

Can you now explain why water in a radiator is protected against freezing by the use of alcohol? How do different amounts of alcohol affect the freezing point of water?

General Problem 3. Are the Uses of Water Related to Its Properties?

127. Uses of Water. — The properties of water determine its uses. Water is used in the digestive juices of the body to dissolve substances. Water also must dissolve minerals from the soil to be of most use to the plant. Because water can dissolve oxygen, it is fit for fish to live in; because water is liquid at ordinary temperatures, it is suitable for boating; because it will freeze at a convenient temperature, it is available for use in refrigerators. With these suggestions, you should be able to make a long list of things that depend upon the properties of water. What would happen:

if water could not be frozen!

or

if ice could not be melted!

or

if the boiling point of water were lower than the temperature of your body!

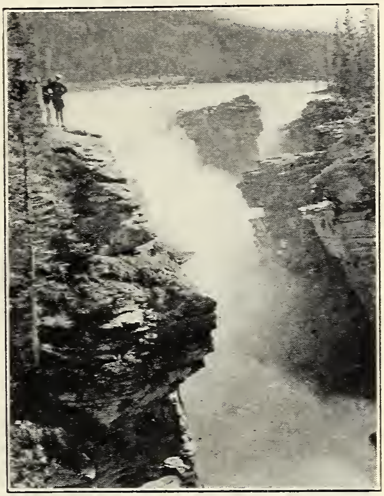
or

if the atmospheric pressure did not affect the boiling point!

or

if water would not evaporate!

128. Water Works for Us. — The cutting and carving of rocky gorges, mountains and valleys, hills and plains have made the earth a beautiful place on which to live. How uninteresting it would be if the surface of the earth were absolutely level and dry, barren of everything that water in the air, streams, lakes, and oceans and in soil make possible!



Courtesy Canadian National Railways

Athabasca Falls, Jasper National Park

Man has learned to harness the power of rushing water to do his work.

Running water turns wheels of industry. The energy of falling water, transformed by electric generators into electrical energy, provides endless helps and conveniences.

Water used for travel and transportation has played a part of vast importance in the life and development of our country. Civilization and progress have followed the water courses. Explorations and discoveries on land have progressed along the waterways. Read of the voyage of Hendrik Hudson up the river that bears his name. First settlements have nearly always been made on the main water courses. This was so because in those early days the waterways offered almost the only ready means of transportation.

Later, the people of the inland drew their produce to the nearest water course for transportation to a settlement. Schools and churches were established at these centers, and so, little by little, education and culture increased. Industries of various kinds sprang up and still the waterway held its own. When, however, the demand for greater speed in transportation developed, railroads were ready, but even these in the beginning

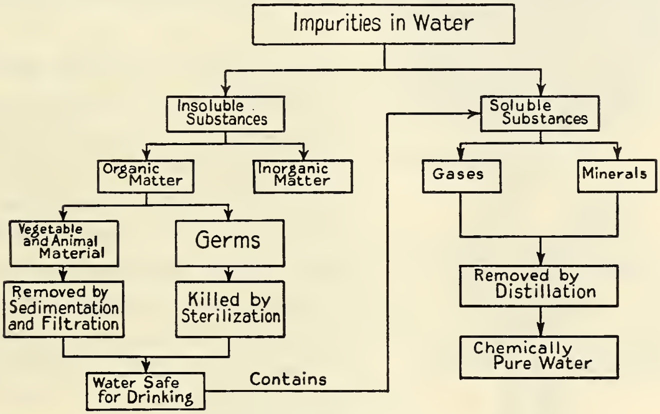
WHERE WATERWAYS HAVE MADE A CITY

Buffalo, located where navigation for the big lake carriers ends, owes to its water transportation facilities its ranking as eighth industrial city of America.

followed the water courses. Now that science has given man so much control over the forces of Nature, he tunnels mountains, bridges ravines, and builds airships that carry men and materials over mountain, valley, and sea. Waterways remain, but, except for ocean commerce, they are not so important as in early times.

129. Water for Drinking. — Your discoveries about the properties of water have to do with pure water.

Pure water, in the mind of the chemist, means water with no foreign matter dissolved in it. It is called *chemically pure.* However, chemically pure water does not occur naturally, and can be made only with difficulty by the chemists. Since the use of water for drinking is of greatest importance, we must investigate the impurities of water to determine whether or not they are harmful, and if they are, how to remove them.



EXPLAIN EACH STEP OF THE DIAGRAM

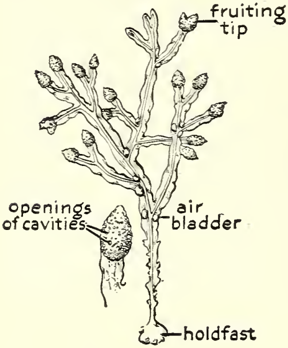
Water from a health standpoint may be safe to drink and yet not be chemically pure. All natural water contains impurities. They may or may not be harmful to man. They may even be beneficial, as, for example, water with certain minerals dissolved in it. The common impurities in water are both *inorganic* (mineral) and *organic* substances. They may be in solution or not in solution.

The *soluble impurities,* that is, the minerals in solution, are not ordinarily removed from drinking water unless they are known to be injurious to health. The minerals found in solution in the water are mostly *bicarbonates* and *sulfates* of calcium and magnesium. Some spring waters contain minute amounts of various minerals that may or may not have special uses to the body. So-called curative mineral waters should be used only on the advice of a competent physician.

Field Research:

Devise and demonstrate a method of separating insoluble impurities from water.

The *organic impurities,* which consist of parts of vegetable and animal matter and living *organisms* such as *bacteria,* may be objectionable or even dangerous. Decaying vegetables and animal tissues may give rise to odors and tastes which are disagreeable, but the greatest objection to them is that they serve as food for the growth of bacterial life, some of which may be harmful. The bacteria found in water are for the most part harmless. However, since most water contains food for bacteria to live on, if a few typhoid germs or other disease germs gain entrance to the water, they may multiply with enormous rapidity, and the disease will be transmitted to people who drink the water. Great typhoid epidemics have been traced usually to the milk or water supply.



WATER PLANTS
These Brown Algae grow in salt water.

Certain *algae* sometimes grow in water and exude an oil which gives the water a fishy taste. While this is not injurious, it is objectionable. The growth of algae may be prevented largely by dissolving an extremely small proportion of copper sulfate (blue vitriol) in the water of the lake or reservoir. Small fish aquaria frequently show a variety of algae grown on the side walls or on stones in the water. In your aquarium, you should not try to prevent the growth of the algae with copper sulfate, for you would likely use too much. Moreover, the algae are food for your snails.

© General Biological Supply House
TYPHOID BACILLI

With our knowledge of the properties of pure water and of the impurities that may occur in water from natural sources, we can investigate, intelligently, sources and treatments necessary to provide us with safe drinking water. The next chapter will deal with those problems.

Key Words

algae	element	pressure
bacteria	freezing point	property
balance	hydrogen	pure
boiling point	impurities	soluble
characteristic	insoluble	solute
compound	melting point	solution
dissolve	organic	solvent
drying oven	oxygen	transportation

Key Statements

1. Water is the most abundant compound on the earth's surface.
2. Nearly all organic matter contains water.
3. Water can be identified by its properties.

4. Pure water is colorless, odorless, and tasteless; it freezes at 32° F. and boils at 212° F., at normal air pressure.

5. Many of the uses of water depend upon its remarkable solvent property.

6. Substances vary in their solubility in water, and the solubility of any substance varies with the temperature of the water.

7. At any temperature, water is saturated with a substance when no more of the substance will dissolve in the water.

8. Some substances dissolved in water cause the boiling point to be higher and the freezing point to be lower than normal.

9. The boiling point of water is lower than normal with low air pressures, and higher with high air pressures.

10. Water serves for transportation.

11. Drinking water which contains harmful or harmless substances can be purified.

Thought Questions

1. What property of water makes it possible for fruit, vegetables, or bread to dry out?

2. Given samples of two colorless liquids, one of which is water, how could you determine which one was water?

3. How can you prove that water dissolves oxygen?

4. How can you prove whether a sample of water contains anything in solution?

5. How can you determine whether a solution of sugar and water is a saturated solution?

6. What is meant by *condensation?*

7. What is meant by *solidification?*

8. What is meant by *pure water?*

9. Does it require more or less time to boil an egg on a mountain than it does at sea level?

10. Try to name a use of water that does not depend upon one or more of its properties.

11. Why may water for drinking need to be purified?

12. Is water safe for drinking necessarily chemically pure water?

PROJECTS FOR YOUR SCIENCE DISCOVERY BOOK

1. Make a list of five common substances and write an accurate description of each. Try your descriptions on your classmates. Can they recognize the substances from your descriptions?

2. From a geography map and a history book, trace the development from a seaport town to some early inland settlement.

3. Make a report on what happens when a solution of salt is allowed to evaporate slowly. Try a solution of alum or sugar.

4. Prove by experiments (describing each process carefully):

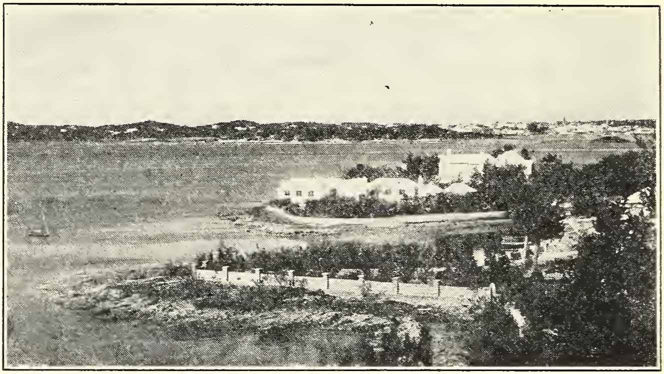
   a. That ordinary water contains dissolved air.

   b. That soil contains water.

   c. Whether granulated sugar contains water.

5. Perform an experiment to illustrate the water cycle in nature.

SURVEY OF TOPIC XI



Can you picture a green island, set in a blue sea, with many coral houses whose white roofs gleam in the sunlight? These white, corrugated roofs are more important than roofs usually are, for they are rain catchers. Would it seem queer to you to have all the water you use for washing and drinking, rain water which is stored in tanks under the back yard? The people on this lovely little island think nothing about it. For years they have caught and stored rain water this way, and they will keep on doing so for many years to come.

In this country we have an abundance of water and it comes from many sources. Rain water, caught in barrels from shingled roofs; water from wells, pumped by hand or machinery; water from springs bubbling out of the earth; water from lakes or reservoirs ready to meet our daily needs at the turn of a faucet.

Unfortunately water from these many sources is not all fit for drinking. The great problem in our cities and towns is not only to provide abundant water but to provide water safe to drink. The next few topics will tell you about this problem in detail, and how it has been solved.

TOPIC XI

THE WATER SUPPLY

The clouds consign their treasures to the fields;
And, softly shaking on the dimpled pool
Prelusive drops, let all their moisture flow,
In large effusion, o'er the freshen'd world.

— THOMSON

Do you know:

1. Where your drinking water comes from? Whether it is rain water, spring water, or well water, whether it comes from a river, or from a natural or artificial lake?

2. How a water supply may become polluted?

3. How fresh water can be obtained from sea water?

4. How the community supply is safeguarded against harmful impurities?

5. How science is able to prevent disease by proper treatment of drinking water?

GENERAL PROBLEM 1. WHAT ARE THE SOURCES OF WATER SUPPLY?

130. For Farm and Hamlet. — Those who live in small villages, on country estates, or on farms usually must provide their own water supply. Therefore, they must have springs or wells or cisterns to supply water for the various and many uses of the household and farm.

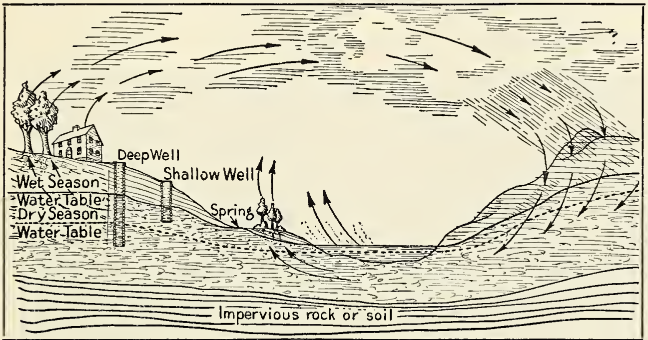
Because of the solvent property of water, spring and well waters are likely to contain mineral matter in solution. This may make their use for cleansing purposes undesirable. Cistern water, on the other hand, is rain water collected from the roof of the house and is more suitable for use with soap because it contains few mineral impurities. The subject of how soap works with water from different sources will involve some interesting experiments which will be discussed later.

A Water Gusher

The largest artesian well in the world which flows 9100 gallons a minute.

131. Springs and Wells. — Springs and wells are fed by *ground water*, that is, by water which has flowed through the myriads of little channels formed by rock particles and crevices. They will supply water generously through dry seasons as well as wet seasons, if their source of supply is below the level of the dry weather *water table*. Water that soaks into the soil rock pores or crevices passes on down to fill similar spaces at varying depths below the surface of the ground. Below a certain depth, depending upon the altitude and climate of the locality together with the character of its underlying rocks, the underground water collects in a sizable quantity. The surface of this underground body of water is the water table.

Just as the surface level of an ordinary lake is higher during rainy spells, so the surface (water table) of the underground lake (ground water) is higher during wet spells or seasons. If the water that feeds a spring (or well) comes from a point lower than the dry weather water table, the spring will not "go dry."



WATER SUPPLY AND THE WATER CYCLE

What is the relation of well water supply to the water cycle? Which well may go dry?

How would you suggest improving a well that goes dry during dry spells? Study the above diagram to help in answering the question.

In studying the diagram, you will observe that the water table is not level but undulating (waving), following to some extent the general contour of the ground surface. Ground water flows slowly by gravity from the higher levels to the lower levels through the rock and soil.

132. Problems of Supply. — A community, large or small, must provide itself with an adequate supply of water that is safe for drinking. Wells, rivers, reservoirs, and lakes are each used, depending upon the population and location of the community. Much of the water will be used for industrial purposes, but since safeguarding the health of its people is the duty of a community, care of its water for drinking is most important.

The problems to be solved by a community in relation to its water supply are:

1. To secure an abundant supply.
2. To safeguard the water from contamination at the source.
3. To bring water to the community.
4. To purify the water for drinking.
5. To distribute the water to the people.

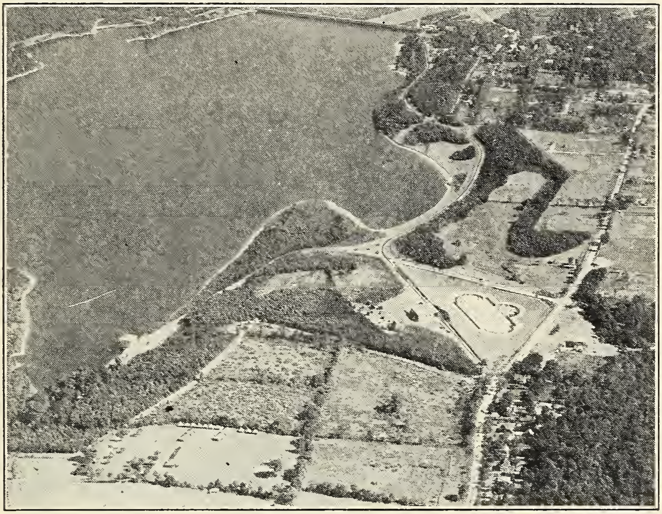
133. An Abundant Supply. — The smaller communities may supply their needs from deep wells from which the water is pumped into large steel tanks for storage and distribution. A tank is usually placed on a near-by hill or on a tower, and water from the source is pumped into it. Thus the water can be distributed by gravity.

Some communities pump water from a convenient river into large reservoirs. River water is especially liable to contamination from industrial wastes and sewage materials. This necessitates special equipment for the purification of the water. The reservoirs are placed at an elevation above the town.

A very desirable source of water is a natural or an artificial lake or reservoir, situated so as to collect the drainage water from a forested watershed located at an altitude above the community. The fewer the habitations on the watershed or drainage area, the less will be the chance of contamination.

Large inland lakes furnish an abundant supply of water to cities on their borders. However, since the water may be polluted with wastes and with sewage, and since the lake may be at a lower altitude than the city, expensive pumping and purifying equipment must be provided. The water is usually transported to the city through *conduits* (kŏn′dĭts — pipes) extending far out into deep water.

In the United States the Atlantic belt in general has an adequate water supply. Reforestation has been



Kensico Reservoir

Millions of gallons of water are pumped daily from this huge reservoir to Manhattan, thirty miles away.

necessary in some localities to preserve this supply and to prevent excessive soil erosion (carrying or wearing away of soil). As new sources of water supply have been required for certain cities, lands of watersheds have been purchased, buildings removed, and millions of trees planted.

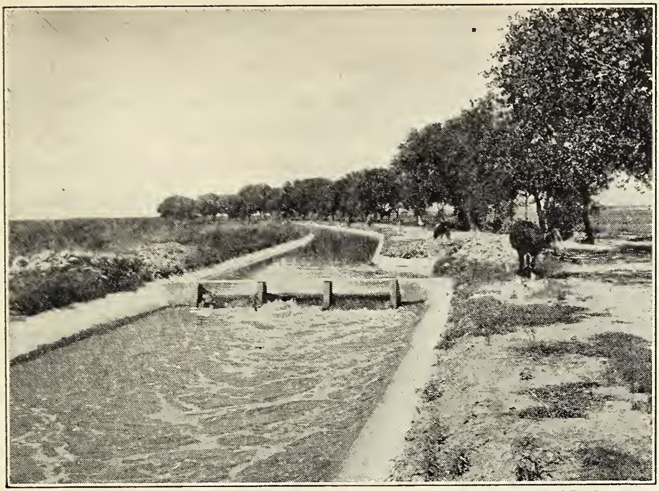
The great area drained and watered by the Mississippi River is rich agriculturally because of the water supply. However, the western third of our country must depend upon transporting water great distances from natural and artificial lakes to preserve its regions of famous gardens and farms. Many a garden spot would soon change back to its desert condition if it had to depend upon local rain and snowfall for its water. In these great open spaces of the West, precious water changes barren lands to fields of berries, large fruits, garden truck, and flowers, as fine as any that Nature can give when water is at hand.

In the Smoke River Valley of Idaho, more than 200,000 people live where all was barren land until man improved the water supply. One hundred and fifty years ago the Los Angeles district had a few thousand population, with scarcely enough water to grow their crops. By means of water brought 250 miles from the mountains, across the Mohave Desert, more than 2,000,000 people are now supported. As the population increases, new supplies will be needed, and Boulder Dam has been constructed to help meet the demand. So it is all through the West. Great water-supply projects are converting deserts into gardens.

Field Research:

In your library look up about one or more great water-supply projects of the West. Report your findings to your class.

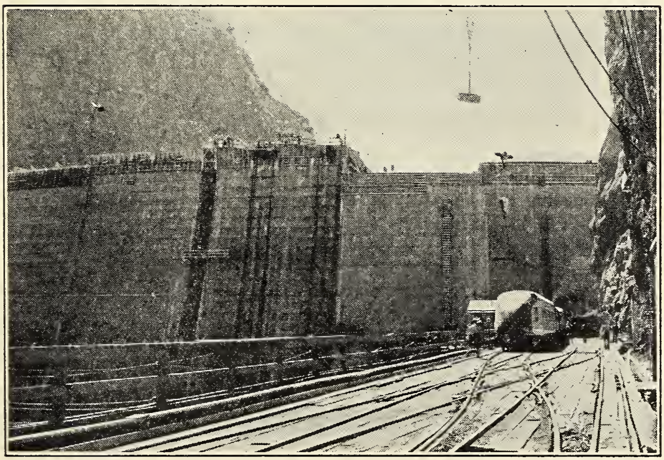
Another problem related to water supply is the rate of soil erosion. In the Southwest, cattle and sheep grazing has resulted in enormous areas losing the cover crop that resisted erosion by flooded rivers. Now the flood waters carry great quantities of silt from the slopes and fill the river channels. Hence each flood overrides



Courtesy Bureau of Reclamation

CARLSBAD PROJECT, NEW MEXICO

Water being carried along this lined canal for irrigating the flat, dry lands of New Mexico.

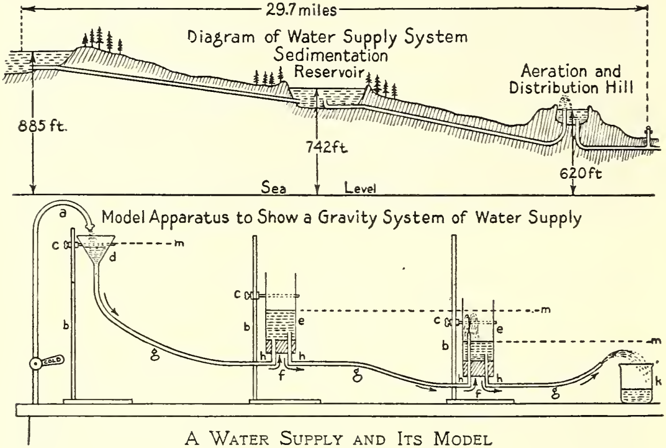


Courtesy Union Pacific

BOULDER DAM PROJECT

Another great water-supply project. Notice the streamline train which brings people to see the progress of the dam.

more land and thus increases the barrenness. Flood control by means of dams and storage lakes and the reëstablishment of the cover crop are necessary to check the destructive soil erosion. Feeding by herds of animals must be regulated to prevent further destroying of the cover crops that still remain.



A WATER SUPPLY AND ITS MODEL

Explain each part of the diagram.

GENERAL PROBLEM 2. HOW IS WATER BROUGHT TO THE HOME?

134. From Source to Reservoirs. — The principles involved in transferring water from the source to a storage place are practically the same irrespective of the source or the size of the community served. In all possible cases reservoirs are placed at an altitude above the community so that gravity may be used to force the water through water mains into the water-pipes of the houses, and to produce enough pressure to cause the water to flow rapidly from all faucets.

In like manner, if the water sources are at a still greater altitude than the reservoirs, the force of gravity can be used to cause the water to pass through conduits down through the valleys and over the hills to the reservoirs, providing that no hill is higher than the level of the water at the source. The alternative to this *gravity system* is a *pumping system.* The pumping system requires more complicated and costly equipment, making it less economical than the gravity system.

135. The Gravity System. — You know that water runs down hill by gravity. You know also that if the water in a stream is blocked or dammed, the water will fill up and overflow the dam, if indeed it does not push the dam out of its way. Water stored in this way exerts a pressure or push to get through a wall or dam. This pressure is due to the force of gravity tending to pull the water down its course to lower levels. The deeper the water the greater the downward pressure.

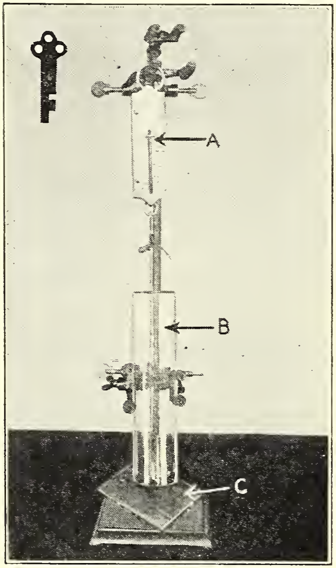
(Key) ***Experimental Problem 24: Does water exert a downward pressure and does its pressure vary with its depth?***

What to use: A 64-ounce spring balance; a glass cylinder ($1\frac{1}{2}$ in. × 12 in.) with ground end; a glass plate, 2 in. square; sealing wax; string; vaseline; a ring stand; and two clamps.

What to do: Fasten the string to the center of the glass plate with sealing wax. Smear vaseline on the glass plate around the wax. Fasten the cylinder in a vertical position. Pass the end of the string up through the cylinder and fasten it to the hook of the balance. Fasten the balance to a movable support on the ring stand.

Adjust the position of the balance so that the glass plate is held up against the cylinder by a force of 4 oz.

Add water slowly to the cylinder and note the depth when the weight (downward pressure) of the water is just enough to push the glass plate away from the cylinder.



(KEY) EXPERIMENT 24
Why is the spring balance used?

Readjust the balance so that it shows a 6-oz. pull. Add water as before, noting the depth required to push down the plate. Make several similar trials.

What happens: 1. Did water stay in the cylinder at first? 2. What held it in?

3. When a certain depth was reached, did the water push out at the bottom? 4. Why?

5. Did the depth of water required to push out the plate vary with the force exerted by the balance? 6. Did the balance measure the downward pressure?

Make a labeled diagram to illustrate each trial.

Conclusion: 1. Briefly, what did you prove? Give the evidence which you think is proof of your statement. 2. What was the relation between the downward pressure and depth?

Application: Why cannot a person dive into water more than a a few feet?

Your experiment proved that water does exert a downward pressure. It proved also that the deeper the water, the greater the downward pressure. Downward pressure is caused by gravity, and so is called *gravity pressure*.

A cubic foot of water (approximately $7\frac{1}{2}$ gals.) weighs 62.4 lbs. In other words, water in a tank one foot square on the bottom would press downward with a force of 62.4 lbs. if the water were one foot deep. If the depth should be increased to 2 ft., the pressure on the bottom (one square foot in area) would be 2 × 62.4 lbs. or 124.8 lbs. It would increase by 62.4 lbs. for each foot of depth.

What would be the pressure per square foot if the water was 60 ft. deep?

Water pressures are generally stated in pounds per square inch. If you know the pressure per square foot, how can you calculate the pressure per square inch?

Besides exerting a downward pressure, water exerts a lateral or sidewise pressure also. An experiment will show you how we know this.

Experimental Problem 25. — *Does water exert a lateral (side) pressure?*

What to use: A tall tin can, with holes 2 inches apart and in line from top to bottom, and wooden pegs to fit the holes.

What to do: Put the can in a sink. Place the little wooden pegs in each hole and fill the can with water. Quickly remove all the pegs. Add water to keep the can full.

What happens: 1. Did the water spurt out of each hole? 2. Did it spurt out of one hole farther than from any of the others? 3. Which one?

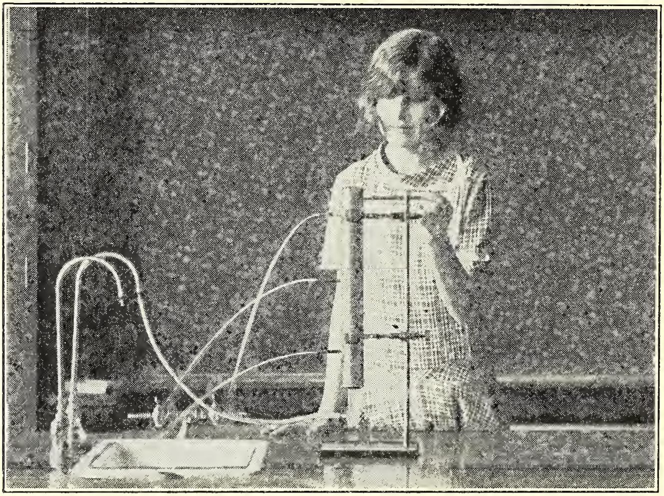
Conclusion: 1. What caused the water to spurt out the side holes? 2. Why did it spurt out farther from some than from others?

Application: Why are dams built thicker and stronger at the bottom than at the top?

Field Research:

Examine the plans for a dam. Explain why it provides for stronger construction at the bottom than at the top.

Now that you have proved that water presses downward and sidewise you will not be surprised to learn that it presses upward also. You know that if you push a piece of wood under water and let go of it, it comes to the surface. The water pressure pushes it up. Perhaps you have discovered that a stone seems lighter under the water than out of it. This is because the



Experiment 25

What evidence do you see that the side pressure is greater toward the bottom of the cylinder?

water exerts an upward pressure on it. At any point in a liquid the pressure is equal in all directions.

You have heard that "water seeks its level." You should be able to explain why.

Experimental Problem 26. — *Does water seek its own level?*

What to use: A bottle with an opening at the bottom, or a funnel; rubber tubing; and glass tubing.

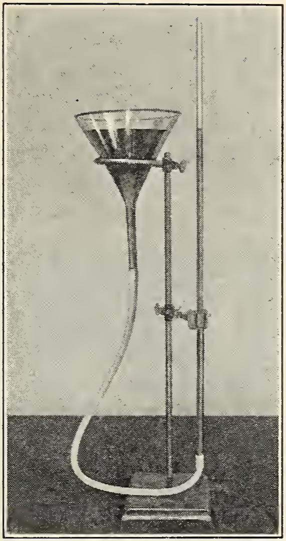
What to do: Set up the apparatus so that the water can run from the bottom of the funnel through the rubber tubing into the glass tube held upright.

Gradually fill the bottle with water.

What happens: 1. Does the water run into the glass tube? 2. As you continue to add water to the bottle, how does the height of the top of the water in the tube compare with the top of the water in the bottle?

Conclusion: Consider what you have learned about water pressure and try to explain what you have demonstrated in this experiment.

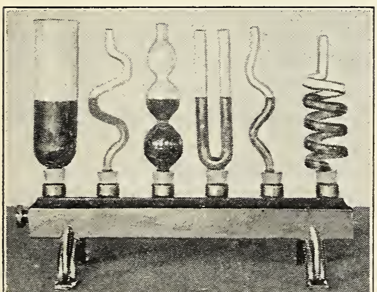
Application: Why is the vacuum tank placed above the engine in some automobiles?



EXPERIMENT 26

Why are the funnel and upright tube connected with a rubber tube? Why not a glass connection?

A gravity water-supply system is an application of the principles of water pressure with which you are now familiar, namely, that water seeks its level because of gravity pressure; gravity pressure always occurs in water since the force of gravity is always acting; water exerts a pressure sideways and upward as well as downward; the downward pressure and the lateral pressure increase with the depth of the water.



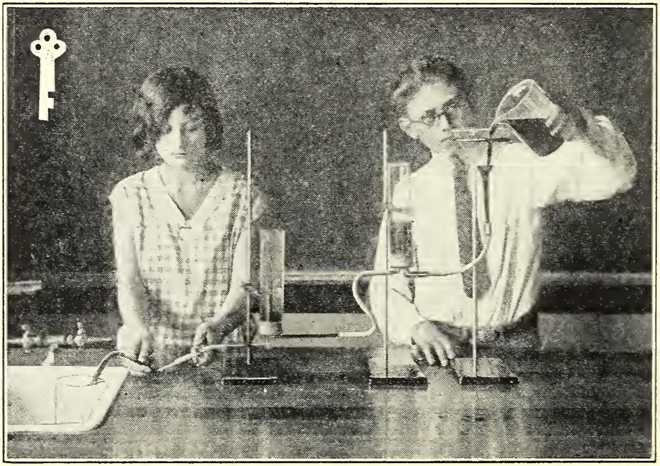
WATER SEEKS ITS LEVEL
Do other liquids act like water?

(Key) *Experimental Problem 27: How does a model gravity water-supply system work?*

What to use: A funnel or large bottle with an opening at the bottom; rubber and glass tubing; one-hole and two-hole rubber stoppers; two wide-mouthed bottles (12 oz.); pinchcocks; and a glass exit tube, drawn to a small opening.

What to do: Study the diagram (page 262) of an actual gravity system used by a large city and set up a model as represented by the diagram.

When all is connected properly and pinchcocks (representing valves) have been tightened, fill the large bottle (representing



(KEY) EXPERIMENT 27

What does each part of the apparatus represent?

a lake) with water. Adjust the "valves" and allow water to flow to the bottle representing the city reservoir. When in operation, allow the water to flow out through the pointed exit tube.

What happens: How high does the water go?

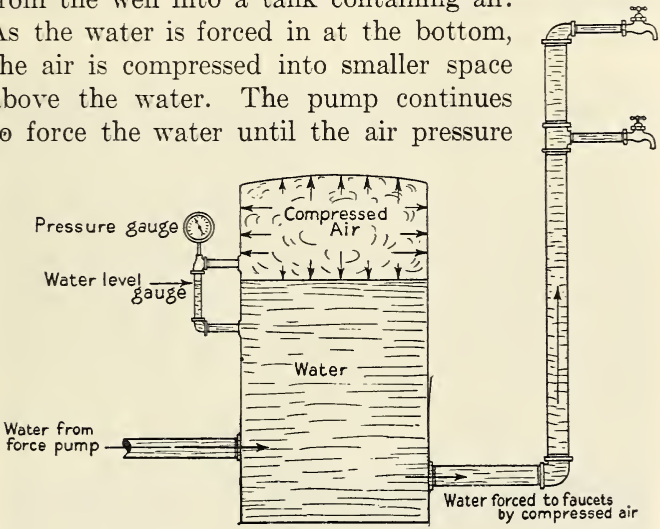
Conclusion: State how and why gravity causes the water to pass from the lake to the city reservoir. What causes the water in the conduits to go over hills? Explain the height to which the water was forced from the outlet tube in the city reservoir.

Application: What is the result of the difference in altitude between the reservoir and the tall buildings?

Field Research:

Using the altitudes given in the diagram (page 262), calculate the pressure per square inch at the first reservoir and at the city reservoir.

136. Pumping System. — Many people, living outside a community water-supply system, install a private pressure system. A motor-driven pump forces water from the well into a tank containing air. As the water is forced in at the bottom, the air is compressed into smaller space above the water. The pump continues to force the water until the air pressure



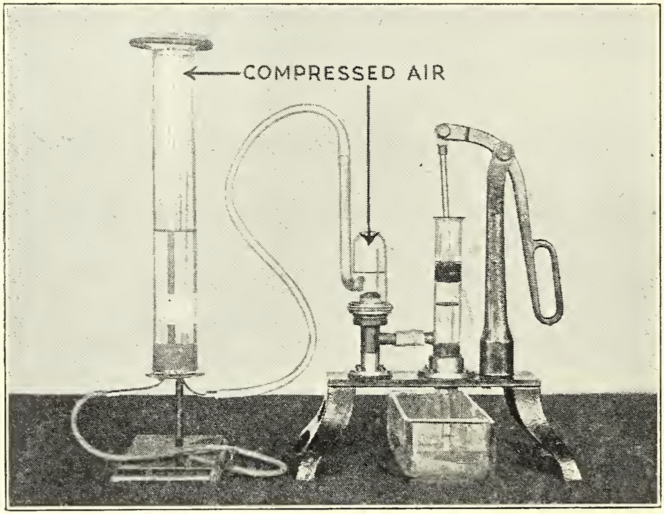
A Pressure Tank

To what is the force of the compressed air due?

becomes 40 lbs. or 50 lbs. per square inch, as required. The motor is then automatically stopped. When the air pressure in the tank drops to about 20 lbs. per square inch, the motor automatically starts and more water is pumped into the tank as before.

A pipe leads from near the bottom of the tank to various other pipes and faucets. When a faucet is opened, water flows out, being forced through the pipe by the expansion of the compressed air in the top of the tank. In such a system the tank is usually placed in the cellar.

The same plan is used to supply cistern water for use in the house, although separate tanks and pumps are necessary. Other pumping systems use large tanks placed on elevations, if possible, and often at considerable distances both from the pumping station and the service outlets.



EXPERIMENT 28

Does compressed air get from the pump into the glass cylinder?

Experimental Problem 28. — *How can compressed air be used to supply water?*

What to use: A model force pump; a wide-mouthed bottle (12 oz.) or tall cylinder; a two-hole rubber stopper; glass and rubber tubing; a pinchcock; a glass nozzle; and a dish for water.

What to do: Set up your model to work as illustrated. Place water in the dish (to represent a well or cistern) and operate the apparatus.

What happens: Observe how the air in the bottle (tank) is compressed when you pump and how it expands when you allow water to flow from the nozzle. Where does the force come from that compresses the air?

Conclusion: 1. In a water system of this kind, what forces the water through the pipes to the faucets? 2. How does this differ from the water pressure in a gravity system? 3. What relation do you think exists between the pressure of the air in the tank and the height to which the water will be forced?

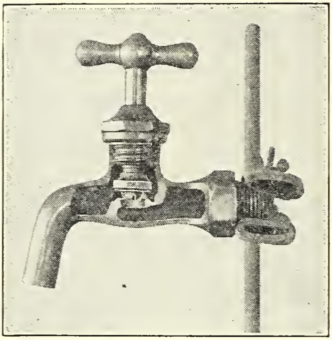
Application: Instead of an air pressure tank in the basement, could you use an open tank in the attic? Explain.

Now that the water is at your door, you are concerned with its distribution to various parts of your house. You are also concerned with its safety from the standpoint of your health. Therefore, the next few sections will help you to discover facts about your home water system, how the water is made pure and safeguarded for your use, and how you may further protect your supply and thereby your health.

General Problem 3. How Is Water Distributed and Controlled in the Home?

137. Plumbing. — Water must be brought into the house and waste water taken out. In communities with a common supply system, the water is brought to the house through water mains and distributed through small pipes. Water and sewage wastes are disposed of through waste pipes which empty into special disposal tanks or into city sewers. Plumbing has to do with water and waste piping in the house.

138. Water Faucets. — Faucets are an important part of your home water system. Ordinary faucets used in kitchens and bathrooms are usually made of nickel-plated or chromium-plated brass. If chromium is used, a different base metal is required. Nickel is a white metal that does not rust readily in air. It is easily polished and kept in good appearance. Chromium is a white metal, very hard, and it takes a high polish. It is less easily oxidized, that is, rusted, than nickel and so is preferred by some. The chromium plate is very thin and is dissolved by acids which tend to destroy its luster.



A Faucet
Is the faucet open or closed?

Faucets for the house must be simple in construction and easily taken apart for repairs. Most people find it desirable to have a faucet open and close without very many turns of the handle. One type of faucet is in general use. It is made in various shapes, but a little investigation will disclose that its several varieties work according to the same general principle.

Field Research:

Take a faucet apart and compare the parts with those shown in the figure. Put the faucet together and work it.

During your investigation try to discover what makes a faucet leak, and how to repair it.

Note: **If you try to repair a leaky faucet at home, be sure the water is turned off in the basement, or below the sink or washbowl where the faucet is located.**

139. Self-Closing Faucets. — In public buildings, including schools, where water is supplied for the convenience of the public, it is wise to use a self-closing faucet. The self-closing faucet is very much like the one you have studied except that a coil spring is fastened to the post. When the faucet is opened, the spring is tightened up, and when the handle is released, the spring closes the faucet. A sanitary type faucet, that is at the same time very convenient, is a gooseneck faucet with a sprinkler head, under which the hands can be held. The water is turned on by pressing a button in the floor. When the foot is removed from the button, the faucet is shut off.

140. Faucets for Draining the Water Pipes. — In the cellar a valve is placed where the water pipe comes from the water meter. When this valve is closed, the water is prevented from entering the house. An outlet just beyond this valve is provided; it can be opened so that the water in the house pipes will flow out if the faucets in the rest of the house are open. Why must they be open? Can you give several reasons why one might wish to take all the water from the pipes?

General Problem 4. How Can Safe Water Be Provided to Safeguard Health?

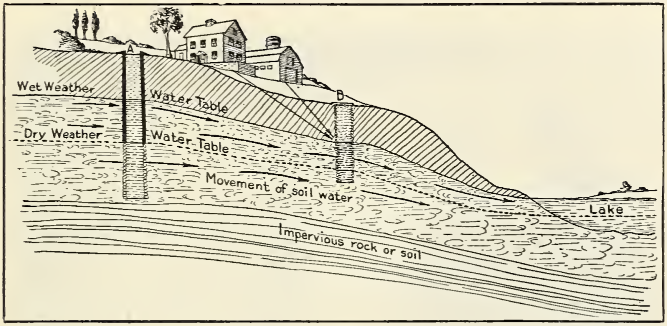
141. Healthful Water in the House. — For home use the water must be clear, free from objectionable odor and taste, and free from dangerous germs. Water from wells or springs which may have been polluted with sewage or industrial wastes should be boiled for twenty minutes or more to kill all possible disease germs before it is used for drinking or food preparation.

Likewise, city water should be boiled if there is any possibility of its containing disease germs. Boiling for less than twenty minutes may not destroy all disease germs and spores (minute reproductive bodies produced by plants). In the case of the city, the Board of Health will usually notify the consumer if there is need for any special care, but great caution should be taken in the use of water that is not known to be safe.

Water that has been boiled tastes flat when cooled, because the dissolved air has been driven out by the heat. Therefore it is a good plan to cool the water after boiling and then to shake it with air, some of which will dissolve and improve the taste.

Faucet *filters* are sometimes fastened on faucets to remove fine sediment but not, as some people think, "to remove bacteria." Most filters of this sort not only are useless but may become a source of danger because sediment collecting in the filter may act as a breeding place for germs. The greatest objection to filters lies in the fact that they give a false sense of safety. If any kind of faucet filter is used, it should be cleaned and boiled frequently. You, as a student of science, should know that filters do not offer any protection against germs.

142. Vacation Dangers. — When one is out for a hike, auto trip, or camping, great care should be taken with respect to drinking water. "The Old Oaken Bucket" may bring water from a well into which seeps drainage from barns or outhouses. The water, though it may be clear, sparkling, and cold, may contain disease germs. The farmer says, "It's all right to drink; we drink it." True; it is possible that the bodies of the people who drink it may have built up an *immunity* (resistance) which protects them against the disease. You may not have that immunity, so beware! When you are not certain of the safety of drinking water, boil it before using it.



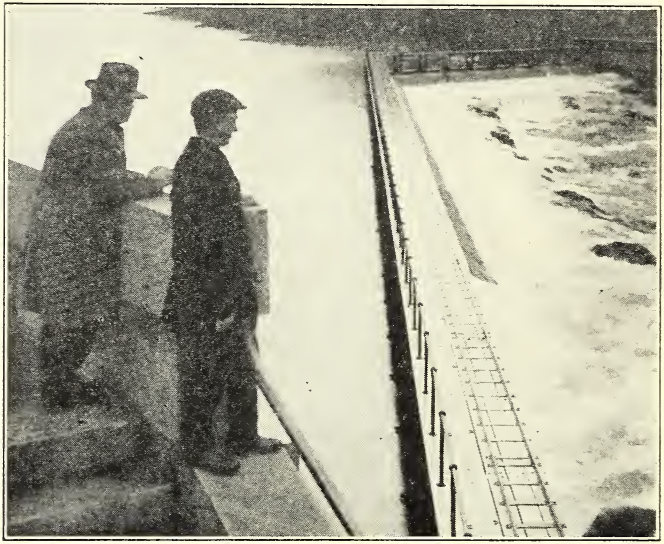
Safe and Unsafe Wells

Which of these wells is unsafe? Why?

143. Community Health. — The health of a community is very closely dependent upon the abundance and safety of its water supply. Lack of water or use of water containing disease germs may threaten the lives of great numbers of the community inhabitants. Therefore, it is the foremost duty of a community to provide an adequate supply of safe water.

Highly trained engineers, scientists, and health officers are required to develop plans, direct construction of dams, conduits, reservoirs, and install and operate purifying equipment to guarantee a satisfactory supply. Before proceeding to the next section, review the problems of providing an adequate and healthful water supply to a community (Section 132).

144. Sanitary Control of the Sources. — Let us study a typical city to see how it safeguards its water supply, how it brings the water from the source to the reservoir, and how it purifies the supply. This city secures most of its water supply from two lakes (natural reservoirs), one 395 feet in altitude above the city, and the other 586 feet in altitude above the city. The two lakes



SAFEGUARDING THE WATER SUPPLY

A constant guard is maintained at this water supply reservoir to check the purity of the water and the amount that goes over the spillway.

together have a surface area of about 2800 acres and a drainage area, supplying the water, of about 45,000 acres of land, much of which is forested.

What is the relation between forests and water supply?

Most of the land bordering the lakes is owned by the city and it is possible, therefore, to restrict people from living on the shores. Hence contamination by sewage is largely prevented. The lake shores are patrolled and kept clean, free from decaying fish, garbage, and campers' refuse.

Not only is the near-by land protected, but the entire drainage area is inspected by health officers, and every effort is made to prevent sewage from outhouses and barns from reaching the streams that flow into the lakes. Cases of contagious diseases, such as typhoid fever, are cared for in such a manner as to prevent the germs from getting into the water supply.

The same care should be exercised with respect to the drainage into springs and wells used as private sources of water supply. All cities and other thickly populated areas should see to it that similar protection is given their water sources. Science and the engineer leave room for no failure in such matters.

145. Bringing the Water to the Reservoirs. — Since the lakes are above our typical city, the flow of water takes place by gravity through large conduits. Referring again to the diagram on page 262, you can trace the course of the water. An intermediate reservoir provides a place where the fine sediment can settle. From this reservoir the water flows by gravity to the distribution reservoirs placed on hills near the city.

The water, after traveling long distances through closed conduits, loses much of its dissolved oxygen, and so it is sprayed into the air as it comes into the distribution reservoir. This process is called *aëration.* It causes the water to dissolve the oxygen of the air, which improves the taste of the water, helps to oxidize organic matter, and, to some extent, kills certain kinds of germs that may be in the water.

146. The Purification of Water. — The purification of water on a large scale consists of:

(1) Getting rid of the insoluble material.
(2) Killing any disease germs that may be present.
(3) Aërating the water.

The insoluble material is removed partly by settling. The water is passed slowly through large tanks. This gives time for most of the sediment to settle. From the settling tanks the water is passed through filters to remove the last traces of sediment.

Bacteria in water may be killed by dissolving a very minute amount of liquid chlorine in the water (0.1 to 0.5 parts chlorine to 1,000,000 parts water). The chlorine and the water form an oxidizing substance which acts as a powerful disinfectant. The chlorine treatment may be given both before the water has been allowed to stand for settling and after filtering, or only after filtering, depending upon the quality of the water in the beginning. Occasionally water is *chlorinated* just before it goes into the distributing conduits. Other methods of killing germs in large quantities of water are by the use of a gas called *ozone*, and by treating the water with *rays of ultra-violet light*. These latter methods, however, are not so easily controlled as is the chlorine method. They are also more expensive and, consequently, less frequently used.

147. Chemically Pure Water. — We have learned that by "chemically pure" water the scientist means water which contains no dissolved gases or solids and no suspended material. It is very difficult to obtain absolutely chemically pure water, but water sufficiently pure for most chemical purposes may be obtained by simple *distillation*.

The separation of two or more substances by the process of distillation depends upon two factors:

(1) The mixture must contain a liquid which may be changed to a gas, that is, it may be boiled at a convenient temperature and changed back to the liquid state again by cooling.

(2) The material (or materials) dissolved in the liquid must not be *volatile* (readily changed to a gas), or (if it is another liquid) it must have a much higher boiling point than the first.

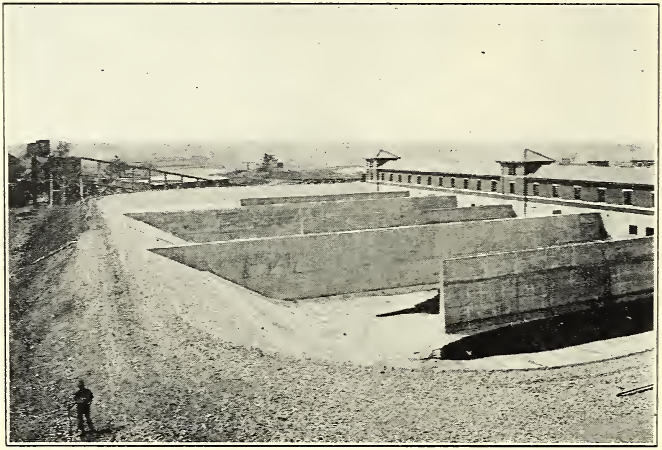
Ewing Galloway

TESTING DRINKING WATER

Some of a city's tax money is spent for expert chemists to guard the water system from pollution.

When a sample of water containing substances in solution is boiled, the water portion changes to a gas (steam) and escapes, and the solid materials of the solution remain as a residue, since they will not change readily to the gaseous state. The gaseous water given off is condensed to a liquid again by passing it through a pipe surrounded by cold water.

Any two liquids may be separated by distillation, provided the boiling point of one is considerably lower than the boiling point of the other. For example, alcohol has a boiling point of 172.4° F. and water a boiling point of 212° F. Therefore, it is possible to separate these two liquids by keeping the temperature



Settling Basins

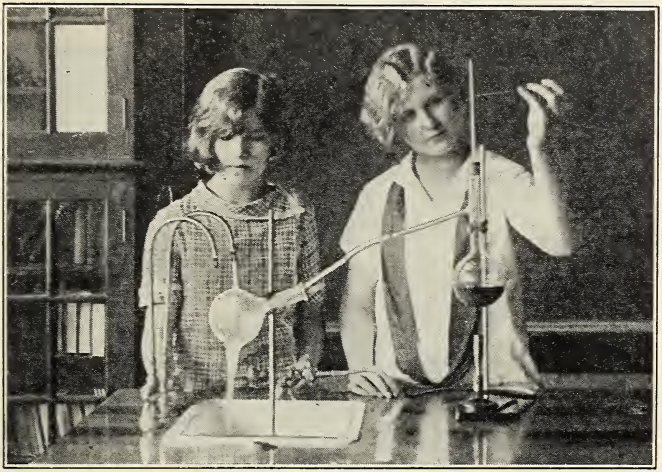
Why do you think the water has been removed?

of the mixture only slightly above 172.4° F. At this temperature the alcohol will change to a gas and escape to the condensing tube, leaving most of the water as a residue. However, a very small amount of water will also be driven off with the alcohol since water evaporates to some extent at all temperatures.

Experimental Problem 29. — *How can pure water be obtained from a salt solution?*

What to use: A distilling flask (250 cc.); a condenser flask; a beaker; and salt water.

What to do: Set up the apparatus as in the picture. Start the cold water running outside the condensing *flask.* Heat the solution slowly to boiling and keep it boiling quietly. Test the *distillate* for color, odor, and taste.



EXPERIMENT 29

Why are the girls allowing the water from the faucet to run over the flask at the left?

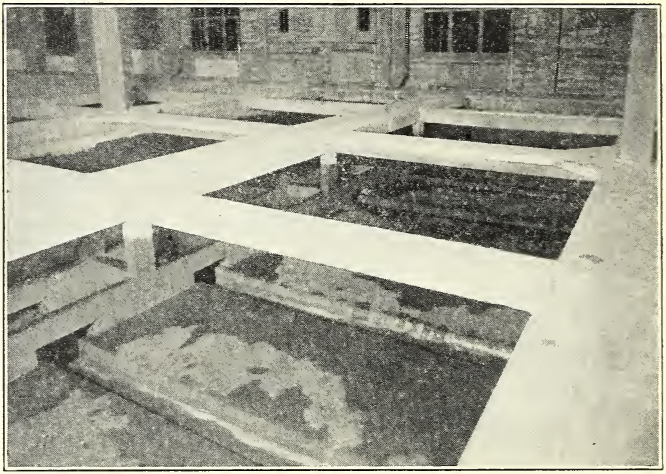
What happens: 1. Did steam form and pass out of the distilling flask? 2. Could you see the steam change back to liquid in the condensing tube? 3. How fast did the distilled water drop from the condenser? 4. Describe the distilled water. What was left in the flask?

Conclusion: Explain how you prepared the pure water.

Application: How does the making of maple sugar depend upon distillation?

Commercial water *stills* (devices for distilling) are made of metal. Means are provided to operate the still continuously and to care for the distilled water automatically so that large quantities may be produced with the least possible amount of attention.

148. Applications of Distillation. — The process of distillation has many important applications. *Gasoline* used in automobile engines is a liquid obtained from *crude petroleum* by distillation. At different distilling temperatures different liquids are driven off from the



FILTERS

The filters are being cleaned by forcing water up through them. The process is called "back washing." Do you see evidence of dirt being washed out?

petroleum, such as *kerosene* and various grades of *lubricating oils*.

Soft coal is put into iron *retorts* (stills) and heated. This causes gases to be given off that are not condensed by cooling and that are combustible. These gases are *coal gas*, used in illuminating gas, and *ammonia*. The latter can be separated by passing the gaseous mixture through and over water. The coal gas is insoluble in water and passes on, while the soluble ammonia is dissolved. The residue in the retort is called *coke*. This kind of distillation is called *destructive distillation*. *Wood alcohol* is obtained by destructive distillation of wood.

Key Words

aëration	filter	retort
chlorine	gravity	sanitary
condenser	insoluble	sediment
conduits	lateral	sewage
contamination	oxidize	source
destructive	plumbing	spring
distillation	pollute	water supply
downward pressure	purify	water table
drainage area	reservoir	well
faucet		

Key Statements

1. Well waters and spring waters contain minerals in solution.
2. Wells and springs are fed from ground water.
3. Water for a community should be abundant, safeguarded at the source, and purified before distribution.
4. Water may be safe for drinking and yet not be chemically pure.
5. Water may be crystal clear and cold and yet be unsafe to drink.
6. Lakes and rivers are common sources of water for community uses.
7. Water may be brought by gravity to a community from sources higher than the community. From sources lower than the community, water must be pumped into storage tanks or reservoirs for distribution.
8. Water exerts a downward (gravity) pressure due to its weight.
9. Water pressure increases with its depth.
10. At any point in water, pressure is exerted equally in all directions, down, up, sideways.

11. Water flows downhill, or seeks its level because of gravity.

12. In small systems, compressed air in a tank in the basement can be used to force water through the pipes of a house.

13. Plumbing consists of devices for distributing and controlling water in the house and disposing of wastes.

14. A community must employ trained people to plan, construct, provide, and test an adequate water supply.

15. The water sources of a community must be protected against contamination.

16. The purification of water for drinking purposes includes separation of insoluble sediment and killing of disease germs.

17. Chemically pure water may be prepared by distillation.

Thought Questions

1. What care should be taken in locating a well on a farm?

2. Why are wells a possible source of danger in villages that do not have a sewage system.

3. Why are dams constructed with thicker walls at the bottom than near the top?

4. Why will not faucet filters take germs from water if germs are present?

5. Why should drinking water of unknown source be boiled?

6. Why do some wells "dry up" during dry spells when others do not?

7. Why does cistern water not contain minerals in solution?

8. What are the desirable characteristics of a water-supply source for a large city?

9. What advantages has a gravity system over a pumping system of water supply?

10. What evidences can you give from observations of Nature that water exerts a gravity pressure?

11. Why is a galvanized water pipe preferable to a plain iron pipe?

12. What happens when water is mixed with air?

13. How may large quantities of water be treated to kill any disease germs?

14. Why must substances have different boiling points if they are to be separated by distillation?

Projects for Your Science Discovery Book

1. Investigate your home to discover how it is supplied with water and how the wastes are carried off. How many sizes of pipes are used? Are the pipes galvanized (coated inside and out with zinc) or are they black iron, or brass? Are the hot-water pipes of the same material as the cold-water pipes? Report your answers with explanations.

2. Make a diagram of the water pipes of your home.

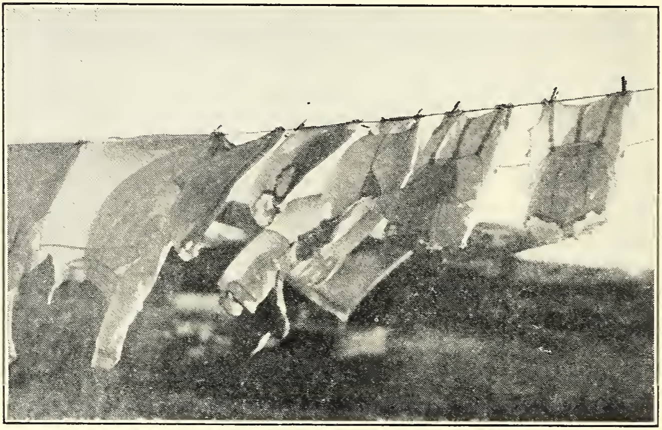
3. Visit your community water supply and make a diagram which explains it clearly.

4. What special care is taken to safeguard your water supply?

5. Find out what water pressure is required for fire protection in your community.

6. Write an account of some famous water-supply system. Get your information at first hand, if possible.

SURVEY OF TOPIC XII



We need water for cleanliness, and water for real cleanliness needs a helper. That helper is soap.

To-day there are many varieties of soap on the market, offered for as many purposes — from the laundry soap for the finest of laces to the perfumed toilet soap for the most delicate of complexions. There is soap for salt-water bathing; soap for hard water; soap for the baby's soft skin. There are tiny guest-sized cakes; medium-sized cakes; big, round bath cakes, and soap in chips and powder. These many soaps come in all the colors of the rainbow, and in fragrant odors from the spicy pine of northern forests to the heavily scented jasmine of southern gardens. There are even soap balls and dolls and animals for the littlest brother's or sister's very own.

Makers of toilet goods are doing everything they can to lure us into "the habit of cleanliness" by offering for our use the most attractive soaps, powders, and tooth-pastes that science can produce. Personal hygiene has always been a duty; but now it has become an extremely pleasant duty.

TOPIC XII

USES OF WATER IN THE HOME

I will open rivers in high places
And fountains in the midst of the valleys:
I will make the wilderness a pool of water,
And the dry land springs of water.

— ISAIAH

Do you know:

1. **What makes water hard?**
2. **How to soften hard water?**
3. **Why rain water is soft water?**
4. **How soap works?**
5. **How to have good teeth?**
6. **How water helps to keep the home sanitary?**

GENERAL PROBLEM 1. HOW DOES WATER ACT AS A CLEANSING AGENT?

149. Hard and Soft Water. — One of the important uses of water in the home is as a cleansing agent. Certain characteristics of the local supply have a definite bearing on its usefulness for cleansing purposes. The terms "hard water" and "soft water" indicate that some water contains lime materials in solution while other water is not so affected. Perhaps the terms came originally from the fact that it is hard (difficult) to make a good soap suds with hard water, and easy to make the suds with soft water. Or perhaps the feeling of the two kinds had something to do with their naming.

The minerals that cause hardness are *calcium bicarbonate* and *magnesium bicarbonate, calcium sulfate,* and *magnesium sulfate.* Wells, springs, and lakes are fed with water that has passed through soil and rock layers. In its course, this water dissolves minerals of various kinds. If the rocks and soil contain lime materials, the water will dissolve some of them and become hard.

In your earlier study of science you have learned that the air contains *carbon dioxide.* This carbon dioxide gas of the air is slightly soluble in water and forms *carbonic acid* with the water. (Carbon dioxide plus water gives carbonic acid.)

Field Research:

Your breath contains carbon dioxide. Using a soda-water straw, blow your breath through water containing a piece of blue litmus paper. After a few minutes, does the paper turn pink? If so, it shows that you have formed an acid in the water.

Water containing small amounts of carbonic acid dissolves limestone slowly, forming calcium bicarbonate, which causes the water to become hard.

Rain water is soft water, for it has had no opportunity to dissolve minerals. If rain water soaks into the ground and comes to the surface as spring water at some remote point, it may pass through limestone and become hard water. If, however, it travels through rock and soil that do not contain the lime materials, it will remain soft.

Distilled water is soft water. Does this help to explain why rain water is soft water? (Recall the facts about the water cycle.)

150. Temporary and Permanent Hardness. — Water when it is boiled sometimes forms a deposit in the teakettle. The deposit is due to heating the *calcium bicarbonate* present in the water in the form of a solution. Like baking soda, which is sodium bicarbonate, it decomposes when heated and gives off carbon dioxide gas, and leaves *calcium carbonate*, which is insoluble in water. In the heating process the bicarbonate is decomposed and separated from solution by boiling. Therefore, if a water is hard because it contains bicarbonate of calcium (or of magnesium), it can be softened by boiling. This sort of hardness is called *temporary* hardness. Calcium bicarbonate (soluble) plus heat forms calcium carbonate (insoluble).

Hardness due to other lime (and magnesium) compounds, calcium sulfate and magnesium sulfate, is not affected by boiling and is called *permanent* hardness.

Would teakettles used in some localities get more deposit than in other places? Why?

Field Research:

Perhaps you know an engineer who will tell you some facts about "boiler scale" and how it hinders the heating of water in the boiler. It will make a good story to bring back to your class.

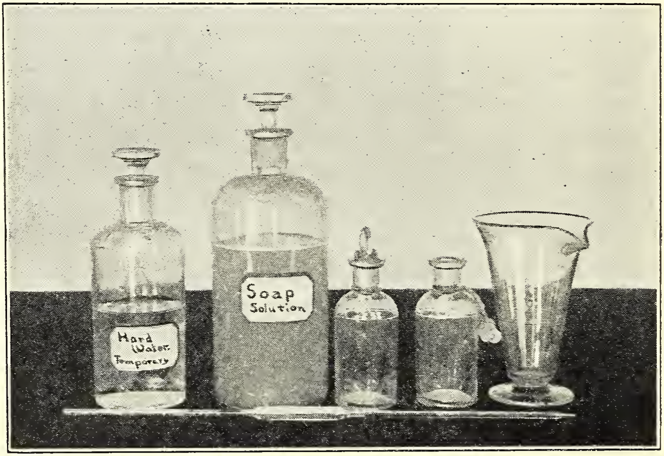
Experimental Problem 30. — *Can temporary hard water be softened by boiling?*

What to use: Water with calcium bicarbonate in solution (made by passing CO_2 through limewater until the precipitate that forms redissolves, and then diluting the solution ten times its volume with distilled water. Save a portion for Experiment 31); a dilute soap solution; two 8-oz. bottles with glass stoppers; and a dropping tube.

What to do: Boil a portion of the hard water for several minutes and then cool it to room temperature.

Put equal volumes of boiled and unboiled water into the two bottles, labeled 1 and 2 respectively.

Now add the soap solution, drop by drop, counting each drop, to the water that has not been boiled (2) shaking the water between drops. Keep adding soap until a fine permanent suds results (a suds that will last for one minute).



Experiment 30

Why do you think the dropping tube has an enlarged section ?

Repeat the soap test, using the boiled water (1).

What happens: 1. How many drops of soap did you use for the unboiled water? 2. The boiled water? 3. Which was the softer water?

Conclusion: 1. Did boiling the water soften it? 2. How?

Application: Why does some water leave more of a deposit in automobile radiators than water from other sources?

Your experiment has proved that the temporary hard water can be softened by boiling. Boiling does not, however, soften permanent hardness. In most cases of hard water the permanent hardness is much greater than the temporary hardness. A method has been found of softening permanent hard water with washing soda.

(Key) ***Experimental Problem 31: Can hard water be softened by the use of washing soda?***

What to use: A sample of temporary hard water (saved from Experiment 30); a sample of permanent hard water (made by shaking some distilled water or rain water with a small amount of calcium sulfate); a dilute soap solution as used in

(KEY) EXPERIMENT 31

Why must equal volumes of each sample of water be used?

Experiment 30; four 8-oz. bottles with glass stoppers; and a dilute solution of washing soda (one teaspoonful to one pint of water).

What to do: A. Label the bottles 1, 2, 3, and 4. In 1, place one ounce of the temporary hard water; in 2, one ounce of the temporary hard water and one half teaspoonful of the washing soda solution, and shake.

Using the soap solution as in Experiment 30, find the number of drops required to make a permanent suds in 1 and in 2. Record your data.

B. Repeat as above, using permanently hard water in 3 and permanently hard water plus one half teaspoonful of the washing soda solution in 4. Record the number of drops of soap solution used in 3 and in 4.

What happened: How many drops of soap solution did you use in 1? in 2? in 3? in 4?

Conclusion: 1. Can temporary hard water be softened by the use of washing soda? 2. Can permanent hard water be softened by the use of washing soda?

Note: You may repeat the experiment using borax solution, trisodium phosphate, or any commercial water softener instead of the washing soda.

Application: Do you think the use of water-softening substances would save soap? Why?

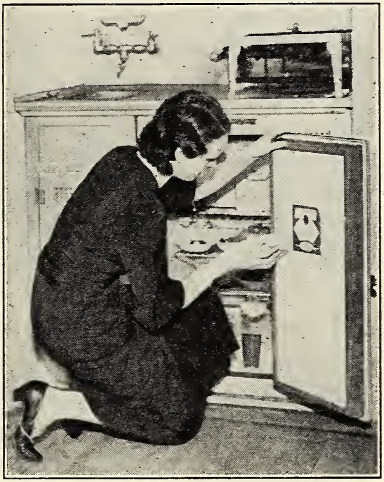
In laundries and heating plants where soft water is an advantage, special water-softening equipment is used that works continuously as the water passes through the equipment. Arrange a trip to such a place to find out how the softening is accomplished, what substances are used, and the advantage of softening the water.

The use of soap with the water is a very necessary aid in cleansing of fabrics, woodwork, dishes, the skin, the hair, or the teeth. We have learned that the hardness of the water affects the amount of soap needed. Now we should investigate soap to find out what it is, how it is made, and how it works.

General Problem 2. How Does Soap Aid Cleansing?

151. Varieties of Soap. — There are many varieties of soap, some of which, according to advertisements, will do very special things. As a matter of fact, soap has just one common use, namely, it helps to clean. All essential differences in soaps depend upon whether they are made from vegetable or animal oils and fats, whether they are made from potash or from soda ash, whether they float or sink in water, and whether they occur as a hard cake, a soft jelly, or as a water solution, called "liquid soap."

152. Soap Substitutes. — Some soap substitutes are well suited to special purposes. There is no substitute, however, which will economically and satisfactorily take the place of a good, pure soap. There are a large number of soap powders or cleansing powders which contain small amounts of soap with varying amounts of *washing soda* or other water softeners. In some cases, scouring material is added.



Spick and Span

What soaps are best for this kind of cleaning?

Scouring powders have an important use, provided the scouring material is not hard enough to scratch the surfaces that are scoured. Once the polished surface of a utensil becomes covered with fine scratches, the difficulty of keeping it clean is increased. Therefore, care should be taken when using scouring powders to use one which will not in any way scratch the surface of the object being cleaned. Some soap substitutes contain no soap whatever. They are substances (washing soda and sodium triphosphate) which help loosen dirt or which soften the water, and so make less soap required.

A cake of soap, although it appears to be dry, contains a certain amount of water. A cake of soap that you buy may be from 15 per cent to 50 per cent water.

Field Research:

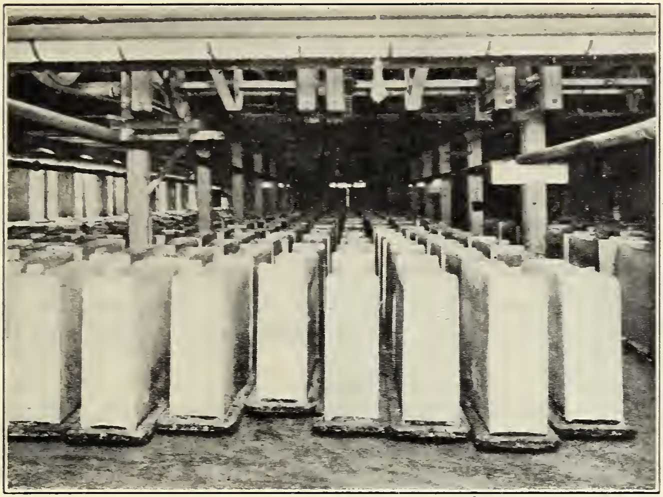
Cut a few thin slices of soap from the center of a cake. Weigh them and dry in an oven at 220° F. for one hour. Weigh the residue. Calculate the percentage of loss of weight as water. You can compare one soap with another by this method.

Soaps are sometimes "loaded" with cheap substances that make the cake larger and heavier. Such substances are called *fillers* and may or may not have a value. For example, a soap for use with hard water may have some washing soda (sodium carbonate) added to help soften the water. It is probably cheaper to buy washing soda and pure soap separately and then add the washing soda to the water as needed.

Rosin is sometimes added to soap and is generally indicated by its yellow color. Rosin is a filler that has doubtful use in a soap. It may help in the formation of a suds or lather. Water glass is sometimes added to soap. It is a filler that has no use and serves only to adulterate the soap.

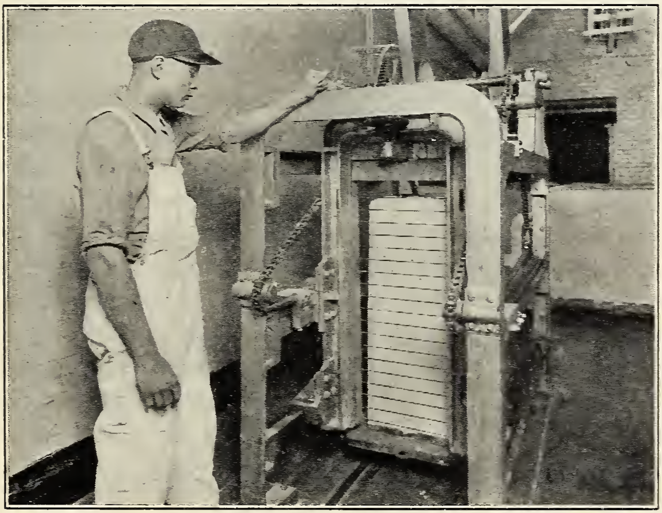
Some soaps are called *medicated soaps* to indicate that they have some curative materials (drugs) in them. It is better to use drugs only on the advice of a physician whether for use on the skin or in the body. Do not use medicated soaps unless advised to do so by a physician. They are expensive and probably of no more use than a good quality of toilet soap.

Soaps are made by the action of an alkali on a fat or oil. Before investigating the manufacture of soap we shall study briefly the raw materials used in its manufacture.



Courtesy Procter & Gamble

SLABS OF SOAP READY FOR SLICING



Courtesy Procter & Gamble

A SOAP SLICING MACHINE

153. Fats and Oils. — Oils and melted fats make a grease spot on paper or cloth. Therefore, a piece of white paper will serve as a ready test for fats and oils.

Field Research:

Test small samples of fats and oils as follows: Drop or rub a little oil or fat (warmed, if necessary) on a piece of white paper. Hold the paper to the light. A "grease spot" will appear lighter than the paper. If held so that light is reflected from the paper the spot will appear darker than the paper. This is because the greased or oiled paper is more transparent to light than the paper itself.

Animal fats are usually solid substances at ordinary temperatures, but are easily melted, and if heated to boiling, the fumes may catch fire. Butter fat has such a low melting temperature that it is melted by body heat and this makes it especially valuable as a food. The fats (called oils) obtained from seeds or other parts of plants are usually liquid at ordinary temperatures though they may be made solid by cooling.

Fats and oils sometimes become *rancid* (spoiled) when allowed to stand for a while where it is warm. The rancid odor is due to fatty acids that are formed. Cream, butter, lard, and suet are *animal* fats. Olive oil, peanut oil, cottonseed oil, and linseed oil are examples of *vegetable* fats. Both animal and vegetable fats or oils are used in making soaps. Linseed oil has a property that none of the other oils mentioned possesses. It will dry hard, due to oxidation, when exposed to air, and for that reason it is used in paints. Linseed oil is also used for making what is called linseed-oil soap, recommended for cleaning woodwork.

154. Alkalies. — The chemist classifies many substances as *acid*, *alkaline*, or *neutral* substances. *Acids* have a sour taste. They turn an organic coloring substance, called *litmus*, pink. (Litmus is commonly used as litmus paper, made by soaking strips of paper in a solution of litmus.)

An *alkaline* substance, in solution, has a bitter taste. When rubbed upon the fingers, it has a slippery feeling. It changes the color of litmus from pink to blue, and this fact constitutes a test for alkaline substances. Many alkaline substances are known to the chemist. We are interested just now only in those that are commonly used in the manufacture of soap, such as *potassium carbonate* and *sodium hydroxide*. Household ammonia is also an alkaline substance used in the home for cleaning, but it is not used in making soap.

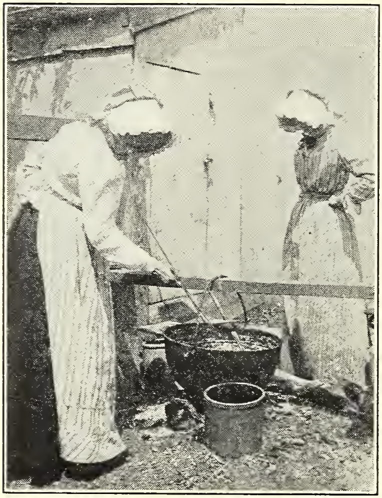
Courtesy Procter & Gamble

MAKING THE ALKALI

Why not use a water-tight barrel?

Neutral substances, such as *salt*, *water*, *glycerine*, and *sugar*, do not change the color of litmus.

155. Soap-Making on the Farm. — Years ago on the farm our great-grandmothers saved little bits of fat and grease from the table, all winter long. The hardwood ashes from the stove were saved and placed in a barrel with layers of straw and lime. In the spring, water was poured on the wood ashes to dissolve out the potassium hydroxide formed from them. The fat was dumped into a large iron kettle and a small fire built underneath. The fat melted and separated from the bone and other materials connected with it. The latter were taken out and thrown away. To the clear, hot fat which remained was added the alkaline solution of potassium hydroxide. The fire was increased and kept under the kettle of fat and alkali for many hours, or until soap formed. The mixture was stirred with a pole of green wood or an iron rod. After a time all the oily, fatty substance disappeared. Also, if the mixture was a good one, practically all evidence of the alkali, such as taste and sting, was lost. The fat and alkali had united and formed soap and a substance called glycerine.



Courtesy Procter & Gamble

MAKING SOAP

Why is the mixture being stirred?

The soap and glycerine were then poured into a barrel where they remained as a soft, dark brown, jelly-like substance. This kind of soap is called *soft soap* because it does not harden into cakes. The alkali from the hardwood ash is mostly potassium carbonate (K_2CO_3). Chemical action with lime mixed with the ashes converts it into *potassium hydroxide*. Soap made from potassium alkali does not harden.

156. Modern Soaps. — The soaps used in our laundries to-day and used for our hands and faces are more pure and are much better soaps than that made on the farm. There is practically no free (extra) alkali in a good soap, to injure the skin, and no free (extra) fat which would make the soap feel greasy. The alkali, sodium hydroxide, is used to make a soap that will harden into a cake.

Courtesy Procter & Gamble

TESTING SOAP ON THE FARM

Notice the crude devices used in the process.

Experimental Problem 32. — *How can soap be made?*

What to use: Lard; a 40% alkali solution (sodium hydroxide); a porcelain evaporating dish; a glass rod; a tablespoon; a teaspoon; an iron tripod; wire gauze; a beaker; and a Bunsen burner.

What to do: Set up the apparatus as in the picture (next page). Put two level tablespoonfuls of lard into the evaporating dish.

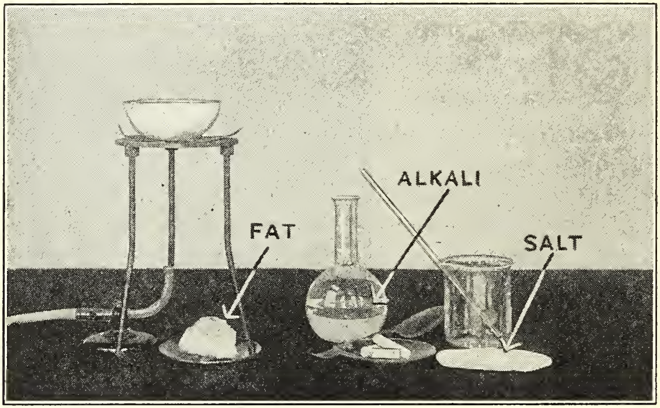
Heat the lard gently until it melts and, while heating, add slowly one teaspoonful of the alkali solution, stirring constantly.

Heat gently, stirring constantly, until there is no evidence of oily particles and until a soap mass forms. Then add 3 ounces of water while heating and stirring.

Pour the solution into the beaker and add one teaspoonful of salt solution (equal parts salt and water), heating gently and stirring.

Set the beaker and contents aside until the next day. Then take off the "cake" formed at the top. Examine the liquid left in the beaker. Test the soap to find if it will form a lather.

What happens: Tell what happens at each operation. 1. What effect did the salt have? 2. Did a solid cake of soap form in the



EXPERIMENT 32

What is the purpose of each substance?

beaker? 3. Did it form a good lather? 4. Was there evidence, in using the soap, of excess fat or excess alkali? 5. If so, what was the trouble with your process?

Note: The liquid left in the beaker consisted of water, excess alkali, salt, and glycerine.

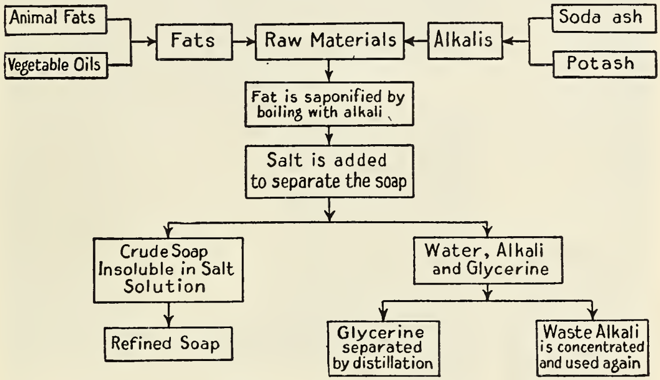
Conclusion: State briefly a method of making soap. 1. Do you think that other fats or oils could be used instead of lard? 2. Try it.

Application: Place a little oil in some water. Add a small amount of washing soda and shake. If suds appear, explain.

The manufacture of modern soap is a very complicated process. Several kinds of fats and oils are available, each having slightly different properties and requiring, therefore, somewhat different treatments.

Boiled laundry soaps and boiled toilet soaps are made by placing the melted fat or oil in a huge kettle.

The proper amount of the alkali solution is added and mixed with the melted fat or oil. Steam is then passed into the mixture. This heats the mixture and at the same time keeps it thoroughly mixed. The fat and the alkali gradually unite chemically to form soap and glycerine. Salt is now added, which causes the soap to separate from the liquids which contain glycerine,



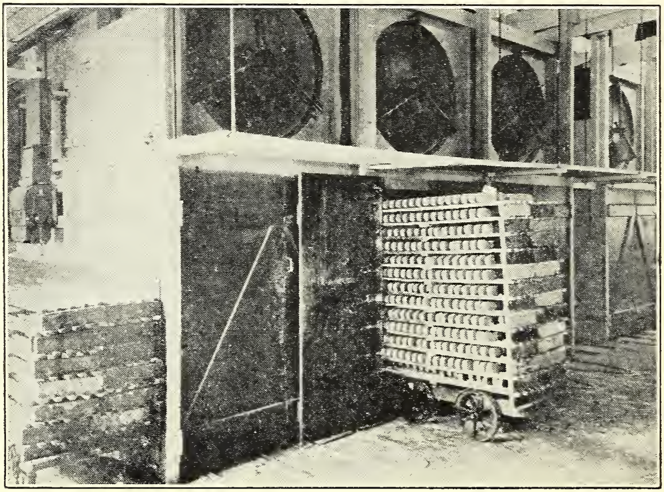
THE MANUFACTURE OF SOAP

Describe each step of the process.

excess alkali, and salt. The soap comes to the top of the liquid. The liquid is removed and pure glycerine is obtained from it by distillation.

The crude soap is treated with a more concentrated solution of the alkali. Water is added, and the mixture boiled until it is fine-grained in appearance. The mixture is "salted" and allowed to stand for several days. The soap rises to the top and the liquor is drawn off, leaving the soap.

The next step in the process consists of adding perfume, borax, washing soda, or filler to the melted soap as required. The soap is then run into boxes and allowed to harden. After it has hardened sufficiently, the soap is cut into small cakes or bars, which are then pressed into special shapes with trade names stamped on. After drying they are wrapped and boxed, ready for the consumer.



Courtesy Procter & Gamble

FROM BIG CAKES TO LITTLE CAKES

Drying small cakes of soap for stamping with trade names.

157. Special Soaps. — Liquid soaps, floating soaps, mottled soaps, transparent soaps, and laundry soaps differ from one another principally in the final finishing processes. Liquid soaps are usually mixtures of potash and soda soaps dissolved in water and containing small amounts of glycerine. Liquid soaps used for toilet purposes are frequently made chiefly from coconut oil. Floating soaps are prepared by stirring in such a manner as to leave the soap full of very minute air bubbles which serve to float the soap in the water.

Mottled soaps are made by adding substances which color the soap. Transparent soaps are made by dissolving hard soap in alcohol and then, after separating any foreign material, the alcohol is distilled off, leaving a transparent, jelly-like mass which is allowed to dry out in molds of the desired shape. Soaps for shaving,

Courtesy Procter & Gamble

AN IMPORTANT LAUNDRY AID

These long ribbons of soap will become soap flakes.

shampooing, use on the skin, and in tooth powders are made with special care to avoid soapy odors, excess alkali or oil, and taste. They must lather freely.

158. A By-Product in the Manufacture of Soap. — An important by-product in the manufacture of soap is the *glycerine.* It is recovered from the waste liquor by distillation. The dilute glycerine thus obtained is concentrated and sold as dynamite glycerine. Dynamite glycerine may be still further purified for medical and other purposes.

159. Making an Emulsion. — That oil and water do not "mix" is true unless science is called to their aid. You know that if you shake a little olive oil (or kerosene) with water and let it stand, the oil will separate and rise to the top. However, when the oil is broken into very small particles by mixing with substances such as soap and eggs, water can be added and mixed thoroughly to form an *emulsion*, that is, a mixture of oil and water that will stay mixed for quite a while.

Field Research:

Try the following experiment to make oil and water stay mixed. To a test tube two thirds full of water add a few drops of oil. Shake thoroughly, and allow to stand for a few minutes. Does the oil become finely divided? Do the tiny drops gradually reunite into larger drops and rise to the top?

Now add a few drops of liquid soap and shake vigorously. Is the oil again divided? Do the drops reunite as before or do they appear to remain mixed throughout the water? If not, add more soap and repeat.

If you have succeeded in making the oil and water stay mixed for a time, you have made an emulsion. The soap sticks to the tiny oil drops and so prevents their uniting to form drops large enough to separate.

Milk is a natural emulsion. You know, however, that after a while the cream (fat) of the milk will rise to the top. So, also, artificial emulsions may separate after a time.

Field Research:

Take a small bottle of milk to school and examine a drop of it with a microscope. Try to see the tiny drops of fat.

160. Blowing Bubbles. — To blow big soap bubbles, a good soap solution is necessary. You know you cannot blow big bubbles with water alone, but when the soap is added, the film appears to be stronger and more elastic, like a thin sheet of rubber.

Field Research:

Try to find out what soap does to water to make bubbles form by making a soap solution and blowing bubbles with it.

Bend a wire into a circle two inches in diameter. Tie a thread from one side of the ring to the other so that it will hang loose. Now " suds " the ring in your soap solution until you get a film to fill the ring. Is the thread held by the film? Does it extend in any special fashion across the ring? Now break the film on one side of the thread with a small piece of wood or other needle-like object. What happens to the thread? Does it look as if the film that was left contracted and pulled the string? Try it again.

If you have studied capillary action, you know that liquids rise into fine tubes such as those found in blotters, in soil, and in wicking. Do you think that water with soap in it would rise up (soak) into a wick or piece of cloth better than plain water?

Field Research:

Secure two clean glass tubes with small bores. Stand one in plain water and the other in water with a little soap in it. Does the water rise higher with soap in it or without the soap?

Soap added to water aids its ability to penetrate small spaces and so increases its capillary action. This effect enables water to soak into fabrics faster and farther than it could otherwise. The solution can also creep along the cloth surfaces better than plain water can, and surrounds dirt particles, enabling the water to carry off the loosened dirt particles in the film which the water forms with the soap. The soap and water combination is an ideal team for cleansing purposes.

161. Soap as a Cleansing Agent. — By "dirt," as referred to on our clothes and bodies and on our woodwork, is meant the daily accumulation of dust, dry skin cells, and like particles. It is the function of soap to remove such dirt. You have discovered that soap will *emulsify* fats and oil so that they will mix with water. You have also discovered that soap and water will soak into fabrics readily. It is these two properties on which the cleansing action of soap depends.

Experimental Problem 33. — *How does soap remove dirt?*

What to use: Test tubes; oil or grease; lampblack (finely powdered charcoal); liquid soap; and a white cloth.

What to do: A. Smear the inside of a dry test tube with oil. First try to rinse the oil out with water. Then try shaking soapy water in the tube and rinsing. Observe the appearance of the oil and soap after you have shaken the tube and contents.

B. Rub a little lampblack into the white cloth. Try to wash it out with plain water and then with water and soap, using a good lather. Examine the lather to find if it has taken up the carbon.

C. For two pupils: Let one wash his hands with plain warm water. Dry with a paper towel. Look for dirt on the towel.

Let the second pupil wash his hands with warm water and soap. Make a good lather and work it on the skin thoroughly. Now rinse the hands thoroughly with warm water. Dry with a paper towel. Compare the respective amounts of dirt on the two towels.

Let a third pupil use cold water and soap, and cold water for rinsing.

What happens: A. 1. By which method was the oil removed from the tube? 2. What did the soap do to the oil?

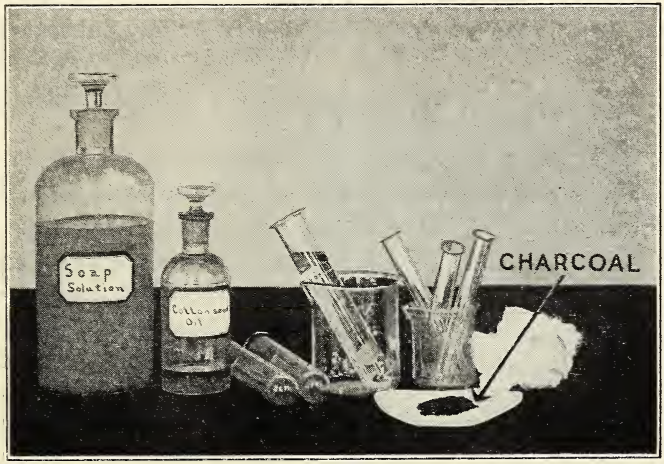
B. 1. By which method was the charcoal better removed? 2. How did the soap help?

C. If the washing and rinsing removed the dirt satisfactorily, no dirt would be left on the hands to be rubbed off by the paper.

1. Which method removed the dirt from the hands the better?
2. What do you think helped to hold the dirt on the hands?

Conclusion: Explain the actions of soap in removing the dirt in each case.

Application: Explain why mayonnaise (a mixture of oil and lemon juice) stays mixed.



EXPERIMENT 33

What does the charcoal represent?

Hot water is usually better for use with soap to clean greasy materials. In order that the soap can emulsify the grease quickly, the grease or fat must be melted. Hot water will melt the common greases and fats such as occur on the skin, fabrics, or cooking dishes and table china.

Thoroughly emulsifying the fats and oils makes it possible for them to mix with water and be rinsed off. Soapy water soaks into the fabric or thoroughly wets the skin or other surface and loosens the dirt, which may then be rinsed off.

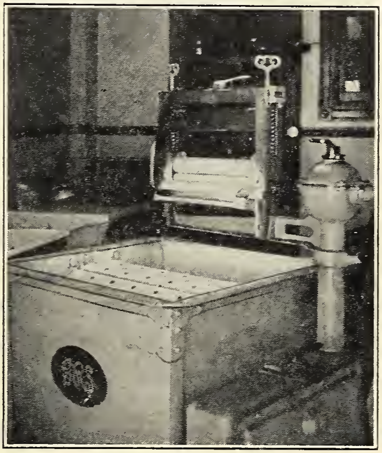
162. Laundering Fabrics. — Proper laundering of fabrics not only keeps them clean and wholesome, but extends their length of use. Good soap, water at the proper temperature, and correct application are the foundation of good cleansing methods. Clothing, especially that worn next to the body, absorbs perspiration and dirt. The skin gives off a fatty or oily substance that lodges in the clothing. Worn-out scales from the skin become entangled in the fabric. Such conditions make frequent laundering necessary.

When washing fabrics, care must be taken not to cause them to shrink or to lose their color. Woolen fabrics shrink very easily. However, being careful not to change the temperature abruptly, and the use of soap free from excess alkali will largely prevent shrinkage.

Washing powders and bleaching agents should be used cautiously, if at all. If the water is hard, you can save soap by adding the correct amount of washing soda or borax. Expensive water softeners in small packages are no better than common washing soda even though they are widely advertised. The water softener should be thoroughly dissolved before soap is added to the water.

White fabrics when washed with soap are slightly discolored after drying, even though they have been thoroughly rinsed. They are then *blued* to make them look white. Yellow and blue colors mixed in the proper proportion make white. Too much blue, of course, leaves a blue appearance. There are many brands of bluing substances on the market. Some are iron compounds and may leave rust spots on the fabric unless great care is taken to use the right amount. It is safer to use bluing compounds that do not contain iron.

163. Machines for Laundry Purposes. — Although soap and water are reliable agents in the laundry, unaided they do not noticeably lighten the work of cleaning. Therefore, labor-saving devices are an important part of home equipment. Their development rests upon one or more scientific discoveries. The discovery by chemists of the action of soap and water in removing dirt is an example. In your study of the use of soap, you proved that the removal of dirt depends upon the fact that the soap emulsifies the grease, and also soaks into the fabric to loosen the dirt. Hard mechanical rubbing is not necessary to this action. Warm water with soap and sufficient agitation to form a suds are all that is needed.



A Washing Machine

The modern washing machine is designed to assist in the formation of an emulsion and to hasten the penetration of the soap and water into the fabric. It does this by various types of motions. It does not rub. Therefore the clothes are made cleaner, with less destruction to the fabric. It is equally important to rinse the clothes thoroughly so the water may carry away the emulsified grease and loosened dirt. This also the modern machine does with a minimum amount of wear and tear on the cloth.

Then, too, the old method of wringing the clothes by hand to get rid of the excess water was laborious and destructive to the fabric. The hand wringer which squeezes the clothes between rubber rollers is an improvement over hand wringing. Even this method is hard on the buttons. Some machines depend for their action upon the same force that throws mud from a rapidly rotating wheel and prevents the earth and other planets from being drawn into the sun, — centrifugal force.

Field Research:

Try this out of doors. Saturate a cloth with water. Roll it into a compact ball. Tie a short, strong string (one foot long) to the ball and whirl it rapidly on the string. What happens to the water in the cloth?

Machines are built that allow the water to drain out. The bowl is then whirled (rotated) very rapidly, causing a strong centrifugal force. The clothes become packed against the sides and the excess water is carried by the centrifugal force out of the clothes, leaving them only slightly damp.

164. Removing Stains. — Stains on clothing and linen are usually due to contact with materials containing fats or oils. They may also be caused by contact with fruit juices, tea, coffee, chocolate, ink, or grass. Water, although it may help to remove spots, often needs assistance to be effective. Stains may be classified as follows:

A. Soluble in water, cold or hot.

B. Insoluble in water.

1. Soluble in denatured alcohol, carbon tetrachloride, or chloroform (non-inflammable liquids). **Caution: Gasoline should never be used in or about the home**

for cleansing gloves, garments, fabrics, or other materials on account of its inflammability.

2. Emulsified by soap solution.

C. Insoluble in above liquids.

1. Stains on cotton and linen goods may be bleached with chlorine compounds and bleaching powder solution such as Javelle water. (See directions for making and use as given on a can of chloride of lime.)
2. Stains on woolen and silk fabrics may be bleached with an alkaline solution of hydrogen peroxide, with sulfur dioxide, or with sodium bisulfite.

Chlorine compounds *must not* be used with silk and wool.

The above classification may well be followed unless the character of the stain is known. Coffee, chocolate, and tea stains can usually be removed by hot water if they are not allowed to dry. Otherwise Javelle water may have to be used. Oil and grease stains may be removed by hot water and soap unless water will spot or shrink the fabric, in which case use carbon tetrachloride. Grass stains are soluble in denatured alcohol; iodine stains in chloroform. Iodine stains on the skin can usually be removed by rubbing with diluted household ammonia.

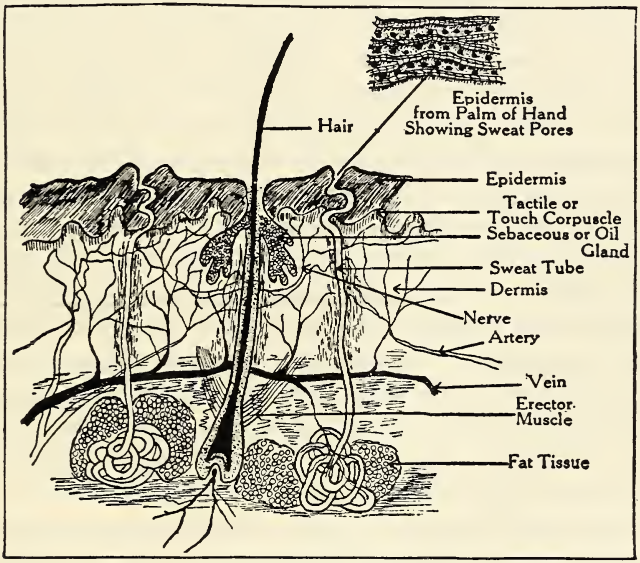
General Problem 3. Why Is Personal Hygiene Important?

165. A Clean Skin. — To understand clearly why the proper use of soap and water on the skin is necessary, we must study the *function* (*duties*) *of the skin.* The skin is composed of two main layers. The *outer layer* consists of flat cells which have no feeling in themselves, and are continually worn off from the surface to be replaced by new cells of the same sort from underneath. The lack of sensitiveness of the outer layer, together with its toughness and elasticity, enables it to serve as a protecting layer of the body.

The *inner layer* of the skin is very much *alive* and very sensitive to touch, to warmth and cold, and to pain. It is also abundantly supplied with nerves, and tiny blood vessels called *capillaries.* This inner layer of skin contains, too, a great number of little coiled tubes or glands called *sweat glands.*

Just as when you have a fire in your furnace, there is a certain amount of ash or waste material that has to be carried out, so it is with your body. You eat food which is the fuel and inhale oxygen to burn it, and there is a considerable amount of waste matter that must be eliminated by the body. Much of this waste matter is eliminated through the skin by the process of *excretion.* Each one of the little sweat glands has a *pore* (opening) through the outer layer of the skin. If the pores become clogged, the sweat glands cannot get rid of the waste matter they contain. If the waste matter is held in the skin, it may cause *pimples, blackheads,* and a skin that is not clear. Also, if this waste matter is not eliminated, it produces a toxic (poisoned) condition in the body that makes one feel dull and have headaches.

A second important function of the skin, together with its nerves and capillaries, is as a thermostat to regulate the temperature of the body. You have learned that when liquids evaporate, they absorb heat and so cool the surface. When water from perspiration evaporates from the skin, it takes heat from the skin. If a person tends to become overheated from violent exercise, the sweat glands, acted on by nerves, open up and pour more sweat out onto the skin. This evaporates and so removes heat from the skin and blood underneath. Thus the body is protected from being overheated. Anything that interferes with these actions may result in overheating of the body, so you have another reason for keeping the pores in condition to do their work.



THE STRUCTURE OF SKIN

Besides desiring a clean skin for the sake of our own good feelings and good health, we have a duty towards those about us. A person whose skin is clear and clean is much more pleasing to us than one with a dirty skin. Moreover, a skin which is allowed to become unclean gives off a decidedly objectionable odor. While this odor may not be noticeable in a well-ventilated room containing few people, in a crowded room there is an accumulation of such odors which becomes very offensive. Consequently, the use of soap and water to keep the skin in a healthy working condition is a duty which we owe not only to ourselves for health's sake, but to others for social reasons.

166. The Use of Face Powders. — A brisk but gentle rubbing or massage of the skin serves to draw to the surface an increased blood supply which is indicated by the glow of the skin. Occasional treatment of this sort will help to maintain the skin in a healthy condition. Many people use powders (and rouge) to add to or suggest an appearance of cleanliness and freshness. Such measures are not good substitutes for soap and water. People who thus carelessly or ignorantly cover up a dingy skin, rather than take time for a thorough cleansing, are risking skin trouble which may in time affect their health. Moreover, the continuous use of face powders to *imitate* this healthy appearance is objectionable since they tend to fill the pores and so prevent the natural cleansing of the skin. They tend also to produce a dryness of the skin which results in a coarseness that is not pleasing.

The use of powders to cover up skin defects is unfortunate not only because they do not cure the skin defect but because, on the contrary, they may increase the skin trouble. Some face powders are objectionable not only for the reasons stated but because they actually contain harmful ingredients which, if the skin is broken, may produce sores.

An occasional use of simple powders, such as *talc*, may be of assistance in preventing the skin from chapping when exposed to severe weather. On the other hand, a healthy skin is not likely to be harmed by frequent exposure to the weather, provided it is kept clean and free from foreign substances.

Skin blemishes such as moles, pigment spots, birth marks, or warts should not be irritated in any way, since various kinds of sores may result which are difficult or impossible to heal. If they are such as seriously to interfere with one's appearance, a physician-specialist should be consulted. Quack skin and beauty doctors and unprescribed skin preparations should be avoided.

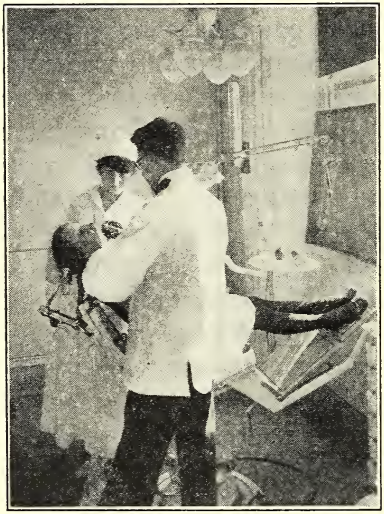
167. Clean Teeth. — There are certain soap preparations, like tooth pastes and powders, which are not often regarded as soap. Many tooth pastes are dental soaps with various substances such as wintergreen or peppermint added for flavor. Often a small amount of very fine pumice is added to act as a grit for scouring.

When you clean your teeth, you are making the teeth, tongue, and mouth more healthy and safeguarding the entry to your stomach; you help to prevent decay of the teeth and make them more sightly; and you keep your breath pure and wholesome. Therefore, cleaning the teeth is of great importance. Once a day is not enough to preserve a good set of teeth, much less to preserve a poor set. They should be cleansed twice a day at the very least, and it is better if they are cleansed after each meal.

If a little particle of food is allowed to remain a few hours in between the teeth where it is warm and moist, it rapidly decays and adds a foul odor to the breath. You can easily prove this by drawing dental floss between the teeth and noticing the odor on the floss. Not only does such matter give a disagreeable odor to the breath but every decayed particle of food serves as a developing place for bacteria which may cause the decay of teeth, or other mouth diseases.

Learn how you can thoroughly cleanse your teeth, and practice the method consistently. You will save yourself many an ache and many a dollar. Use only good brushes and safe tooth pastes or powders. Careful brushing is an essential part of the care of the teeth. Also use dental floss to clean between the teeth. Beware of poor tooth pastes and powders.

168. Visit Your Dentist. — Soap and water will be good friends to your teeth, if you give them a chance. But they, alone, are not enough to assure healthy teeth. So important is it for us to have our teeth examined regularly that the authorities of many schools provide dental assistance in the schools. In some high schools no pupil is allowed to graduate if he has not given proper care to his teeth. Why is this? It is because a person with good teeth is less likely to be sick, and, therefore, of more economic value to the community.



The School Dental Clinic
A little girl patient is protecting her teeth.

Have your teeth inspected and cleaned at least twice every year by your own dentist unless this has been done in your school.

Cavities do occur. They are small at first, easy to fill, and cause little if any discomfort. However, the cavity, if long neglected, grows larger and larger and becomes painful and difficult to care for.

Without good teeth food is not properly masticated. Hence the food which is swallowed cannot be properly digested in the stomach without extra work on its part.

Digestive disorders may cause poor teeth and poor teeth undoubtedly set up digestive disorders and so the trouble piles up. With a good set of teeth you can eat your way to good digestion and health.

169. A Shapely Mouth. — Every person has two separate sets of teeth. The first set to appear is called the *temporary* or *deciduous* set, for they fall out at an early age to make place for the *permanent* set.

An exception is the *first molar* that appears when the child is about six years of age. This molar is permanent. It should be given especial care. Sometimes the temporary teeth are neglected because they are known to be temporary. However, the child's temporary teeth should be given just as good care as the permanent teeth.

The mouth of the young child is smaller than that of an adult and so there are fewer teeth in the deciduous set. When it is time for the permanent teeth to appear, the roots of the first teeth are absorbed and the new teeth push toward the outer part of the gum, causing the temporary teeth to fall out.

Proper food and clean teeth are the first step to healthy teeth and healthy teeth promise a healthy mouth. But the dentist has taught us that there is another factor involved in the care of our teeth, — regard for their placement. It is a wise plan to have a young child's mouth examined by X-rays to determine whether permanent teeth are in their proper location and pointed in the right direction. While the jaw is in the formative stage, it is easily pushed out of shape by one or more of the permanent teeth pushing in where there is too little room. Another cause of misshapen mouths is mouth-breathing due to adenoids or other obstructions to normal breathing.

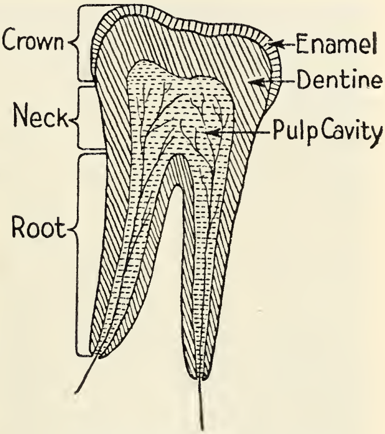
Three X-Rays of Teeth

The first shows new teeth pushing the old ones out; the second illustrates occlusion (the way teeth fit together); and the third shows a filling. Note the root canals in all three.

170. Parts of a Tooth. — A knowledge of the general *structure* of our teeth will also help us in our care of them. A tooth may be considered as divided into three parts — the *crown*, which rises above the gum; the *root*, by which it is held in a bony socket of the jaw; and a narrow portion between the crown and the root called the *neck*.

Over the outer surface of the crown is found a layer of very hard mineral matter called *enamel*. The enamel layer is thickest on the biting end of each tooth and thinnest at the neck. This is replaced by a kind of cement on the outside of the roots which helps to fasten the tooth in place.

Inside the tooth is a substance called *dentine*, which is similar to bone. Inside the dentine is a small cavity filled with nerve tissue and blood vessels, held in position by a mass of connective tissue called *pulp*. The function of the nerve tissue and blood vessels is to supply materials for the repair of all portions of the tooth. These blood vessels and nerves communicate with the other blood vessels and nerves of the body through a small opening at the base of each of the root *prongs*.



THE STRUCTURE OF A TOOTH

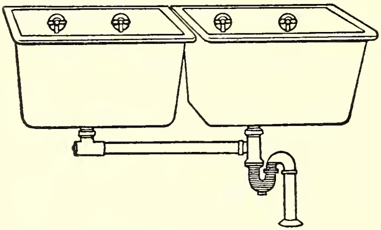
171. Tooth Decay. — Although it may not be strictly true that "a clean tooth never decays," you may be certain that uncared-for teeth decay much more quickly. The decay of a tooth is closely connected with the breaking, cracking, or disappearing of the enamel, and with proper foods. Food particles left between the teeth decay. The bacteria which come to live in such spots cause the enamel at this thin portion to be dissolved, and decay of the dentine results The decaying process often continues inside the tooth for a long time before it is noticeable except when examined by a dentist. Therefore, the importance of frequent excursions to a competent dentist is apparent.

Another possible cause of decay is a receding of the gums. The portion of the tooth not protected by enamel is thus exposed to the action of bacteria. Receding gums are a symptom of a disease which if allowed to continue almost certainly results in premature loss of the teeth. If this condition occurs, a specialist should be visited at once.

While the foregoing causes contribute to tooth decay, it is thought that fundamentally tooth disease and health are directly related to proper diet. Calcium- and phosphorus-containing foods are essential to proper growth and repair of the teeth. Also foods must contain vitamins C and D to promote the utilization of the minerals. In very young children, especially, is proper diet important to the formation of good teeth.

General Problem 4. How Are Household Wastes Carried Away?

172. Sinks, Bathtubs, and Laundry Tubs. — Just as water is a good cleansing agent, so the water itself will carry the dirt with it to the sewers if suitable equipment is provided. Sinks, bathtubs, and laundry tubs are all sanitation and labor-saving devices. They depend for their value upon the force of flowing water that enables it to carry substances along with it just as water in the river can carry sand and stones.

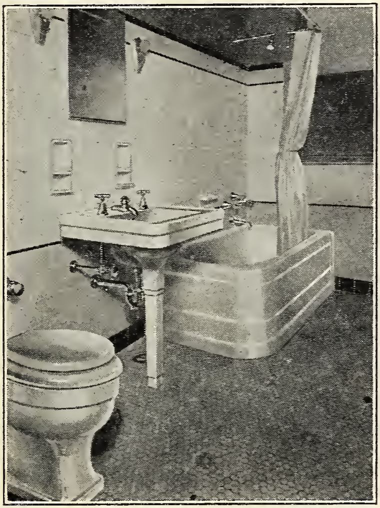


Laundry Tubs and Trap
What does the shading in the trap represent?

Field Research:

Investigate the water-using devices in your home to find out why they are located as they are, what material they are made of, and how best to keep them clean and in repair. Make diagrams to illustrate what you find.

Sinks should be placed so that the plumbing can be readily examined. Metal sinks (enamel or porcelain lined), sinks of special non-rusting metals, and porcelain sinks are most easily cleaned and kept sanitary. Sink waste pipes should be provided with traps to catch and hold dirt, sand, hair, and other insoluble material that gets through the sieve in the bottom of the sink or washbowl. This is true also of washtubs and bathtubs. *Traps* prevent the drain pipes from becoming clogged with débris.



Courtesy Crane

MODERN BATHROOM EQUIPMENT

Where is the trap for the washbowl? For the tub?

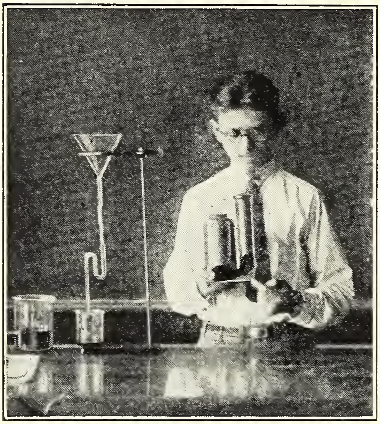
173. Traps. — You have examined the waste pipe running from your sinks, bathtubs, and laundry tubs, and have discovered that the water runs through a sieve in the bottom of the sink down through a pipe to the trap. A trap is so constructed that the water runs down one side and fills the other side to the overflow. This much of the trap is always filled. Then when more water runs into the first part, the second part overflows.

Field Research:

Examine a waste trap provided by the teacher or obtained from a plumber. Note how waste water enters and leaves. Is it so constructed that some water always stands in the trap?

Why is that? Make a drawing to show the construction of a trap and explain how it works. Has the trap a "clean-out"? Why is that necessary?

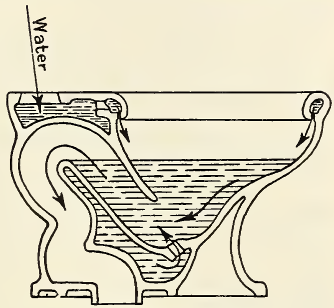
The trap serves two purposes. The water standing in the trap will prevent gases or foul odors from coming from sewer pipes into the room, but the important purpose of the trap underneath the sink is to prevent débris such as matches, toothpicks, coffee and tea grounds, chunks of vegetables, and grease from passing down to the pipes in case they get through the drain sieve in the sink. The trap is so constructed that the face, or the bottom, may be removed easily in order to clean out the débris from time to time.



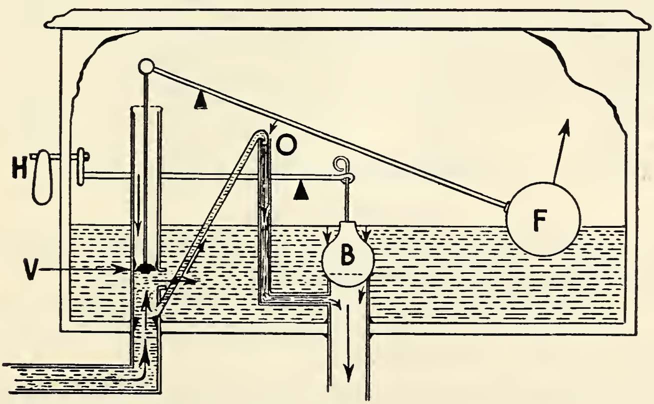
A Class Demonstration of Trap Construction

174. Toilets. — Toilets are equipped to prevent backflow of gases and to provide a rush of water to carry the wastes away. In a *siphon-jet* toilet the water stands on both sides of the tongue and so effectually prevents backflow of gases from soil pipes. The water enters the basin and fills it to the rim. When the tank is flushed, some of this water flows down the side and some down through the jet, filling the outlet, which then acts as a siphon (a bent tube for drawing liquids over the side of a container), and all the water is carried out into the soil pipe.

The construction of an ordinary *float valve flush tank* is shown at the bottom of the page. If the tank is emptied, the float *F* sinks to the bottom and the supply valve opens, allowing water to enter. At the same time the hollow rubber or metal ball *B* closes the outlet. As the tank fills, the float rises and finally shuts the supply valve at *V*. The ball *B* is kept in place by water pressure above it. If now the trip *H* is pulled, the lever arrangement raises the ball, which, once raised and being lighter than water, floats, allowing the water to run out. When the tank is emptied, the ball drops down, closing the outlet again. The float drops and the tank refills. *O* is the overflow.



A Siphon-Jet Toilet



A Flush Tank

Explain how it works.

The proper disposal of human waste (sewage) is one of the most important municipal and rural problems, because the germs that produce typhoid fever, tuberculosis, cholera, dysentery, diarrhea, and other ailments may be carried in it.

175. Sanitary Plumbing. — Your study of the uses of water as a cleansing agent and as a carrier of wastes from the home, and of the devices to perform the latter work, is from the standpoint of sanitation and health. You have already discovered that plumbing is generally installed to permit easy cleaning, and you have learned how to care for the different devices. See that you do your share in keeping these devices clean and sanitary.

The next chapter will tell you how wastes from the home are disposed of.

Key Words

alkali	fat	perspiration
ammonia	function	plumbing
baking soda	glycerine	skin
by-product	hard water	soap
cavity	lime	soft water
dentine	litmus	teeth
deposit	mineral	temporary hardness
emulsion	molar	trap
enamel	permanent hardness	washing soda

Key Statements

1. "Hardness" of water is caused by calcium and magnesium bicarbonates and sulfates dissolved in the water.

2. "Temporary hardness" can be decreased by boiling. It is caused by bicarbonate of calcium and of magnesium. These minerals decompose when heated.

3. Permanent hardness is not affected by boiling, but can be decreased by the use of water-softening agents. It is caused by sulfate of calcium and of magnesium.

4. Deposits in teakettles and boilers result from boiling water which has temporary hardness.

5. The principal function of soap is to act as a cleansing agent.

6. The cleansing action of soap depends upon its ability to emulsify fats and oils and to help water loosen dirt particles.

7. Soap substitutes usually contain some soap and other ingredients such as washing soda and grit. Some substitutes, although they contain no soap, are valuable because they will soften water and loosen dirt.

8. Water-softening substances, used with hard water before adding soap, effect a worthwhile saving of soap.

9. Soap is made by the action of an alkali on a fat or oil.

10. Glycerine is a valuable by-product of the manufacture of soap.

11. An oil emulsion occurs when the oil is so finely divided by an emulsifying agent that it will stay mixed with water.

12. Laundry machines are labor- and fabric-saving devices.

13. The treatment of a stain for its removal depends upon the character of the stain; *i.e.*, whether it is soluble or insoluble.

14. The functions of the skin are excretion, temperature regulation, sensation, and protection.

15. An unclean skin (or accumulated perspiration solids) results in objectionable body odors.

16. The evaporation of the moisture of perspiration from the skin acts as a cooling process to prevent overheating of the body.

17. Face powders as a rule are to be avoided. Some are harmful, if used to excess.

18. Food allowed to decay in the mouth results in objectionable breath odors.

19. The three main parts of a tooth are: crown, root, neck.

20. Diseased teeth are responsible for many ills of the body.

21. Proper diet, including certain minerals and vitamins, is necessary to prevent tooth decay.

Thought Questions

1. Why does hard water require more soap to form a suds than rain water?

2. How can you soften water containing bicarbonates?

3. How can you soften water containing sulfates?

4. Why is water called "hard"?

5. What is an advantage of using water softeners with hard water, in addition to soap?

6. Why are soap substitutes called soaps?

7. In what ways is an alkali different from an oil?

8. Why was farm-made soap of the early days a soft soap?

9. Why does a soap solution clean better than water alone?

10. Why does hot soapy water result in better washing than cold soapy water?

11. What is a bleaching agent?

12. Explain how whirling wet clothes dries them? How does this differ from what happens when clothes dry on a line?

13. How may powders used on the skin counteract the benefits of bathing the skin?

14. What conditions are likely to precede tooth decay?

15. What advantages are likely to result from frequent visits to a dentist?

16. What relation has a shapely mouth to the teeth?

17. How is modern plumbing a sanitary provision?

Projects for Your Science Discovery Book

1. Examine all the varieties of soap used in your home. Read on the wrapper what is said about each kind. Test each kind to find which one makes the best lather on your hands. Report your discoveries.

2. Make a collection of household substances and test with litmus paper. List them and indicate in each case whether it is an acid, alkaline, or a neutral substance.

3. Make a report on various laundry equipment machines and their advantages for laundry work.

4. Write a story about two boys looking for a job. One has a clean skin, fine, carefully kept teeth, and a bright, alert eye. The other boy is like the first except that his teeth show neglect.

5. Compare the shape, number, and functions of your teeth with those of a cat or dog. Explain the differences.

UNIT IV. COMMUNITY SANITATION

LOOKING AHEAD INTO UNIT IV

One of the most important things a town or city government has to do is to get rid of the refuse and wastes from countless kitchens and toilets in the community. Not only does proper disposal of such wastes keep the city or town clean and beautiful, but it directly protects the lives of its citizens by preventing the spread of disease.

Open sewers running through a town, streams poisoned by the seepage of sewage into them, and heaps of garbage and tin cans piled up in some vacant lot are things of the past. Part of the taxes collected from home owners is used for properly disposing of such waste, and strict laws have been passed about them which must be observed by house builders and home dwellers.

Once, long ago, in medieval castles, bones and scraps from the table were dropped on to the rushes which covered the floor and left to be eaten by the dogs or to be carried out when the old rushes were changed for new. Today, modern incinerators burn such wastes and recover fats and mineral matter for commercial use.

The responsibility for a community's good health and clean appearance is a joint responsibility, shared by the government and by the citizen. No one of you is too young to do your share in keeping your community clean, healthful, and beautiful.

SURVEY OF TOPIC XIII

Did you ever think about how a big city cleans up? In the early morning, when traffic is at its lowest ebb,

sprinklers equipped with whirling brushes scrub the streets, and men (often called white wings because they are dressed in white) pick up and dispose of the papers and rubbish in the parks and along the sidewalks, so that when the inhabitants awake and walk abroad, the city will have a bright and shining morning face.

The smaller communities may not go about their problems in just this way. But you have certainly heard of "clean-up week," "paint-up week," and been reminded to "swat the fly" and "drain the swamps and get rid of the mosquitoes."

The cool, shadowy pine grove that makes a lovely picnic spot quickly looks untidy and unattractive if papers, fruit skins, and empty boxes are left behind; roadsides, bordered with wild flowers, look very unkempt if motorists throw out papers, boxes, and bottles along their way; and the gentle little waves running up on a silver beach look very uninviting if fruit skins and other débris bob along their surface. Make it your habit to pick up and clean up, wherever you are; Nature has so many beauty spots — let us keep them so.

TOPIC XIII

THE HEALTHFULNESS OF THE COMMUNITY

We are coming to recognize that priceless as is the power to cure disease, power to prevent it is of far more worth to the community. — Rush Rhees

Do you know:

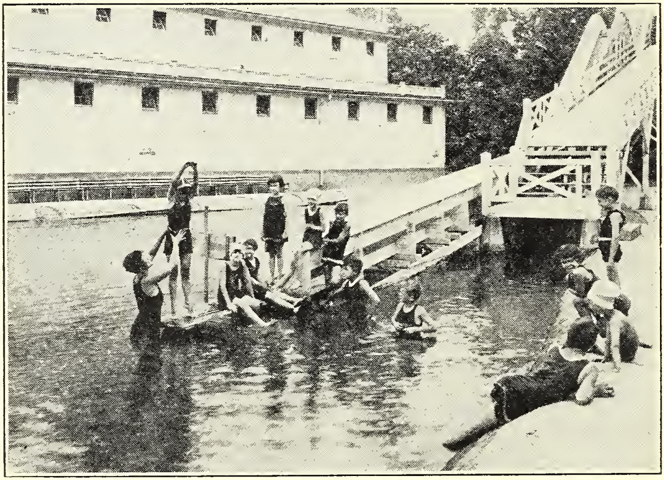
1. **Why the healthfulness of your city is a concern of yours?**
2. **Why garbage should be protected from flies?**
3. **How to clean and disinfect a garbage pail?**
4. **What valuable substances are obtained from garbage?**
5. **Why sewage disposal is a health problem?**
6. **Whether substances of any value can be removed from sewage?**

General Problem 1. What Are Some Problems of Sanitation?

176. The Water Supply. — The maintenance of an adequate supply of water for industrial and personal uses is a health problem of first importance. You are familiar with and should recall at this time how your water supply is guarded at the source, protected, and purified for the consumer.

Water is especially suited to the life and reproduction of germs. Hence the importance of preventing typhoid and other disease germs from gaining access to it cannot be overestimated.

Water in abundance is required for proper sewage and street wastes disposal, and for general city cleanliness. Many communities now support indoor or outdoor swimming pools, where the water is kept sanitary by sterilization. These swimming pools are of great value not only from health and exercise standpoints, but also



Teaching the Children How to Swim

Why is a swimming place like this a profitable investment for a community?

because many people thus have an opportunity of learning how to swim. It naturally follows that the more people there are who can swim, the less danger there will be of lives being lost in water disasters. Water for all kinds of water recreations is a most valuable asset to community good-fellowship and health.

177. Sewage and Garbage Disposal. — Next in importance to the need for safe water for drinking is the need for proper disposal of sewage and garbage. Human beings who are sick contaminate sewage and rejected food with disease germs. Therefore, sewage and garbage become a possible source of contagious diseases through transmission by flies and other insects or through contamination of the water supply. Then, too, good sewage and garbage disposal means cleanliness and freedom from offensive sights and odors.

Washing City Streets

Why is this necessary in modern cities?

178. Clean Streets. — Much of the filth and débris of the streets is washed by rain or by street flushing into the storm sewers. Street dirt contains not only manure from horses, refuse spilled from wagons, pieces of food material of all kinds which feed flies and serve as breeding places for them, but it also contains expectorations of people who are afflicted with some form of contagious disease. Therefore, the streets should be cleaned of all refuse daily; they should be sprinkled regularly to keep down the germ-carrying dust; and they should have an occasional washing from the city water mains.

Tourists using the roads and parks and wooded groves around a town are often thoughtless about throwing out, or leaving, litter and refuse from their lunches. See that you join the group of thoughtful and considerate people who help to keep all highways and parks clean and sightly.

General Problem 2. How May Sewage Be Disposed of Properly?

179. What Is Sewage? — Waste matters from indoor or outdoor toilets, waste water from water basins, bathtubs, and sinks, and street flushings make up what we call sewage. Sewage contains dead organic matter and countless numbers of living organisms, bacteria and *protozoa* (one-celled animals). Some of these low forms of life are harmful, but many of them are useful. The useful ones act as tiny scavengers and help to break down the organic matter of sewage so that the air can change it into oxygen and nitrogen compounds, thus rendering it harmless and inoffensive. The nitrogen compounds are useful to plants.

Under ordinary conditions the waste matter from an adult in one year is about 900 pounds, most of which is water. If to this is added the scrap matter of the streets and kitchens, such as bits of food, fats, milk, fruit, vegetables, tea and coffee grounds, paper, and about 15,000 gallons (about 62.5 tons) of water a year used by each person in a city, one can get an idea of the enormous mechanical problem involved in sewage disposal.

180. Water and Sewage. — Because germs that produce human and animal diseases eventually find their way into sewage, it is important to prevent sewage contamination of all water courses, ponds, and lakes, for some person or some animal is likely to need that water for drinking. Fish will not live in water that is badly contaminated with sewage.

Not only is the healthfulness of water related to the sewage disposal problem, but large quantities of water are required to carry the sewage materials to the disposal plants.

Field Research:

If you know of a stream that is polluted, examine it to find the kinds of plant life and animal life it contains.

Sewage contamination results in decreasing the oxygen content of the water; in the growing of water scums and molds; and in the destruction of fish, — all typical of stagnant water.

181. Disposal in Rural Districts. — Objectionable methods of sewage disposal sometimes encountered in rural districts and small towns are indicated by the following cautions issued by the Department of Agriculture (Farmers Bulletin No. 1227).

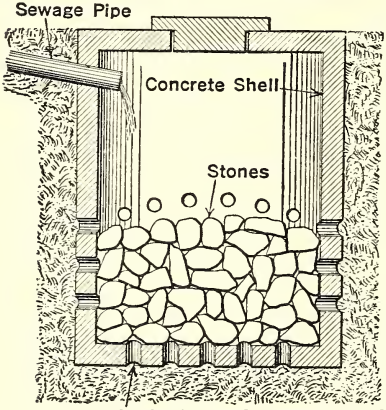
1. Never allow the farm sewage or excrements even in the minutest quantity to reach the food or water of man or live stock.
2. Never expose such wastes so that they can be visited by flies or other carriers of disease germs.
3. Never use such wastes to fertilize or irrigate vegetable gardens.

4. Never discharge or throw such wastes into a stream, pond, or abandoned well, nor into a gutter, ditch, or tile drainage system which naturally must have an outlet into some water course.

Field Research:

Examine a fly's wing, eye, and foot under a microscope. Catch some flies and place them under a wire screen with bread and water. Watch them for 15 days to observe their life history.

182. Disposal in Suburban Districts. — In country districts, villages, and new city and suburban districts where sewers have not yet been installed but where running water is available, sewage is frequently allowed to flow through tile into a covered tank or hole called a *cesspool*, filled with stones, brick, tile, or other coarse material. This arrangement serves as a free place for the sewage to collect, and from which the liquid portion can seep or drain away slowly. It is not a desirable method, since no provision is made for the destruction of dangerous germ life nor for the prevention of foul odors which sometimes accumulate. Then, too, at regular periods the cesspool must be opened and the refuse taken away and buried or burned.



A Cesspool

Explain the use of each labeled part.

183. The Dilution Method. — The *dilution* method depends upon the principle that if a harmful material is diluted enough, it is not to be feared. Some cities dump their sewage into large rivers or in artificial river canals with an abundance of rapidly flowing water. Two things result. The sewage is greatly diluted and the flowing water is able to dissolve more of the oxygen of the air than it could if it were stagnant. The dissolved air oxidizes some of the organic matter and makes it harmless. The oxidizing action is brought about largely by certain forms of bacteria which thus perform a very useful work.

If the stream is overloaded with sewage, complete decomposition of the organic matter does not take place, and the stream becomes a possible menace to health. The stream, at least near the sewage inlet, is rendered unfit for any use by man.

Another dilution method, much practiced, is to conduct the sewage by conduits far out into a lake or ocean. This plan has objectionable features because there is always potential danger of disease germs being distributed to drinking water intakes in the case of lakes, and to bathers in all cases. To what extent fish may become infected is a problem not yet answered.

184. The Chemical Toilet. — In rural and suburban districts where running water is not available, the use of chemicals to decompose sewage is successfully practiced. An iron tank is arranged to hold several gallons of a concentrated solution of *caustic soda* (sodium hydroxide), to which is added a small amount of *blue vitriol* (copper sulfate) or of *copper chloride.* The tank is provided with an outlet near the top so that as liquids collect, overflow takes place into a second tank, at a lower level, filled with stones.

From the second tank the liquids flow through tiles under the ground to an area where it is safe to let the liquids soak into the ground. The solid organic matter of the sewage is acted upon by the caustic soda and liquefied into harmless substances. Odors are absorbed by the copper compounds. Occasionally the chemicals must be allowed to run off and a new charge must be added.

185. The Septic Tank. — The *septic tank* method depends for its action upon a kind of bacteria that lives

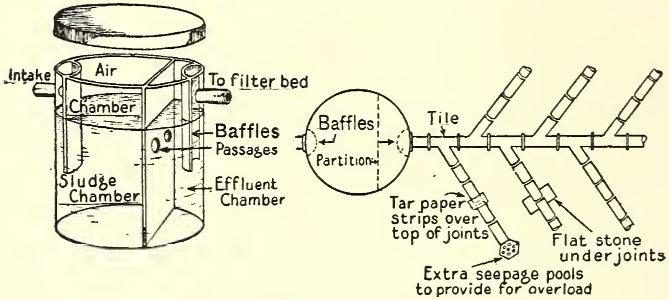


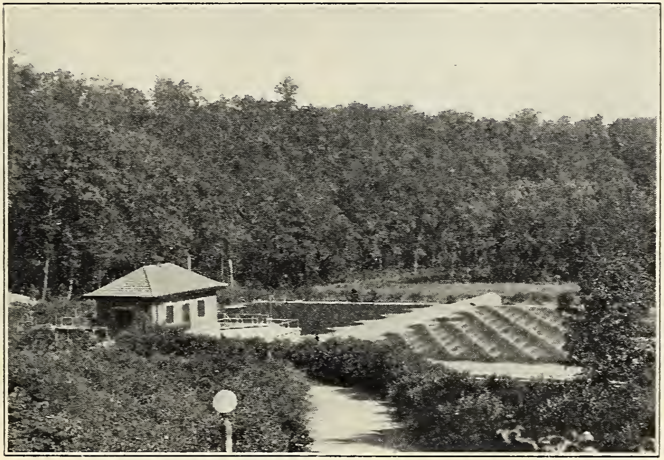
Diagram of a Septic Tank and Filter Bed

Why are there two chambers in the tank? Why are there so many drain tiles?

on organic matter and does not need air. A watertight tank made of steel or concrete is divided into at least two compartments. The sewage flows into the first compartment in which most of the insoluble organic matter, called *sludge*, settles to the bottom. Excess liquid flows over the partition into the second compartment where more sludge is formed, and so on through each succeeding compartment until only a clean and inoffensive liquid is left to flow from the final compartment. This clean and harmless liquid may be allowed to drain into the soil or into bodies of water sufficient to give considerable dilution.

The organic matter of the sewage is acted upon by the bacteria in the sludge and in a scum that forms at the surface. The bacteria help to break the offensive material up into harmless liquids and gases.

Study of the diagram on page 336 will help you to understand the general principle of a septic tank, and



Aërating Sewage Liquids after Treatment

What is the purpose of the aëration?

how it is constructed. Its value depends upon the myriads of helpful bacteria that decompose the organic wastes.

In general, the principle of the septic tank is utilized in modern sewage disposal plants for cities. Sometimes the *effluent* (liquid that flows out) is sprayed into the air to enable it to dissolve oxygen of the air (aëration). This further purification must, of course, be made before the liquids are allowed to pass into a stream or lake.

General Problem 3. How May Garbage Be Disposed of Properly?

186. What Is Garbage? — Garbage consists essentially of vegetable matter with some meat, fat, and bones. A ton of garbage will contain approximately 1460 pounds of water, 80 pounds of grease, and 460 pounds of solids.

Field Research:

Watch the garbage pail for a few days to discover what goes into it. Does it contain only unavoidable waste? Or does it contain waste that is the result of carelessness?

Your investigation of garbage will no doubt disclose the fact that it consists of the inedible parts of meat and vegetables, unfinished servings, moldy foods, and decayed fruits. Perhaps you will identify fats, oils, and grease, protein in pieces of lean meat, and carbohydrates in vegetables. All of these materials will decompose (decay), if allowed to stand too long. Offensive odors are then given off and flies attracted.

Four problems relating to the garbage are:

(1) to reduce the amount by being careful in the handling of foods.

(2) to provide a suitable garbage pail.

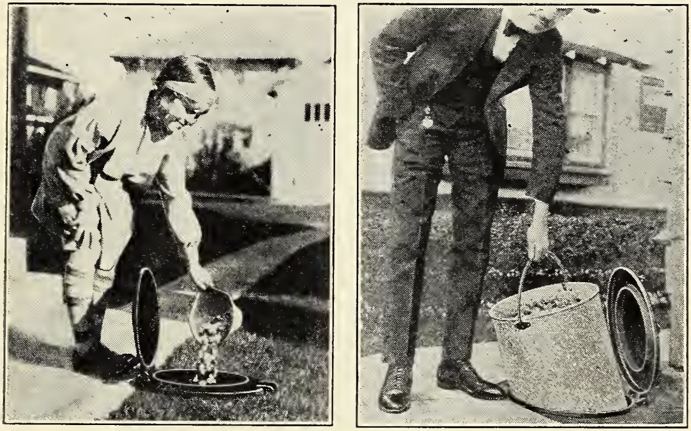
(3) to have the garbage collected before it decomposes badly.

(4) to dispose of the garbage without offense to the community and at a profit to the community.

Because decay proceeds faster when the weather is warm, garbage becomes offensive quicker in summer than in winter. Therefore, it should be collected or disposed of more frequently in summer than in winter.

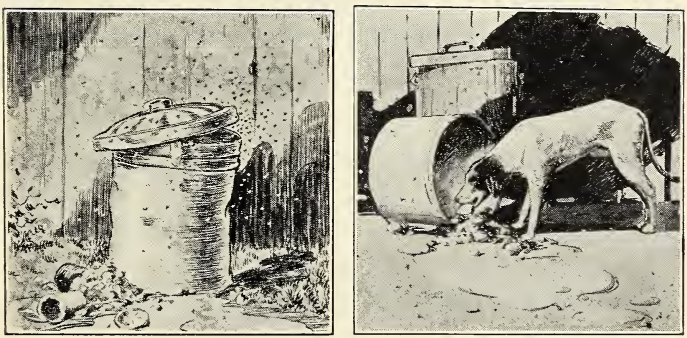
In camps and on farms garbage should be disposed of daily.

187. Garbage Receptacles. — Garbage pails should be strong, water-tight, and non-rusting. The covers should be fastened so that they cannot be removed by



Sanitary Garbage Pails

What are the advantages of this type of pail?



Courtesy The Majestic Company

Unsanitary Garbage Pails

What objections are there to this type of pail?

dogs. Frequently the pails are placed in inclosed compartments or in holes in the ground and suitably covered.

Field Research:

Make a trip to the store and study the different types of garbage pails on sale. Determine from the store clerk what he thinks are the advantages of each type. Decide in your own mind which is best and why. Report your findings and conclusions to your class. A drawing will help your description.

If garbage pails are left uncovered or are uncovered by dogs, the food material likely to be scattered about will attract flies and will present an unsightly and unsanitary appearance. The garbage pail should be cleansed thoroughly each time it is emptied. A good method to use in cleaning it is to sprinkle a little *chloride of lime* into the pail, then add hot water and stir with a cloth on the end of a stick or with a long-handled brush.

The chloride of lime is a disinfectant and deodorizer. It will destroy any bacterial, mold, or insect life present. Also, with hot water to melt the grease, the chloride of lime will react with the grease so that it can be easily rinsed out, leaving the pail "sweet" and clean.

The pail will not rust so rapidly if you will dry it and air it after cleaning. Why?

188. Houseflies and Garbage. — If given the opportunity, flies lay their eggs wherever there is decaying filth. Garbage left in a pail or lying about until the meat and fat begin to decay forms food that flies like very much, and while there to eat, they lay their eggs. The eggs hatch into larvae called *maggots*. These change into *pupae* (a resting stage), from which emerge the new-born flies. A new generation of flies arrives every ten or twelve days from early spring to late fall and the female fly lays over 100 eggs at a time. The increase in numbers is so rapid as to be past calculation. Bright sunlight, heat, and exposure to air will usually destroy fly eggs and larvae.

A FLY

There are many varieties of flies. Is this a house fly? Catch one to compare with it.

LEG AND FOOT OF A HOUSEFLY

Can you tell why germs are so easily carried on a fly's foot?

189. "Swat the Fly." — To combat this dangerous insect, the following rules should be observed:

1. Destroy all flies in the house, especially every fly that enters a sickroom.

2. Eliminate breeding places, — decaying matter of all kinds and manure. Most flies are born in unguarded manure piles on farms and in villages.

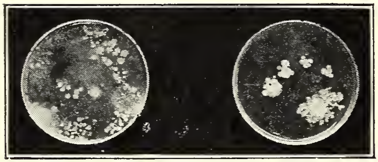
3. Prevent flies from getting at food in your home and in stores.

4. Securely screen all doors and windows.

5. Remove any possible breeding source at least every ten days to interrupt the generation.

6. *Remember,* when you see a fly in your house or on your food, that it probably came directly from a near-by place of filth and may carry disease germs on its feet and body.

The common housefly has so often been the carrier of typhoid fever germs that scientists have formed the practice of calling it the typhoid fly. A useful and cheap poison with which to attack this insect is a spoonful of formaldehyde in a pint of water, with a small amount of sugar to sweeten the solution. Pour it into small dishes and set the dishes wherever you find need for such measures. (**Caution: Put the dishes where children cannot reach them.**) There are also commercial preparations for spraying which are more effective and more convenient than the preceding method. The spray is harmless to individuals and to clothing.



BACTERIAL COLONIES

A fly walked on the agar in the left-hand dish. A boy touched the agar in the right-hand dish with the tips of thumb and fingers. Explain.

Spring and early summer are the best times to make your fly-killing campaign most effective. But bear in mind that it is quite as important to avoid the conditions which breed flies as it is to kill the flies when they appear. "An ounce of prevention is worth a pound of cure."

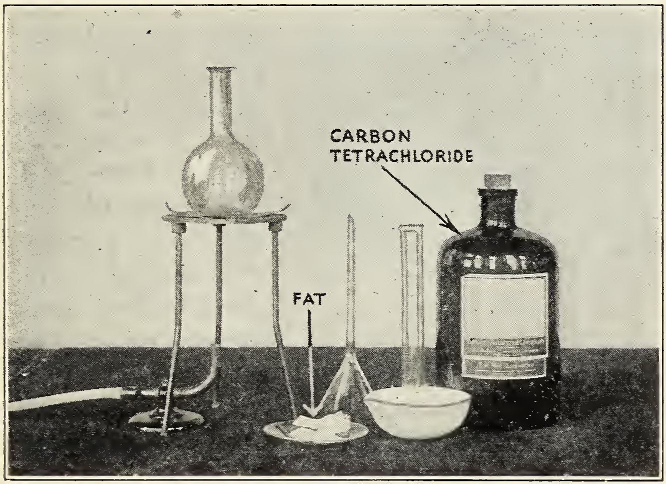
190. Private Disposal of Garbage. — The problem of getting rid of garbage from the farm home or in districts where there is no garbage collection is an important one that must be solved. You will agree that the garbage should not be thrown out where it can decompose and become a menace to your health or that of your neighbors. It should be buried or burned. The best method of private disposal is burning. *Incinerators* (ovens for burning garbage and other refuse) are available for installation in homes or for outdoor use.

191. Community Garbage Disposal Problems. — The safe and economical disposal of garbage for a community has had the attention of scientists and engineers for many years.

Feeding community garbage to hogs was found to be unsatisfactory because the hogs contracted such diseases as hog cholera, pneumonia, and hoof and mouth disease.

Burying large amounts of garbage required large areas of land which became a nuisance and health hazard.

Burning was found to be wasteful and objectionable. Various plans have been developed consisting essentially of ways to separate out the fats for soap making and to *reduce* the other material to fertilizer.



EXPERIMENT 34

Is carbon tetrachloride inflammable?

Experimental Problem 34. — *How can fat be dissolved from garbage?*

What to use: A small piece of fat meat (cooked) and pieces of vegetables to represent garbage: a 250 cc. pyrex flask; 50 cc. of carbon tetrachloride; an iron tripod; wire gauze; a Bunsen burner; an evaporating dish; and a funnel.

What to do: Grind or chop the foods into small bits. Place two tablespoonfuls in the flask and add 50 cc. of the carbon tetrachloride.

Set the flask on wire gauze on the tripod. Place the funnel over the flask with its stem in the opening of the flask.

Heat the mixture slowly for several minutes. The funnel acts as a return condenser to prevent too great loss of the solvent.

After a few minutes, pour off the clear liquid into the evaporating dish and place it on the wire gauze and tripod in place of the flask. Heat carefully until the solvent appears to be gone. *Do not heat the residue hot enough to burn it.*

Allow the contents to cool and examine them.

What happens: 1. Did you observe solution of the fat taking place? 2. Was there a fatty residue left in the evaporating dish? 3. Tell why you think it is fat. Where did it come from?

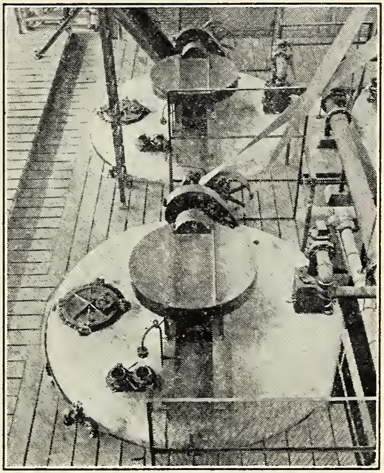
Conclusion: How can fat be dissolved from garbage?

Application: How can a grease stain be removed from a fabric?

192. A Modern Garbage Disposal Plant. — The garbage is collected regularly by a large number of men using especially constructed wagons. It is collected early in the morning, generally before the city is awake, and frequently enough to reduce the nuisance of offensive odors during collection. The wagons are driven to the disposal plant situated usually in the heart of the city, and here the garbage is taken into the receiving room, where it is weighed.

It is then lowered through chutes into great kettles and covered with a solvent of grease. The kettles are then closed air-tight. Each kettle holds five tons of garbage. The kettles have a jacket of double bottoms and sides and in this space steam is circulated to heat the garbage. Inside the kettle is a propeller-shaped arm that revolves slowly to keep the garbage and solvent thoroughly mixed. The steam is turned into the hollow wall or jacket and heats the mass to a temperature of about 208° F.

The heat causes both water and solvent to pass off as vapor through pipes. Enough solvent is added so that at the end of about twelve hours of cooking, all the water of the garbage has been driven off, and a quantity of solvent remains which contains the grease and fat in solution. This continued heating also kills any germs or other life that may have existed in the garbage and renders the garbage inoffensive.

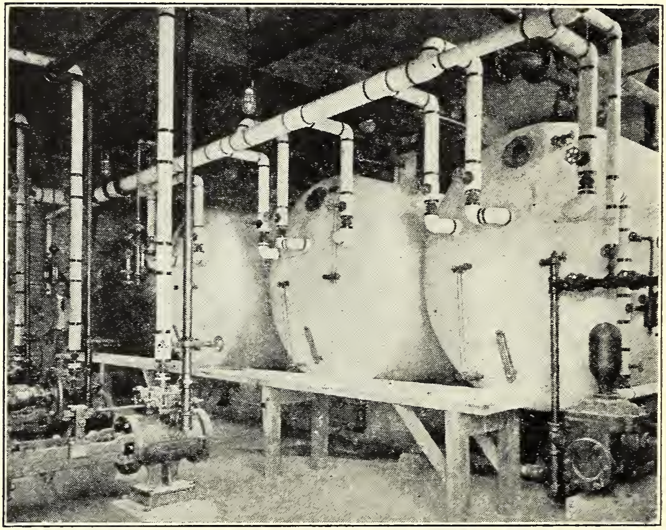


Tops of Garbage Reducers

Why are the steam pipes near the reducers ?

The steam is cut off from the jacket and the grease solution is drawn out through strainers at the bottom of the kettles. More clear solvent is added to the mass in the kettle and stirred and drawn off. The process is repeated until no fat or grease is left in the garbage. This "working" takes about one hour. Any solvent remaining in the mass is driven out by heating for four hours. The solvent vapor thus driven off is passed through cooling pipes to condense it to a liquid to be used again.

The material left in the kettle is dry and lifeless. It consists of all material not soluble in the solvent, including bones, tin cans, and whatever non-garbage stuff was carelessly put into the garbage pails of the community. This dry material is taken out of the kettle and screened. The large pieces of material are passed over a magnetic operator that holds on to all pieces of metal such as tin cans and nails. What gets



Courtesy C. O. Bartlett & Snow Company

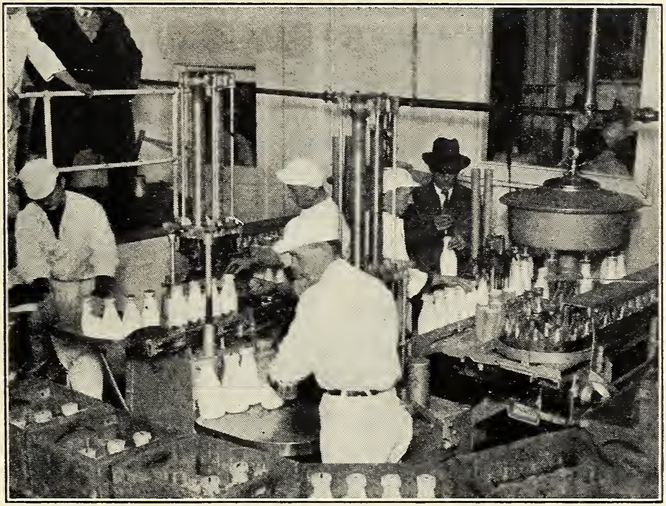
STILLS FOR THE RECOVERY OF GARBAGE SOLVENT

What property of the solvent is taken advantage of in this process?

by the magnet is crushed and then screened again. The final material that goes through the screen is sold as fertilizer.

The solution of fat is pumped into a still and heated, which causes the volatile solvent to pass off as a vapor through condensing pipes, leaving the non-volatile grease and fat behind. The fat which is left is hot and in the liquid state. It is pumped to fat-storage tanks and sold to glycerine and soap factories.

The above process, called the *Cobwell Process*, has the advantages of being sanitary, inoffensive, and economical. It is economical because the equipment can be placed near the center of the city, where the distance for the garbage to be hauled is small; the process recovers practically all of the fat; valuable fertilizer is obtained; and the solvent is recovered with small loss.



PROVIDING FOR PURE MILK

A Board of Health inspector inspects a milk bottling plant. Why is this necessary?

GENERAL PROBLEM 4. WHO IS RESPONSIBLE FOR SAFEGUARDING COMMUNITY HEALTH?

193. Village and City. — Whether you live in the country, village, or city, you are responsible for any act or neglect that may endanger the health of others. As a student of science you have discovered natural laws which help you to understand the rules for sanitation.

It is important, therefore, that you accept as a civic duty your responsibilities for promoting public health by coöperation with health officers chosen as your representatives.

County and city boards of health are charged with protecting your water supply and milk supply. They must provide inspectors of groceries, markets, and all places where food is offered for sale, in order to maintain good sanitary conditions. Barber shops, beauty parlors, and the like are subject to health and sanitation rules set up by proper authorities.

Working usually under the Board of Health are schools and community doctors and nurses, who help to promote sanitation and healthfulness in the school and home. With these officers you should coöperate fully and intelligently.

194. State and Nation. — While an individual village or city has certain responsibilities for sanitation and health protection, the state must have authority over matters that affect relationships among them. So we find that to the State Board of Health, milk and water supplies, foods for sale, housing conditions, and so on, are all objects of state control for the protection of the health of its citizens.

In like manner the nation must have its health bodies to regulate or control shipments of foods of all kinds from one state to another. Pure food and drug laws and laws for the control of cosmetics are required to protect individuals everywhere.

Field Research:

Obtain copies of your local, state, and the national codes for sanitation and note wherein they overlap and wherein they are supplementary.

Now that you have gained some knowledge of the factors which govern the health of your community and the organizations set up for the protection of health, you are ready to turn to the study of a chief source of food supply, — the farm and garden. Health and good food have a very close relationship.

Key Words

blue vitriol	effluent	oils
carbohydrates	fats	pupae
caustic soda	fertilizer	reduce
cesspool	garbage	septic tank
chemical toilet	grease	sewage
Cobwell Process	housefly	sludge
contamination	incinerators	solvent
decomposition	maggots	typhoid fever
dilution	magnet	unsanitary
disposal	nitrify	volatile

Key Statements

1. The properties of water make it a satisfactory medium for sewage disposal.
2. Sewage consists of wastes from sinks, toilets, and streets, mixed with or dissolved in water. Sewage contains bacteria.
3. Disease germs may be present in sewage; hence its proper disposal is an important factor in the health of a community.
4. Untreated sewage should not be allowed to pollute streams.
5. Flies should be prevented access to farm and home wastes of all kinds.
6. The presence of flies often indicates the location of filth.
7. A cesspool is a drainage tank for sewage.
8. The chemical toilet depends for its efficiency upon the dissolving action of alkali.
9. The septic tank sewage disposal plant depends upon bacterial action to render the sewage harmless and inoffensive.
10. The application of scientific knowledge should result in the protection of inland and ocean water from pollution.

11. Garbage consists chiefly of food wastes. It should be protected from flies, and should be disposed of before it decomposes.

12. Knowledge of the habits of flies is important in the campaign against disease.

13. Proper disposal of garbage involves frequent collections, inoffensive disposal plants, and the recovery of useful products.

14. The principle of the septic tank is the best to follow in the disposal of sewage.

15. Clean streets are found in healthful communities.

16. Sewage and garbage are efficiently disposed of in a healthful community.

17. The water supply in a healthful community is protected from pollution.

18. Communities, states, and the nation have health boards for the care and promotion of sanitation and health.

Thought Questions

1. What properties of water fit it for sewage disposal purposes?

2. Why will fish decrease in streams contaminated with sewage?

3. What principles are involved in garbage decomposition?

4. Why is garbage especially attractive to flies?

5. How is the knowledge of the life history of the fly applied to its control?

6. What is the relation of the fly to garbage and to health?

7. What property of fat is made use of in the disposal of garbage?

Projects for Your Science Discovery Book

1. Learn to open a clogged sink, using an air cup. Explain what makes the cup work.

2. Write a brief discussion of why cities install sanitary and storm sewers.

3. Make a drawing of the waste pipes of your house.

4. Keep a record of the garbage collections in your community to determine whether or not they are frequent enough.

5. Make a study of flies. Watch where they go and what they eat. Report on what you discover.

"THE ORIGINAL OF HUMAN ART"

Pure element of waters! wheresoe'er
Thou dost forsake thy subterranean haunts,
Green herbs, bright flowers, and berry-bearing plants,
Rise into life and in thy train appear.

—WORDSWORTH.

UNIT V. THE FARM AND GARDEN

LOOKING AHEAD INTO UNIT V

There are formal gardens, rose gardens, and old-fashioned gardens. There are big landscaped gardens and tiny gardens on window sills. There are big truck farms or little backyard garden patches. But whether big or small, formal or informal, a garden always delights the eye with its flowers of all the colors from Nature's paint-box, or its little green shoots in their soldier-straight rows, to become, later, heavy with ripened fruit.

Nature has spent countless millions of years preparing the soil for your garden and moving it from far places by glacier, wind, or water. Nature has prepared seed for you to plant. Nature has provided the warmth of the sun, and the rain, to make the seeds grow. But Nature has also provided weeds, which may choke your garden plants; and insects which destroy the tender shoots; and diseases which attack the blossoms and the fruit.

Let us learn how we may use the generous gifts of soil, seed, and sun and rain to make a garden bloom; and how we may control and hold in check the weeds, and the harmful insects, and the lurking diseases waiting to destroy what we have made.

SURVEY OF TOPIC XIV

A flower garden is a lovely thing and can become an enchanted spot of flowers, butterflies, and bees in the daytime and warm, sweet odors at night — but such a garden takes time, infinite patience, endless care, and skillful planning.

The farm garden, where the "oats, peas, beans, and barley grow," needs the same patience, care, and planning to yield its best crop.

All plants do not like the same kind of soil; so we must learn something about soils, what they contain, what their uses are to the plant, and which soil is best for which plant. We do not need to wait for warm days to start our garden, if we know something about starting seedlings in the house, and transplanting them when the proper time comes. We do not need to guess about our garden if we learn something about the selection of seed. We do not need to have a hodge-podge of a garden, if we plan a garden as an architect plans a house, and then work toward that ideal.

TOPIC XIV

GARDEN PLANS AND PLANTING

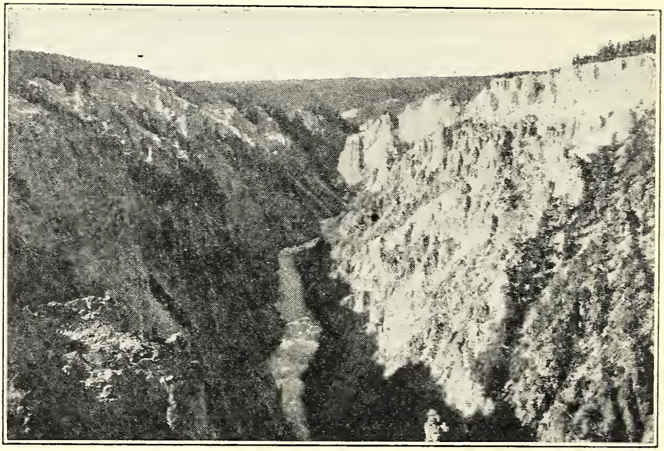
I have in mind a garden old,
Close by a little known highway,
Where aster, pink, and marigold
Keep their long summer holiday.
— Hutt

Do you know:

1. **How to care for garden tools?**
2. **How to plant a seed?**
3. **Why garden soil is worked?**
4. **Whether all the seeds grow that are planted?**
5. **Whether bacteria in the soil are important to plant life?**
6. **What a garden plan is?**

General Problem 1. How Is Soil Prepared?

195. What Soil Is. — Soil is weathered and ground-up rock, mixed with varying amounts of decaying organic matter (humus), water, air, and living organisms. The soil in your garden may have been formed by the weathering and decay of local rock, or it may have been brought from distant places by glaciers or rivers. For perhaps a billion and a half years water has been at work preparing soil for plant growth. Rocks, ages old, have been broken up, ground into tiny particles, and mixed to form soils with a variety of minerals in them — minerals required as plant food. But soil is more than a mixture of lifeless materials; it is teeming with life, and contains life-giving oxygen, nitrogen, and water.



The Work of Wind and Water

Courtesy Northern Pacific Ry.

The Work of Glaciers

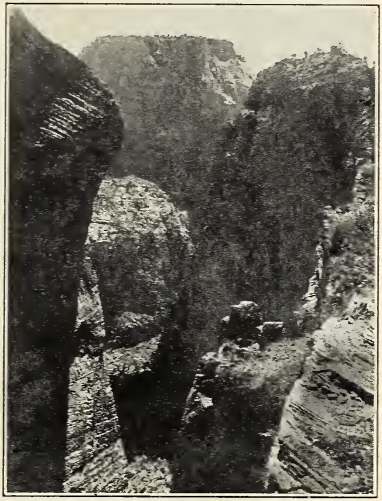
Rich soil is left at the foot of Mt. Rainier by the twenty-eight glaciers which flow along its sides.

Soils vary widely on account of the rock substances which compose them. That is why we have clay, sandy, loam, and muck soils. Each is characterized by its name. Each requires special treatment and is best fitted for particular crops.

Soils differ, also, in size of particles, and so we have coarse gravel, fine gravel, and fine sand. The size of the particles is important in relation to drainage and air and water content. The finer the soil, the more air and water it can contain.

Field Research:

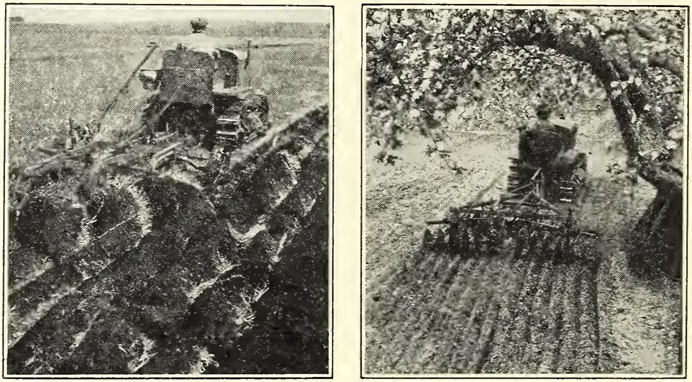
Investigate the soil of your neighborhood to determine how it was formed and where it came from.



El Gobernador
Weathering has been going on here for ages past.

196. Parts of the Soil and Their Uses to the Plant. — Every part of the soil has its value to the plant, so a successful gardener or farmer must know the parts and their uses. Some of the bacteria in the soil help to decompose organic matter, releasing nitrogen to the air and making the residue suitable for plant use. Other bacteria take nitrogen from the air and combine it with oxygen and certain minerals in the soil to form an important substance — a nitrate — needed for plant growth. Without air (with its oxygen) in the soil this work would stop. Some of the soluble minerals are taken up by the root-hairs of plants with water from the soil and used by the plant for manufacturing its food.

The humus (organic matter) feeds bacteria and holds moisture in the soil. A mixture of sandy soil containing a little clay and humus (a sandy loam) in suitable



Two Kinds of Soil

Soft, wet peat thick-grown with tough grass makes plowing difficult. Flat ground and loose, sandy soil offers little trouble to this farmer.

proportions is desirable for gardening. Sandy soil, alone, drains too freely and dries out. Clay soil absorbs a larger amount of water than sandy soil. It gets sticky and soggy and does not allow the water to circulate freely. When it dries, it cakes and cracks. Water escapes rapidly through the cracks, leaving the dried clay chunks that are difficult to work properly. The mixture, sand and loam, retains moisture well and is easy to work.

197. Preparing the Soil for the Planting. — Any soil that is gardened intensively must be fertilized and supplied with humus for each succeeding crop. Some-

Ohio Agricultural Experiment Station

Stands of Corn

Which one of the three stands do you think received the best fertilizing?

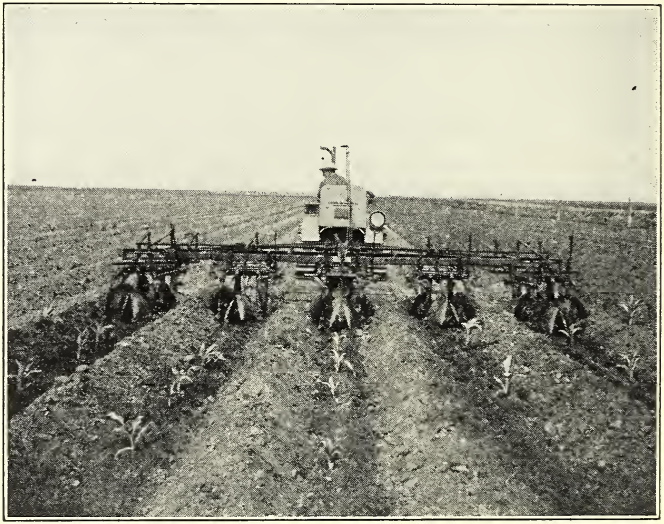
N. Y. S. Agricultural Experiment Station

Barley Cultures

The cultures are seven weeks old and show growth under different conditions of soil treatment.

1. Rotted manure; 3. Fresh manure; 25. Soil compost; 27. Rotted manure and straw.

times on larger gardens and farms the humus is supplied by planting rye, or other leafy crops, the previous fall and plowing or spading under the green blades in the spring. Crops sown in the fall, for plowing under in spring, are called *green cover crops.* Plant food materials are supplied sometimes by changing the crops



CULTIVATING YOUNG CORN

What benefit comes from cultivating the soil? What protects the plants?

from season to season and by adding farm manure and other fertilizers. The farm manure also adds to the humus supply.

After proper fertilization the soil is plowed or spaded as deeply as practical and harrowed about two weeks before the planting time. Just before planting, the garden plot is again harrowed thoroughly to produce a finely divided soil at the surface. The time between the plowing and final harrowing allows the weeds to start from seeds left over from fall. The final harrowing destroys these weeds and is a large factor in the prevention of weeds later on. Graining or cultivating has its value also in conserving water in the soil, although its principal value lies in destroying weeds.

When you think back to what you learned about capillary action, you will remember that any very fine tube has a tendency to draw up any water in which it is placed. Drop the corner of a piece of cloth into water, and you can quickly see what happens. 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 serve as tiny tubes through which the water will escape from the soil by this very thing — capillary action. Soil graining, then, tends to break up these tubes and smother them, thus preventing the evaporation of soil water.

Field Research:

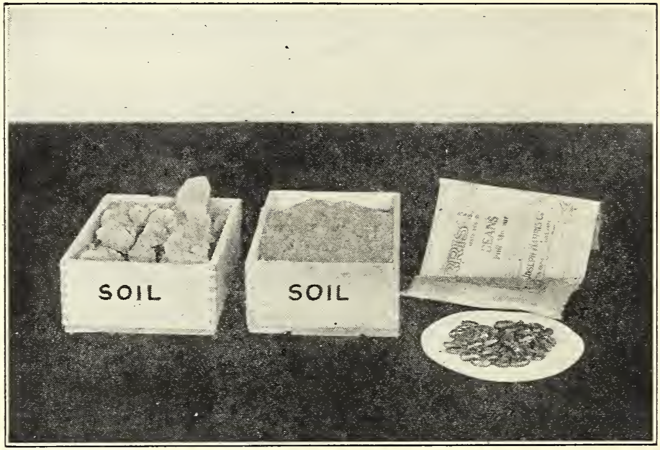
Examine several places where soil has been worked and others where it has not been worked to discover any differences in water storage.

Experimental Problem 35. — *Will seeds grow better in soil that is finely grained than in unbroken soil?*

What to use: Two boxes of equal size; two samples of the same soil, one finely mixed and the other left in coarse lumps; and a package of seeds — peas or beans — that have been soaked overnight.

What to do: Fill the boxes, one with lump soil and the other with fine soil. Plant the seeds according to directions on the package, but do not break up the lumps. Water both boxes alike when you have planted the seeds.

Set the boxes in a warm place and observe and record results from day to day.



EXPERIMENT 35

Should the same number of seeds be planted in each box? Why?

What happens: 1. Do the seeds grow alike in both boxes? 2. Does the soil dry out faster in one box than in the other? 3. Why?

Conclusion: Which method of preparing the soil promotes the better growth? Explain.

Application: The smaller the seeds the finer the soil should be. Why?

GENERAL PROBLEM 2. WHY HAVE A PLANTING PLAN?

198. Your Garden Plan. — The most successful garden is the one planned long ahead. This is true whether you plan for a vegetable garden, flower garden, or a landscaping plan to include the house, shrubs, flowers, and vegetables. He who waits until planting time to plan his garden is likely to be disappointed. In fact, a garden is a year-round affair and not just a spring and summer interest.

If your comprehensive plans for landscaping your grounds are not complete, you should select your garden plot in the fall. See that the weeds are removed before the season closes and that green cover crops are sown if needed.

A Garden of Annuals and Perennials

For the spring planting, January is not too early to begin your plans. (Refer to your Science Discovery Calendar for suggestions.) Is it to be a flower garden, a vegetable garden, or both? Are there shrubs to be placed for decorative effect about the home? If flowers, are they to be *annuals* or *perennials?* Annuals are plants that grow flowers and seeds the first year, after which the parent plant dies. Perennials are plants that bear flowers and seeds each year for a number of years.

Field Research:

Send for seed and plant catalogs from reliable seed houses to help you decide what varieties of seed and plants you wish.

In selecting your seed, plants, and shrubs, you must have in mind the time of *maturity* (the time when the plant reaches its full growth). Some small vegetables mature quickly, and their place in the garden should be replanted with second sowings of the same or some other seed.

If flowers are in your plan, you should consider a color scheme and plan to have a succession of blooms from early spring to late fall. Your perennials and shrubs must be given a permanent place in your scheme, and other planting must be made accordingly, keeping in mind color, time of flowering, and height.

Field Research:

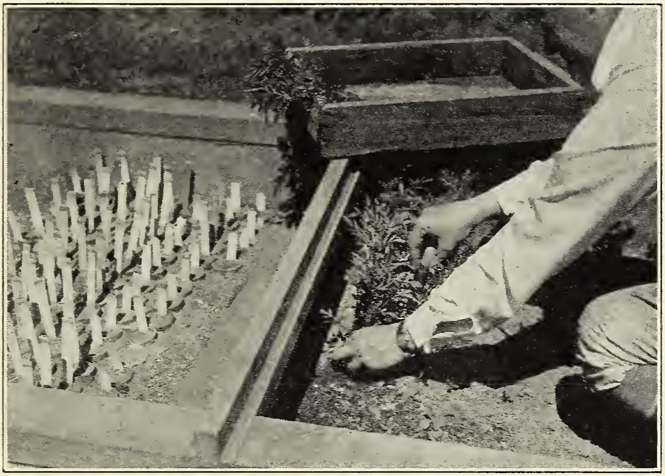
Study some of the books listed in the bibliography to learn how other people have planned their gardens, and what they have planted. Visit commercial show gardens for suggestions of arrangement and varieties of shrubs and flowering plants.

The decision of what seeds, plants, and shrubs to plant can be made only by considering at the same time the size of your garden plot and where each plant is to be placed. Therefore, you should measure your plot and draw a plan of it to scale.

From your catalogs and garden books you can determine how far apart rows of vegetables should be and how much room must be given for each of the plants or shrubs you select. You can then draw the rows on your paper plan and can mark locations for individual plants. Do not forget to keep in mind the succession of vegetables and flowers.

Your plans should include a planting calendar. Some of your seeds will be started in *flats*, in *hotbeds*, or in *cold frames* (page 363), for transplanting later.

These must be carefully timed, taking into consideration the date of late spring frosts and the average



Transplanting Perennials

Plants are being removed from the cold frame. What advantage is there in using a cold frame?

temperature of the growing season. The date for outdoor planting should also be placed on your planting calendar.

Field Research:

Write the Weather Bureau for data regarding frosts and the average temperature for your locality in spring and fall. Study these in planning your garden.

The successful farmer plans his crops as carefully as a flower or vegetable grower. The farmer must plan for feed for his stock as well as crops to sell. The soil in one part of the farm may be better suited to one crop than another. Then, too, the farmer must plant for his market.

199. Seeds. — The following clipping from a newspaper tells its own story.

"'Taking the gamble out of agriculture' is a proposition that works for everyone's welfare. And the fundamental gamble in farming is the seed sown, whether you are working under glass or on a thousand-acre ranch. Think of the nurseryman who buys 20,000 dollars' worth of seed from abroad, plants them, waits and works a year, and finds out that most of the seed had no life. This has really happened. Think of the buyer of wheat seed, and the uncertainty attending this first step toward a 'crop,' with all the hazards of wind and weather to follow, to say nothing of insects and diseases. . . . At Yonkers, the Boyce Thompson Institute for plant research has, in the short time since its dedication in the fall of 1924, made some notable contributions along this line, especially in seed control. A few simple facts have put both speed and certainty into the purchasing and planting of seed."[1]

Here is one other illustration to show the importance seed plays in gardening and farming. A certain variety of cabbage seeds was obtained from two sources. Both quantities *germinated* (started to grow) satisfactorily, but the plants of one sample produced cabbages that weighed an average of 3200 pounds to the load while cabbages from the other seed, grown side by side with the first plants, produced cabbages that weighed an average of 4100 pounds to the load.

Such examples as these indicate that you should select your seed with great care. Seeds that will not germinate properly, waste time, land, and money for you. Seeds that germinate but that grow inferior products are also to be avoided. You can test your seeds for germinating quality.

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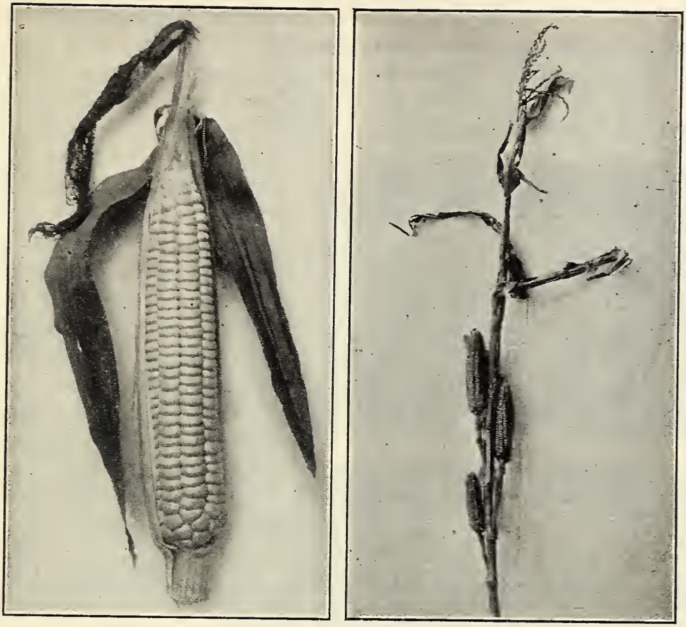
[1] *Democrat and Chronicle*, Rochester, N. Y.



Golden Bantam Corn

Ready to eat. Ripened for seed.

Experimental Problem 36. — *What per cent of my garden seeds will germinate? Will it pay to plant them?*

What to use: Seeds to be tested; wet blotting paper; pie tins (two for each sample of the seeds to be tested); and a hand lens.

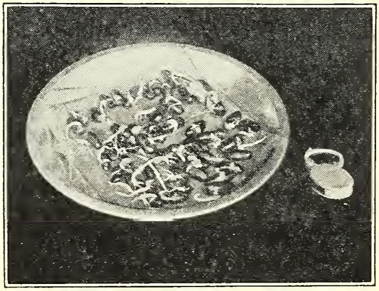
What to do: Thoroughly wet a piece of blotting paper and place it in one of the pie tins. Count out 50 seeds of a sample to be tested and cover them with a second piece of wet blotter, and then with a pie tin but not air-tight.

Repeat with as many samples as you wish to test, and place the tins in a warm place. Keep the blotters moist but not standing in water.

After 48 hours examine the seeds of each sample, and count the number that have started to grow. Recover the seeds and examine them again after another 24 hours. Again count and record the number that have germinated.

In each sample calculate the per cent of seeds that germinate.

What happens: Did all the seeds of each sample germinate? Examine some of the seeds that did not germinate to observe whether they appear to have been well-formed seeds.



EXPERIMENT 36
Why should you know just how many seeds you use?

Conclusion: 1. In each sample of seeds what per cent germinated? 2. Is the per cent of germination high enough to warrant planting the other seeds of the sample? 3. Is it worth while to test seeds before planting them?

Application: Does it pay to buy cheap seeds?

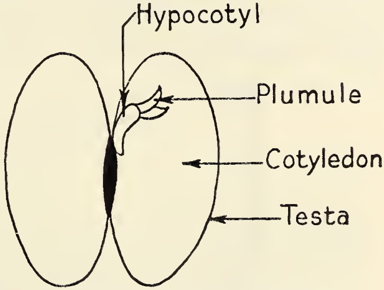
Your investigation of the germination of seeds raises the question as to the parts of a seed and their function.

Field Research:

Soak a few seeds of beans and peas over night. With a needle remove the outer skin, if the seed has one. (Refer to the diagram on page 367 for names of parts.) Carefully separate the parts and using the hand lens, look for the little plant.

The *testa* (skin) protects the seed during its resting period. The two bulky parts (some have only one), the *cotyledons*, supply food to the little plant until it develops roots and leaves and is then able to manufacture its own food.

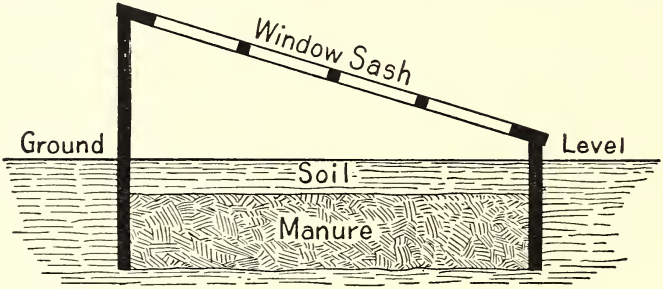
200. Hotbeds and Cold Frames. — If you wish to raise early vegetables and flowers, you will have to learn to use hotbeds and cold frames. Both of these devices are boxes, with sides 12 inches to 24 inches high, set part way down in the soil and covered with frames with glass in them. The frames are adjustable to permit proper ventilation of the bed. The glass allows the radiant energy of the sun to go through and warm up the soil underneath. At night it largely prevents the loss of heat from the soil. For these reasons, the soil under glass will get warm enough to cause seeds to sprout and plants to grow long before the soil outside would permit the growth. The hotbed takes advantage of heat formed by the gradual decay (oxidation) of farm manure to make the soil warmer than it would be under glass alone.



THE STRUCTURE OF A BEAN SEED
Learn the use of each part.

To make a hotbed, a foot or more of soil is removed from within the box and a thick layer, one to two feet deep, of unrotted manure is put in. This is then covered with four to five inches of rich garden soil. This much is better done late in the fall. In the spring, the manure rots and gives off considerable heat to the soil. Therefore, with the top covered with glass, the soil warms very early. When the soil begins to heat, it will heat rapidly, and seeds should not be planted until the temperature has subsided to below 100° F.

As the spring advances, care must be taken not to let the plants burn from overheating. The glass must be removed from cold frames and hotbeds for a short time each warm day and, finally, at night as well. Cold frames and hotbeds must be ventilated because plants must have fresh air. The bed, too, must be kept



A Hotbed

Why must the hotbed be ventilated?

properly watered. (Refer to your Science Discovery Calendar for dates of starting seeds and for transplanting.) For detailed directions concerning the use of cold frames, hotbeds, and greenhouses you should refer to special books on those topics.

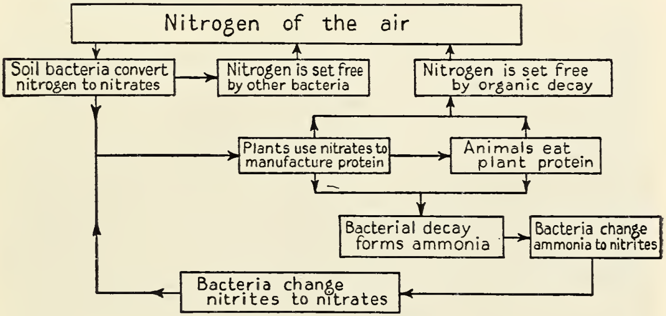
Recently, engineers have devised electrical heating coils to be installed under the soil in the hotbeds. Thus the temperature can be controlled even better than with farm manure.

Part of the joy of gardening is to raise at least a portion of your own seed for the next year. You can thus study the whole life history of a generation of vegetables and flowers. Let some especially fine flowers go to seed. When they are ripe, gather the seed, and place in carefully labeled packages for storage until next spring or planting time.

Field Research:

Read about the work of Burbank, and perhaps you may do a little experimenting with plant breeding and improvement.

201. Rotation of Farm and Garden Crops. — Every plant takes certain minerals from the soil, such as phosphorus, calcium, and nitrogen compounds. Some plants require larger amounts of nitrogen compounds

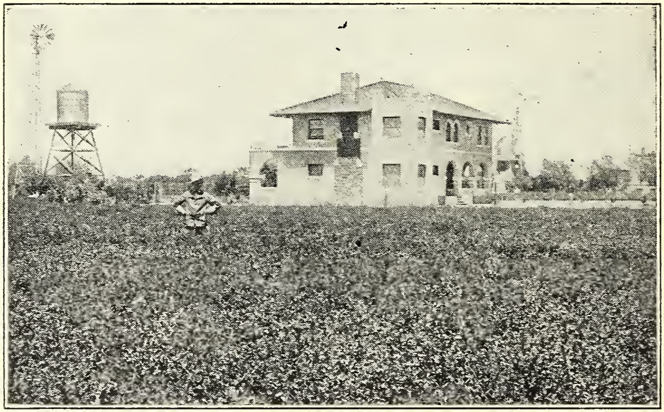


NITROGEN IN NATURE

How many kinds of bacteria are indicated?

than others, and so take excessive amounts of these from the soil. Plants, like clover, alfalfa, and peanuts (and others), contain bacteria in *nodules* on their roots. These take nitrogen from the air and combine it with soil materials to make the nitrogen compounds, thus actually adding nitrogen to the soil. It is a good plan, therefore, to follow a nitrogen-using plant with a nitrogen-adding plant. This plan is called *crop rotation.*

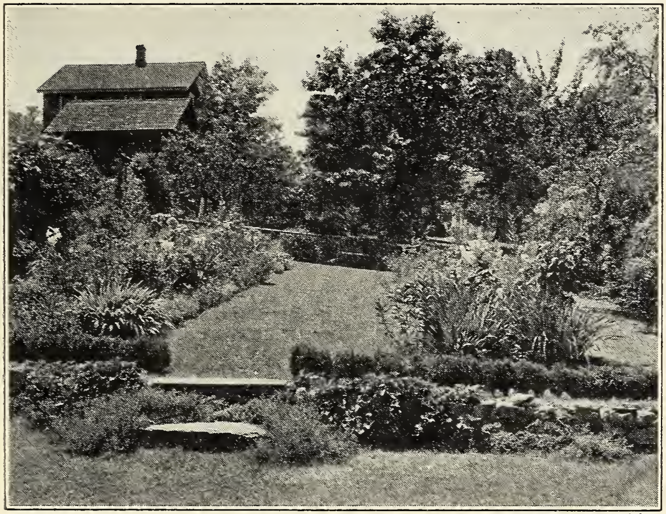
With farm crops, a three-year or four-year rotation is common. In the South, a cotton crop may be followed by oats and then by corn. In the North, root crops, cabbages, and corn may be followed by oats, barley, or wheat. With the wheat will be sown timothy and clover for cropping the following season. Or the wheat may be followed by alfalfa. Clover and alfalfa are nitrogen-adding plants. They may be cropped for two or three years. The exact rotation depends on whether the farm is a dairy farm or grain farm. Always the clover or alfalfa crop is included. Rotation of crops not only gives the soil a chance to recover minerals and



A Crop of Alfalfa in Arizona
Note the windmills used for pumping water for irrigation.

compounds taken from it by the crops, but insects and diseases associated with one crop are likely to disappear while other crops are being sown. Of course with intensive farming as it is practiced in many parts of the United States, chemical analyses of the soil are made and the proper plant foods and minerals are added in correct amounts. Some crops require slightly acid soil, others neutral or alkaline soils. Certain plant diseases thrive in acid soils and not in neutral or alkaline soils. So farming becomes a science of soils and plants.

Garden crops also should be rotated to some extent although soil deficiencies can be made up on small areas with special fertilizers. While you should consult special books on gardening for details on this problem, it will help you to keep in mind that, in general, *leafy* plants should follow *root* plants, and that *shallow root* plants should follow *deep root* growers.



Mattie Edwards Hewitt

A Plan Becomes a Garden

202. The Ideal Garden. — The ideal garden is the one that expresses your own individuality. There are certain fundamental rules which should be followed by good gardeners. But you must apply and adapt the rules to your own special problems of soil, location, and surroundings. Your own choice of variety and color will make your garden different from all others. The success of your garden will depend upon the seed you select, proper planting, and thorough cultivation, and the thought you give to laying out your whole plan in advance.

203. Laying Out the Plan. — Before one lays out a paper plan for landscaping and gardens, he should visit well-planned landscaping projects in parks, private homes, and commercial gardens. Then he should consult books and current garden magazines for suggestions and instruction. If possible, talk with landscape architects.

On a large sheet of plotting paper mark the shape and location of your building, existing trees, shrubs, gardens, roads, and paths. With this as a basis, you can proceed to develop a comprehensive plan.

Your plan should be laid out with an axis of view or central line of development. If your grounds are not level, it may be necessary to include a profile plan to show where you must dig out or fill in to give the grades or slopes the best effect.

The following features are usually included in a landscaping plan and each should receive careful consideration:

(1) Drives and walks.

(2) Foundation planting about building. This consists of evergreens and deciduous shrubs to bring out architectural features of the building, hide walls, and give a tie-up between the building and ground.

(3) Border planting. This is planting along the drives and edges of the plot and consists of trees, deciduous and evergreen, and shrubs, shutting off the garden from public view and forming backgrounds for border beds of flowers.

(4) Lawns and lawn planting. These consist of grass, and specimen trees and shrubs.

Planning a Rose Garden

These landscape gardeners know exactly what they want to do. Explain why they know.

The Rose Garden in Bloom

Are the results of a planned garden justified ?

(5) Hedges, fences, and walls to inclose formal or semi-formal gardens.

(6) Rock gardens and pool.

(7) Arbors, lawn furniture, and the like for decorative effects.

(8) Location, shape, and sizes of perennial and annual flower beds, rose garden, and vegetable garden.

(9) A planting list. Consider the hardiness of trees and shrubs required by your local climate; height, foliage, colors in spring, summer, and autumn.

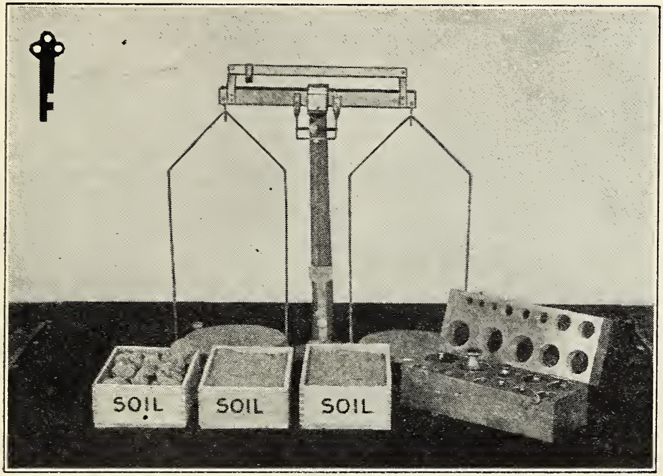
A careful study of the natural surroundings of the home, kinds of soil, drainage, and climate is a desirable preliminary to the laying out of your general plan. A comprehensive plan, even though only small parts of it are planted each season, is better than to plan and plant each part without reference to a unifying plan. Moreover, one derives pleasure in seeing a vision take form gradually. Above all, you should express your own individuality.

204. Garden Tools. — "A workman is known by his tools" holds just as true for a gardener as it does for any other workman. The good gardener buys good garden tools and then takes good care of them. Each time when you have finished using your garden tools, clean off all dirt, and put the tools away in dry condition and thoroughly polished. In addition to tools for working the soil, you will need a simple dusting or spraying equipment to aid in your fight against garden pests.

205. Why Work the Soil? — Your study of soil has shown that water travels through soil by means of tiny tube-like spaces, and that to preserve water in the soil it is helpful to keep the surface soil worked into a fine, loose layer.

(**Key**) ***Experimental Problem 37: Does working the soil help prevent loss of moisture?***

What to use: three flat boxes, holding about two quarts of soil each and three samples of the same soil, except that one sample should be in coarse chunks.



(Key) Experiment 37
Name the parts of the balance.

What to do: Fill one box, *A*, with the coarse chunks, and the other two boxes, *B* and *C*, with finer, pulverized soil. Pack the soil firmly in both of the latter boxes.

Weigh each of the three boxes and set them aside, under cover, for three days. Do not disturb the soil in boxes *A* and *B*, but work the top soil in box *C* until it is finely divided and loose. Do this at the beginning and at least twice each day for three days.

After the third day weigh each of the boxes again and compare their final weights with their first weights.

Calculate the per cent of weight lost in each case.

What happens: Did the boxes of soil lose weight? Did they all lose the same per cent of weight? Did they seem drier after three days, as if moisture had been lost by evaporation? Which box lost the least per cent of weight (moisture)?

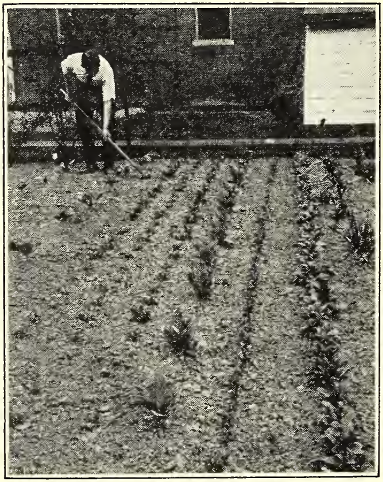
Conclusion: Does working the top soil help to conserve the water in the soil?

Application: Investigate and explain the use of a "paper mulch."

Field Research:

Place a little powdered sugar on the end of a loaf of sugar and set it in a little water colored with ink. Does the ink soak up into loaf? Does it soak up into the powdered sugar? Explain how this illustrates Experimental Problem 37.

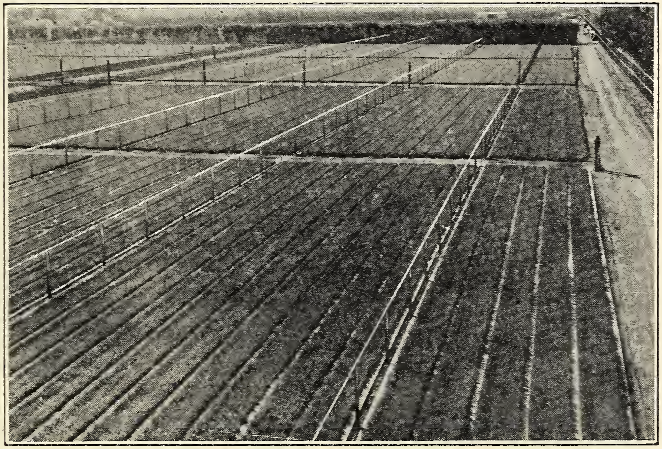
You know that the action of water soaking or traveling up through soil by means of the tiny tube-like spaces is called capillary action. Working the soil to break up the *capillary tubes* is called *mulching* the soil. Sometimes a straw mulch is spread about a plant to help conserve the moisture in the soil.



HOEING ALONG THE ROWS
Why is this necessary?

Working the soil by spading, hoeing, and raking serves also to mix air with the soil. This mixing of air with the soil is called *aëration.* Bacteria at work in the soil need oxygen of the air. The mixing of the top soil with air prevents the soil from becoming *sour* or *acid.* It also retards the growth of weeds, which is most important.

Hoeing is necessary also to heap the soil about the roots of plants as in hilling potatoes, corn, and other vegetables. This helps to hold the plants in place and to keep the light from the roots. If potatoes are left uncovered in sunshine they turn green and taste sweet.



A Nursery of Three Thousand Acres

Seedlings in this nursery are watered by the fence-like rows of pipes.

While working the soil prevents rapid loss of water by capillary action and evaporation, nevertheless some water is lost both by direct evaporation and by *transpiration* through the plant. Transpiration is the process in which water passes out to the under surface of the leaves of a plant, through small pores in the leaf surface. Hence frequent rains or artificial watering are needed to replenish (renew) the supply of soil water. In regions where there are dry seasons, *irrigation* is used to replenish the soil water. Gardens may be watered thoroughly by irrigation only once every three weeks and yet have the soil water conserved by proper mulching. (See page 376.)

All plants, including weeds, not only take minerals from the soil but they use much water. Therefore, weeds should be pulled and seedlings that grow too close to each other should be *thinned* out. Similarly, shrubs and trees should not be too crowded. Even more water is conserved by the elimination of the weeds which results from cultivation than is a result of the mulching.

General Problem 3. How and When Shall the Planting Be Done?

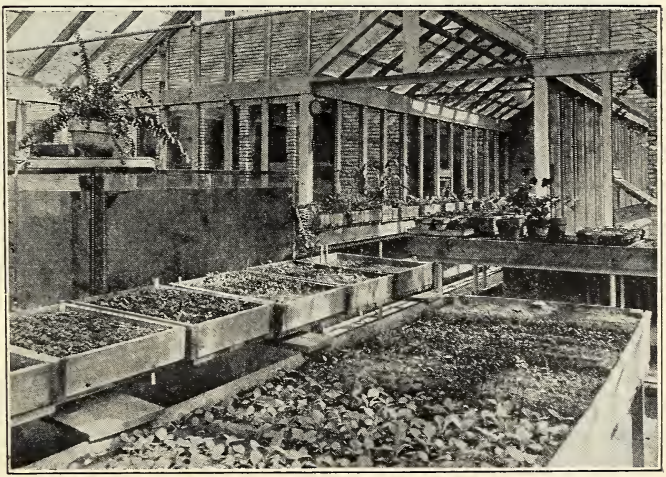
206. Starting Seeds in Flats. — *Flats* are shallow boxes (3 inches to 6 inches deep). When filled with moist sandy soil, they can be used for starting seeds in the house several weeks ahead of planting time outdoors. Seeds should be started in the flats early in February, if you plan to transplant the seedlings into cold frames. March and April is early enough to start seeds in flats for outdoor transplanting.

Especially in localities where the growing season is short, better results follow if seeds are started indoors. Not only many flower seeds, but farm seeds such as cabbage, tomato, and melons are profitably started in this way.

Field Research:

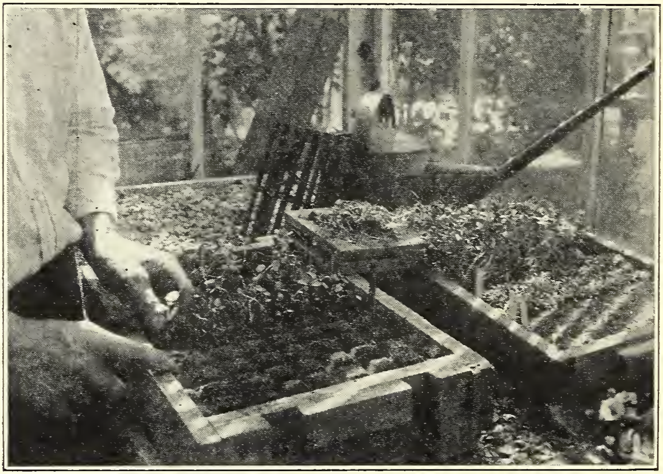
Make a trip to a commercial greenhouse early in February to discover how the workmen are preparing for early vegetable and flower plants. Then prepare a flat for early seed planting. Consult your Science Discovery Calendar for suggestions. The seeds should be covered with firmly packed, sandy soil to a depth of about three times the length of the seed. Keep the flats in a fairly cool room. A temperature of about 60° F. is satisfactory. Moisten the soil a little each day, but do not soak it.

Sowing Seed in Seed Boxes



Flats in a School Greenhouse

207. Transplanting. — The seeds are planted too close together in the flat for proper growth after a few days. Therefore, when the seedlings have grown their second leaf, they should be transplanted either into cold frames or hotbeds, or into other flats where they will be given more room.



TRANSPLANTING SEEDLINGS OF ANNUALS

The soil for transplanting should be a rich loam soil. Your investigations have shown you that the seed contains its own food for the first development, but as soon as the second leaf appears the soil must furnish food-building materials to the plant.

Field Research:

Prepare another flat with moist, rich soil. (Seedlings may also be transplanted into small pots instead of flats.) The night before you wish to transplant the seedlings, they should be well watered.

With a knife or trowel carefully take up a small number of seedlings. Select those that seem sturdiest and set each one in a small hole made with the finger in the soil, and pack the soil firmly about the root. The seedlings should be set in the soil at about the same depth at which they have been growing. They should be set two inches or more apart to give room for proper development.

The plants should be watered daily and placed in sunshine, if practical. If near a window, turn the boxes about, to keep the plants growing straight. As the plants grow larger, they should be gradually accustomed to outdoor air. They can be again transplanted to the outdoor garden as soon as danger of frosts is over. When ready for transplanting to the garden, they should be thoroughly watered the night before.

The soil about the roots should be taken up with the plant. When first set out, the plants should be protected against cold and against too hot sunshine.

208. Transplanting Trees and Shrubs. — Deciduous trees (those that lose their leaves in the fall) are best transplanted before the new buds have started, or after they have dropped their leaves. They are then in a partial dormant condition and able to stand the shock of a change. Roots and branches should be pruned, and the plant set in a hole and thoroughly watered and mulched. The soil must be packed very hard about the roots, and if necessary, the plant supported against the wind by guy strings.

Nursery stock obtained in the fall is usually fresh-dug stock. Spring stock is usually stock that was dug in the fall and held dormant in cold storage until spring. Some spring stock is fresh dug.

Evergreens also become partially dormant in the early fall and may be transplanted then or they may be moved in the early spring. Fall transplantings must have time to make some root growth before freezing weather sets in, hence should be kept well watered.

209. Outdoor Seed Planting. — Seeds are usually planted in rows or hills. Rules for depth of planting are the same as for planting in flats. When the seedlings planted out-of-doors have grown their second leaf, they should be thinned to give proper room for development. After thinning, the soil should be kept cultivated and the weeds eliminated.

OUTDOOR PLANTING
A row of lima bean seeds being sowed in prepared ground.

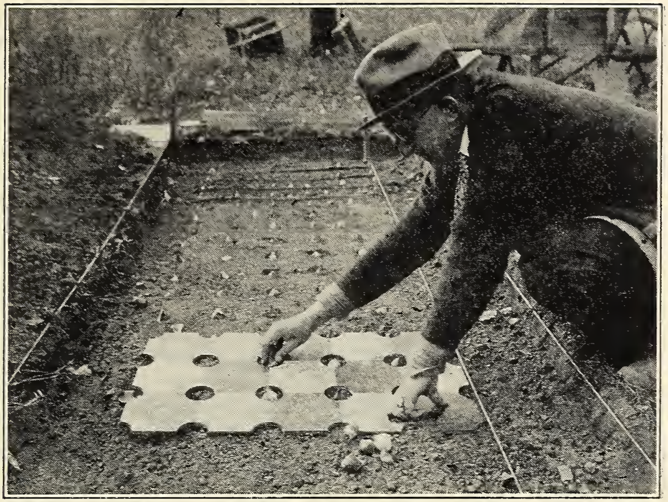
In your garden plan you have provided for successive plantings. You should follow your plan closely.

210. Propagating (Breeding) Plants without Seeds. — Many plants can be started by *cutting* or *slipping* off a branch and letting it take root in water or moist sand. In fact, this is a very valuable method of propagating various plants and shrubs.

Field Research:

If you want to try your hand at this method of propagating plants, you must know what plant to use (see the Science Discovery Calendar) and where to make the cut. At the point where buds grow on the stem — called a *node* — is the place from which roots can be made to grow. To make a cutting of a geranium, begonia, or any non-woody plant, use a sharp knife and cut off the end of a stem just below a node. There should be only one or two leaves above the node.

Place the node end rather deep in moist soil — not too fine,



Planting Tulip Bulbs

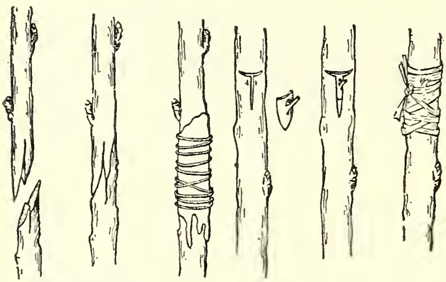
A Field Ablaze with Tulips

Where does the food come from that enables the plant to grow?

for the little stem needs air as well as moisture. After the new plant is well started it can be transplanted to a small pot and later to a larger pot or out-of-doors.

Some plants, like tulips, grow from *bulbs.* These plants form new growths or separate bulbs on the old ones, each year. Therefore, in the summer they may be taken up, separated, and new plants grown from each of the new bulbs. The food stored in the bulb enables it to grow next season.

Some bulbs are often forced for house-flowering in the winter. For this purpose they should be placed in soil in pots and kept very cold (resting) for a few weeks before they are brought into the warm air for forcing. Refer to your Science Discovery Calendar.



GRAFTING BUDDING

Have you ever seen a plant or tree grown in this manner? What was it?

Grafting and *budding* are methods used to propagate many trees and shrubs. By this method a small branch or bud of the variety desired is planted in another tree by opening the bark and inserting the branch or bud into contact with the growing layer of the plant being grafted. Most roses and fruit trees are budded plants. Even shade trees are budded to secure certain characteristics of growth. By such special methods of propagation, it is possible to obtain growing and bearing plants faster than from seeds

Key Words

aëration	evaporation	mulching
annuals	fertilizer	node
budding	flats	organic matter
bulbs	germinate	perennials
capillary action	grafting	propagation
cold frame	hotbed	seeds
cotyledon	humus	soil
crop rotation	irrigation	transplanting
cutting		

Key Statements

1. Soil for successful gardening must be fertilized, supplied with humus, and tilled.

2. A garden, to be successful, must be planned ahead.

3. Annuals produce seed the first year, after which they die; and perennials produce seeds each year for a succession of years before dying.

4. Only tested seeds are worth planting.

5. A seed contains food material to support the growth of a new plant until the plant possesses roots and leaves to enable it to become self-supporting.

6. Hotbeds are heated by decomposing (oxidizing) manure or by electric coils. The glass helps to retain the heat both from decomposition and from the sun.

7. A cold frame is kept warmer than outside air by retaining the heat from the sun.

8. Plants of the family of clover, alfalfa, peas, and peanuts maintain colonies of nitrogen-fixing bacteria on their roots.

9. Rotation of crops is necessary to help eliminate plant diseases, conserve fertility of the soil, and conserve humus.

10. The ideal garden is one that not only produces excellent crops but also expresses the individuality of its gardener.

11. Garden tools will last longer and be more efficient in use if they are always put away clean.

12. Water is conserved in the soil by breaking up capillary tubes, by cultivation, and by destroying weeds.

13. Cultivation of the soil helps to aërate it.

14. Irrigation (artificial watering) is practiced where rain is infrequent during the growing season.

15. For early planting, seeds may be started in boxes in the house or in hotbeds or cold frames.

16. Seeds should be planted out-of-doors only when the soil has become warm enough to insure germination.

17. Certain plants may be propagated by cuttings, others by budding or grafting, and those with bulbous roots by separating the roots.

18. Trees and shrubs may be transplanted successfully when they are dormant.

Thought Questions

1. What is the reason for allowing weeds to start after the first cultivating in the spring, before final cultivating and planting?

2. Why will seeds grow better in finely worked soil?

3. Why is a garden plan and planting calendar desirable?

4. Why are tested seeds preferable to ordinary seeds?

5. Account for the heat formed by the manure in a hotbed.

6. Why must hotbeds and cold frames be ventilated?

7. In rotation of crops, is it desirable to follow one crop with plants of the same family?

8. In what respect is cultivation of the soil similar in its aim to fountains in drinking-water reservoirs.

9. Why will a potato in a hill turn green if exposed to sunlight?

10. Why is it possible to start seeds indoors before it is safe to plant them outdoors?

11. What conditions are required for successful transplanting?

Projects for Your Science Discovery Book

1. Write a story about the local soil in your community, telling how it was formed and from where it came.

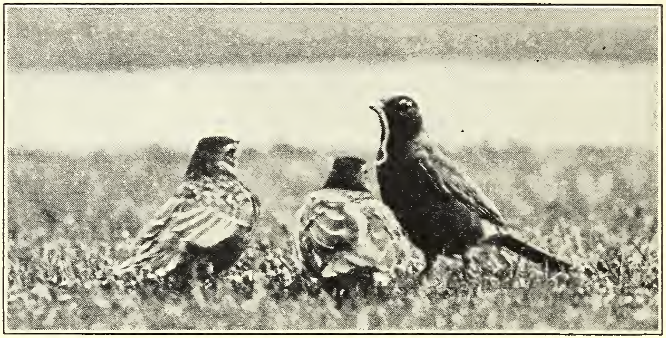
2. Make labeled drawings of a germinating seed of a bean or pea.

3. Make a trip to a near-by farm or country estate, truck, or flower garden and report the facts you discover about its garden plans and crops.

4. Record daily the planting date, date of appearance of seedlings, and other information of interest in connection with the seeds planted in the flats in your schoolroom.

5. Keep a record of your outdoor planting experiments and discoveries.

SURVEY OF TOPIC XV



"The early bird catches the worm." If you are a gardener, you probably hope that this old saying is true. For that reason you will tempt the birds to be neighborly and feel at home in your garden by providing bird houses, bird baths, and feeding stations for them. Birds may sometimes eat plant seeds, but they offset the harm they do by eating the many insect pests that attack your garden in swarms. One way to combat garden enemies, then, is to encourage birds to live in your garden.

You can call on no outside aid to help you with the weeds. You will have to fight them yourself. If you turn your back on them for a moment, or give them the slightest chance, they will overrun your garden, for their roots are tough and their seeds are legion.

When disease attacks your plants, just as when it attacks you, it is time to call the doctor. Science has experimented to learn how to cure these diseases.

Fight your garden's enemies and encourage its friends; destroy the first and foster and make use of the second. When your garden blossoms and bears fruit, all the care and attention and hard work which you have bestowed upon it will be repaid.

TOPIC XV

FARM AND GARDEN FRIENDS AND ENEMIES

A garden is a lovesome thing, God wot!
Rose plot,
Fringed pool,
Ferned grot —
The veriest school
Of peace; and yet the fool
Contends that God is not —
Not God! In gardens! When the eve is cool
Nay but I have a sign:
'Tis very sure God walks in mine.

— Brown

Do you know:

1. **Why weeds are hard to get rid of?**
2. **What an insect is, what it eats, and how it lives?**
3. **How to tell the difference between a beetle and a fly?**
4. **How to protect your plants?**
5. **How birds help you with your garden?**

General Problem 1. How Can Weeds Be Controlled?

211. Ways of Weeds. — Everything that grows has its share of beauty. It is not surprising, therefore, that some weeds in bloom are beautiful to look at; and that others have interesting foliage. But weeds rob the soil of water, minerals, and space needed by your garden plants. Therefore, the weeds must go.

212. Control of Weeds. — Weeds have certain characteristics that enable them to live and propagate even under unfavorable conditions. This makes them difficult to control. Some such weeds are *toadflax, burdock, pigweed, ragweed, mustard,* and *dandelion.*

The *dandelion* has a very tough root that is difficult to kill. The stem can be broken off again and again and new stems will grow. The root can be broken and still it will survive. The juice of the dandelion is bitter; therefore, animals will not eat the leaves. The flower head of the dandelion is really many single flowers bunched together; hence there are many seeds from each flower head. When each seed ripens, it is equipped with an air glider so that it is carried about by the wind.

Field Research:

Collect some dandelion seeds and examine them with a magnifying glass to discover how the seed can be carried by the wind.

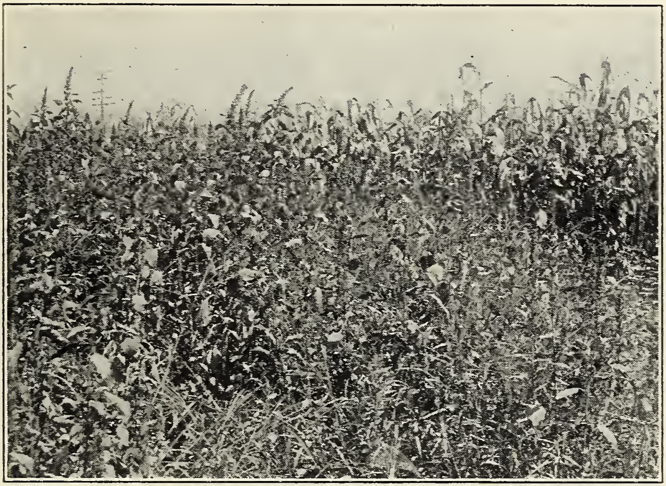
The common *mustard plant* with its small, yellow flower produces a large number of tiny seeds that are very hardy. The seeds will survive many hardships, such as extreme cold, wet, and dry spells, that would harm other seeds. The weed is best controlled by cutting down the plants before the seeds ripen.

Pigweed and ragweed also develop many hardy seeds and must be controlled by keeping them cut down before the seeds develop.

Field Research:

Collect specimens of two or more common weeds that have seeds nearly ripe. Take them to school and count the number of seeds contained in each plant.

Toadflax, burdock, milkweed, wild carrot, and *mullein* (or mullen) are weeds that cause much damage. All together it is estimated that weeds do more than half a million dollars' damage every year. The large number of seeds per weed, their vitality, the ease with which they are distributed, and their adaptability to many



PIGWEED CROWDS CORN

Observe closely to distinguish the weed. What effect has it caused?

conditions of soil are reasons why the weed is an important problem of the gardener and the farmer.

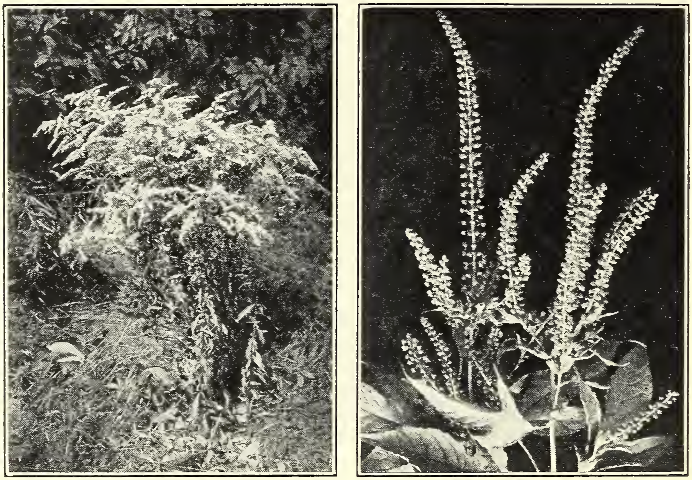
Annuals among the weeds may be practically exterminated in a locality in one season, if none are allowed to go to seed. *Biennials* (plants which produce seeds the second year and die) and perennials are more difficult to get rid of.

Some weeds such as *ragweed* and *goldenrod* distribute pollen that cause nasal troubles in some people. Other weeds such as *poison ivy* are poisonous to the skin.

These weeds should be completely destroyed. Other weeds contain medicinal substances, and should be conserved.

Field Research:

Learn to identify the poisonous kinds of weeds that occur in your locality and know what to do if you or someone else is accidentally poisoned by any one of them. See that such weeds are destroyed in your community.



Goldenrod and Ragweed

What disagreeable effect has the pollen of these two plants?

General Problem 2. How Do Insects Hinder Our Work?

213. Insect Pests of the Garden. — "War to the bitter end" would be the slogan of our insect enemies if they could talk. Man's task of conquering and controlling the vast hordes of destructive insects is gigantic. It will require your coöperation and that of everyone else if it is to be successful. With the aid of science and the natural enemies of harmful insects, there is hope.

It is said[1] that the "damage wrought by insects every year nullifies the labor of a million men."

You have learned something of the rapid increase of flies, if they are not controlled. With many insects the rate of increase is much greater than that of the fly.

Spraying Cabbages with Poison

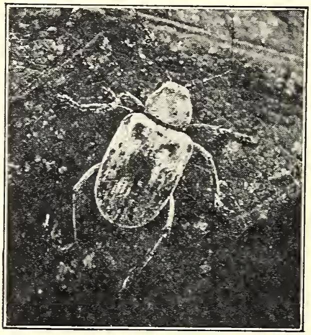
The spraying will destroy the root worms.

While there are millions of different kinds and varieties of insects, your problem as a gardener will have to do only with a small number, some of them harmful and some useful. Certain classes of garden insects attack the roots of young plants while others suck the juice from the plant; still others eat the leaves.

214. Root Eaters and Others. — One variety of insects is known as *root maggots*. They attack the roots of young turnips, radishes, cabbages, and onions.

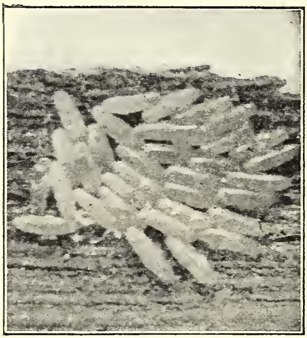
[1] "The Greatest War of All Time, Man against the Insect," by M. K. Wisenhart, in *The American Magazine*, March, 1928.

The winged female (fly stage) lives through the winter and deposits her eggs in the soil very early in the spring. In a few days the eggs hatch and the larvae that are formed begin at once to eat any tender

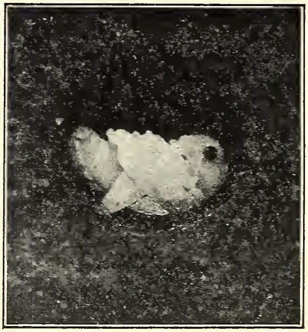


Adult Beetle

Larva



Egg Cluster



Pupa

Life Stages of the Grape Root Worm

roots that are available. At the age of three to four weeks, a larva changes to the pupa stage, that is, it forms a case about itself in which it rests or is dormant for two weeks. During its resting period it changes to the winged stage and breaks from its cage. The winged female deposits her eggs, and so a generation is completed. Each batch of larvae feed largely on roots of plants. Several generations of root maggots are produced each season and they are able, therefore, to do much damage.

Another enemy of plants is the *cutworm.* Its life history is very similar to that of the root maggot.

Gypsy Moth

Name the three stages illustrated.

These insects are attacked by man by collecting and destroying the larvae or by using poisoned bait in the soil before the seeds are planted. The cutworm in the winged stage has two pairs of wings. It is a moth and flies usually at twilight or at night.

Other injurious moths are the *codling moth* (injures apples), *leaf rollers, gypsy moth, browntail moth,* and the *white-marked tussock moth.* The *apple-tree tent caterpillar* is a destructive larva that changes into a moth.

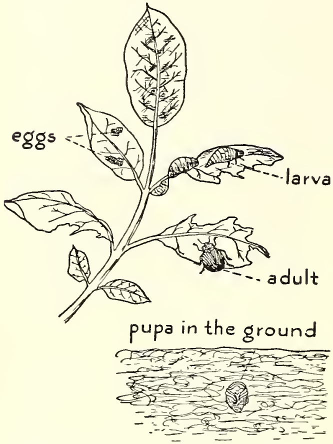
Field Research:

Select one of these moths and make a study of its life history, the damage it does, and methods of control. (See Science Discovery Calendar for suggestions.)

215. Juice Suckers. — The insects called *juice suckers* have mouths adapted to sticking into the leafy parts and stems of plants and to sucking the juices.

Plant lice or *aphids* are a familiar example of these insects. The common *squash bug* and the apple *red bug* are other examples. They are true bugs. Their life history is similar to that of the *butterfly* and *moth.*

There are many species of plant lice. Their eggs, laid in the fall, last over winter and hatch out into lice in the early spring and are matured in a week or ten days. Many of the lice from the winter eggs are females which bear many young. There are as many as three or four generations in a season. The eggs laid in the fall carry the race over the winter months.



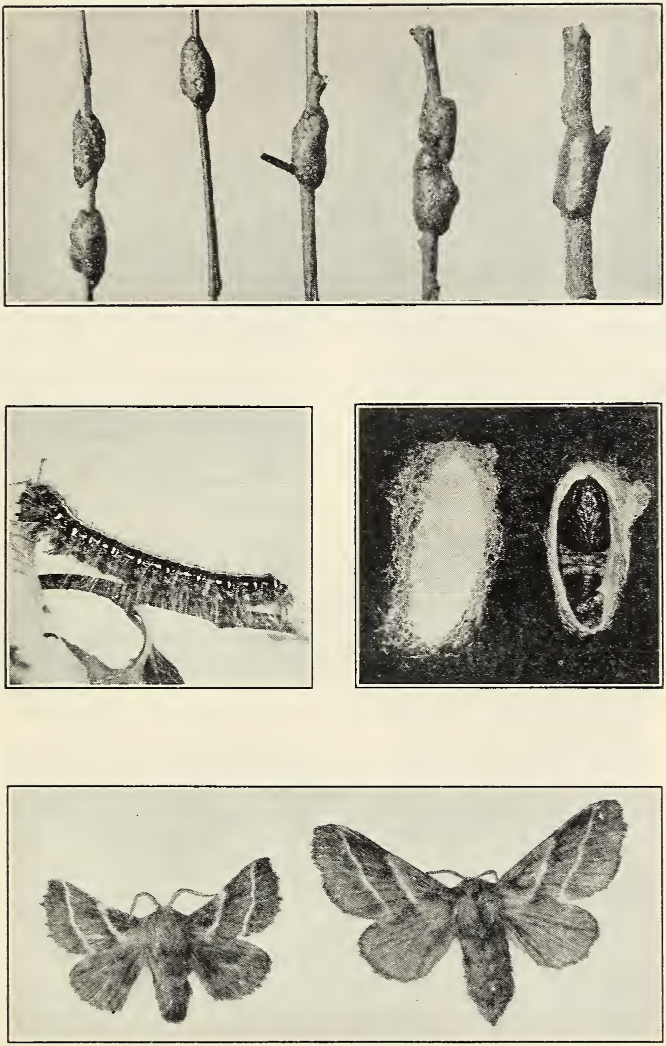
LIFE HISTORY OF THE POTATO BEETLE

In which stage are the leaves eaten? How does this harm the potato plant?

216. Beetles. — The common *potato bug* or *potato beetle* is an interesting as well as a destructive insect. There are many varieties of beetles. Their life history is much like that of other insects. The egg hatches into a larva, which is usually called a *grub.* Then comes the pupa or resting stage and finally the adult insect with its hardened, armor-like wings.

Some beetles like the potato bug feed on plant tissues and some feed on other insects. You can protect your potato patch from the potato beetle by hand picking, or by spraying the leaves with poison.[1]

[1] Directions for spraying or dusting are given in garden bulletins issued by the Department of Agriculture, Washington, D. C.



LIFE STAGES OF THE APPLE TREE TENT CATERPILLAR

Can you name each stage?

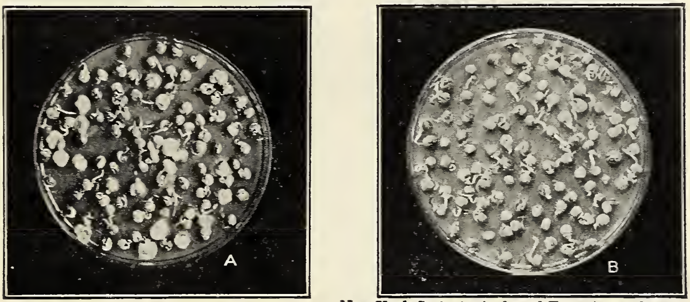
N. Y. S. Agricultural Experiment Station

The Apple Red Bug

Science Takes a Hand

A power-driven sprayer brings swift death to the caterpillars.

Study pictures of beetles in your reference books to make sure you can distinguish those that do harm from those which are helpful, like the *lady-bird beetles.*



New York State Agricultural Experiment Station

TESTING PEA SEEDS FOR DISEASE

A contains some infected seeds. Can you find them? The seeds in *B* are all healthy.

GENERAL PROBLEM 3. WHAT ARE SOME PLANT DISEASES?

217. Plants Get Sick. — *Pasteur*, the great French scientist, little thought that his wonderful discovery of germs and how they distribute disease among animals and mankind would contribute to the health of plants and the saving of millions of dollars. Plants have contagious diseases that are caused by germs. Therefore, it is important to recognize some of the most common diseases so that you may know whether to treat a diseased plant by spraying or dipping, whether to quarantine it, or perhaps destroy it by burning.

In connection with our gardens we are especially interested to know the symptoms of a sick plant and

New York State Agricultural Experiment Station

DISEASED PEARS

The first one is a victim of "San José scale" and the rest of leaf rollers.

New York State Agricultural Experiment Station

TREATMENT OF POTATOES FOR BLIGHT

How does this picture illustrate the method of science?

what to do to prevent other plants from catching the same disease. Certain kinds of bacteria cause a *blight* of the leaves and young stems of fruit trees such as quince, pear, and apple. Germs may enter a plant through the pores, or through a branch which has been broken or cut. The germs are distributed by contact of diseased plant material with healthy material or they are carried by insects from one plant to another. *Cabbage black rot* is a bacterial disease which afflicts cabbages and turnips.

Bread Mold

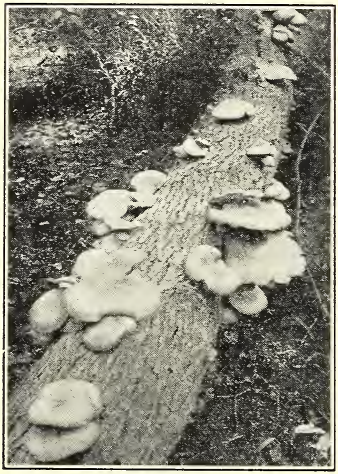
Another class of organisms, called *fungi*, cause even more plant diseases than do bacteria. One fungus with which you are familiar is the ordinary *bread mold.* Mold grows also on bacon and other foods.

Field Research:

Place a piece of damp bread on a plate and cover it with a glass. Observe the formation of mold for three or four days. Examine some of the mold with a microscope.

Toad stools, puff-balls, and *mushrooms* are examples of fungi.

Mold fungi occur in different colors. However, they do not contain any of the green coloring matter, called *chlorophyl,* of ordinary plants, and so cannot manufacture starch as do the green plants. Since fungi cannot make starch (food for themselves), they must live on other plants to get their food. The plant on which they live is called the *host*. Other plant diseases due to fungi are *rust* on grain; *mildew*, which occurs on many plants, especially on fruits like the grape; *potato scale; club root* on cabbage; and *corn smut*. Blights that cause leaves of plants to curl or dry up and drop off are diseases caused by fungi.

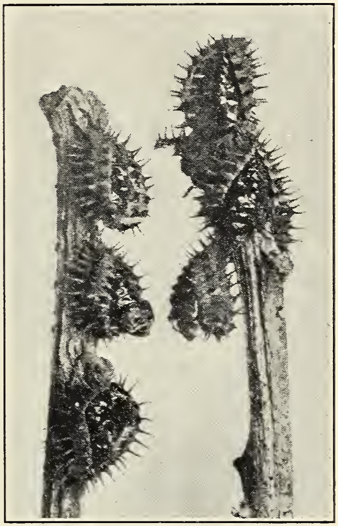


FUNGI

218. Control of Plant Diseases. — Bacterial and fungus diseases of plants are controlled by *fumigation* to destroy the germs, by proper tilling and aëration of soil that has become infected, and by crop rotation. To be a successful gardener, you must let science help you fight the enemies of plant life which enter your garden.

GENERAL PROBLEM 4. WHAT IS THE ARMY OF THE DEFENSE?

219. The Organization of the Gardener's Army. — The gardener, of course, is the commanding general; Nature is his chief of staff; the insects are his infantry; the toads, his artillery; and, coöperating all up and down the line are his aërial scouts, the birds. These divisions constitute the first line of defense, but they are ably helped by many special units which the commanding general calls to their aid. An army must be fed, trained, and directed, and its general must know all of its needs and capacities for service, if he is to be an efficient commander. Because you are the chief of your garden army, you must know the needs and abilities, the habits, and strength of your helpers.



Larvae of the Lady-bird Beetle
How has this beetle helped in our war on insects?

220. Habits and Adaptations of Insects. — The life history of useful insects is essentially like that of the enemy insects. Their habits or customs differ. Many of the enemy insects are *vegetarians*, as, for example, the potato beetle. Members of the infantry are *carnivorous*, that is, they prey on other insects at one stage or another of their life history. Usually they make their attack on the vegetarians. The lady-bird beetle, our familiar friend the lady-bug, eats countless numbers of plant lice. There are more than 2000 species of these beetles, all but a few of which feed on small insects or on eggs of insects. They are usually bright-colored with dark spots on the wing covers, or dark-colored with bright spots. The mouth parts are adapted for biting.

The *praying mantis* is a most interesting insect. His long-jointed, front legs have claws on the end with which he captures unwary insects.

Field Research:

Fix the appearance of a praying mantis in your mind by looking at the picture, then try to find one in your yard. If you find one, capture it and place it with grass and twigs in a glass with a cloth cover. Catch a fly and put it in with the mantis. Watch the actions of the mantis to find out how it moves, catches its prey, and how it eats.

The *ichneumon* (ĭc-nū′mon) fly is among the most important fighters of the garden infantry. There are many kinds of ichneumon flies. Some lay their eggs beneath the skin of their victims. When the eggs hatch, the larva bores its way into the body of its *host* (the living thing upon whose tissue the larva will live), feeding upon the fat and blood of the host until it completes its growth. Some ichneumon flies lay their eggs on the skin of the insects they attack, and others lay theirs near the host insect so that the larva after hatching may find its way to its prey. Organisms that live upon the living tissue of other living organisms are called parasites.

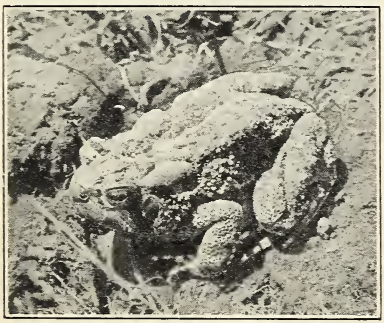
A Praying Mantis

What special adaptation does this insect possess for catching flies?

221. Protection for the Infantry. — If we are able to recognize our friends among the insects, we can leave them unmolested. They are able, for the most part, to take care of themselves. Establishments, however, are provided for the scientific breeding of certain much-needed insects such as the lady-bird beetle, which can be distributed to localities requiring help in the insect war.

An Ichneumon Fly
Is it a friend or foe to man?

222. Toads, the Heavy Artillery. — Science has shown us the way to secure facts and to use the facts to form judgments. Do you believe the toads cause warts to grow on the hand that touches them? It is a fact that the toad has a warty-looking skin, but no one ever "caught" warts by handling toads. If you can find a toad in your garden, and you are fortunate indeed if one lives there, capture him and examine him closely. He will neither bite you nor give you warts. In fact he will rather enjoy the warmth of your hand. By your observations you have learned that the toad has a lightning-quick tongue with which he catches flies and other insects. He is especially fond of large larvae or grubs that try to destroy the roots and leaves of your garden plants.



Our Friend, the Toad
Are you superstitious?

Toads and frogs are cousins and have much the same manners and customs, except that the adult frog prefers to live in and near the water, while the toad is more adventurous. He travels long distances from the pond where he was once a little tadpole, living in the water, and breathing by means of gills much as a fish breathes.

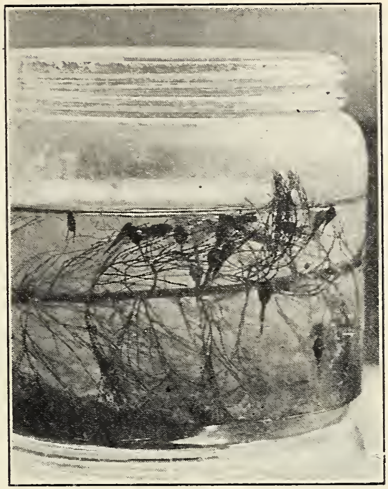
TADPOLES

How can they live in water? If they become toads, can they live in water? Why?

In the country or in your garden, he breathes by gulping air into lungs that developed when he became too old to use his gills.

Very early in the spring the toads travel to a pond to lay and fertilize their eggs. The female toad lays the eggs in the water and the male toad deposits *sperm* (fertilizing) cells over them. These find their way into the eggs, one sperm cell for each egg. Once inside the egg, the *nucleus* (center of development) of the sperm cell unites with the nucleus of the egg. The union of the two nuclei is called *fertilization*, and unless this takes place the eggs will not hatch.

The toad passes the winter in a hole in the ground or lake mud, where he hibernates.

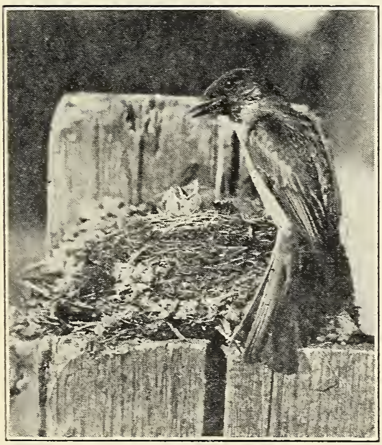


A Tadpole Aquarium

Field Research:

Collect some toads' eggs in the early summer, and put them into an aquarium where you can watch them hatch out into tadpoles. After a few days their hind legs appear and then the tail disappears.

Since toads help to protect your garden by eating large numbers of insects, you should protect the toads. Leave their resting places undisturbed, and do not destroy their breeding places. Tell others what you have learned about toads, and enlist their co-operation in protecting them.



Phoebe
Of what does she make her nest?

223. Birds, the Air Scouts. — Two common birds of the garden and field, the *phoebe* and *kingbird*, make a specialty of darting after flying insects. Phoebe will tell you her name, if you listen. The kingbird shows a white band across the end of his tail as he darts from a branch to capture his prey in the air. Unfortunately, these birds do not always confine their attacks to the enemy. They may devour some useful insects. However, on the whole they are efficient assistants to the gardener. There are several other fly-catchers with which you will become acquainted in your field trips.

Field Research:

Some day when insects are flying about, sit quietly in a convenient spot (take your Field Research Notebook with you to record your observations at the moment) and watch for fly-catchers. Field glasses will help you to observe markings on the birds.

Note the ways of flying of the different birds, where they perch, their size and special markings, and the shape and size of their beaks. Listen for their calls.

Record your observations and later try to identify each bird you see by reference to your notebook.

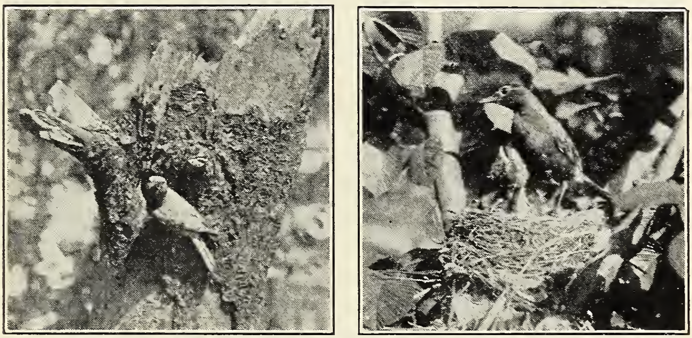
224. Seed Eaters. — Have you planted your garden seeds or sown some grass seed only to have some birds come along and help themselves to a free banquet? Or have they eaten the ripened seed before harvesting? It is true that birds cannot tell the difference between your garden seeds, if they happen to become exposed to view, from the seeds of weeds. However, without the feathered seed eaters it would be very difficult to keep weeds under control. Birds consume hundreds of tons of weed seeds. The *chipping sparrow*, *song sparrow*, *white-throated sparrow*, and the sprightly little *goldfinch* are members in high standing in the Weed Seed Eaters Bird Club. How many other members do you know?

Field Research:

With your field glass, your Field Research Notebook, an alert ear, and quick eye, go out to discover the seed eaters. Note their size, markings, where they hide when frightened, and the shape and size of their beaks. Is there any connection between these characteristics and what the birds eat?

The goldfinch is one of the few birds that sings as it flies. Listen for his song.

225. Grub and Worm Eaters. — You have learned that the larvae of some insects are called *grubs.* They are worm-like but are not true worms. The grubs will change to the insect stage, if they live. True worms,



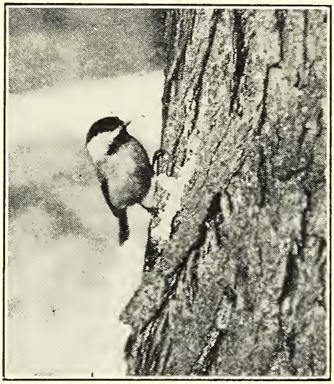
THE HOMES OF BLUEBIRD AND ROBIN

How do their nests differ?

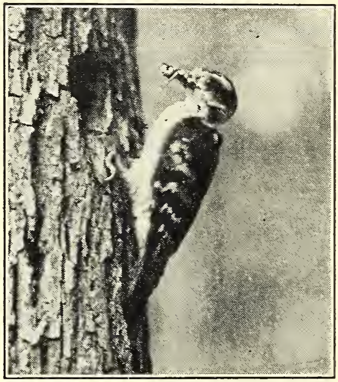
like the earthworm, reproduce new worms. But they do not go through the changes which mark the life history of insects.

Many birds are very fond of both true worms and the worm-like grubs. Such birds are especially helpful to the gardener and farmer in eating many tons of insect grubs. *Bluebirds, robins,* and *orioles* have great appetites for grubs.

226. Birds That Search Out the Tiny Insects. — Have you seen the quiet, prim, little *brown creeper* hopping along the trunk or branches of a tree, hunting a tiny insect? Frequently he starts at the base of a tree and hunts along up the trunk and limbs, then darts to the base of another tree. Another little bird, the *white-breasted nuthatch*, often works head downward as he travels from branch to trunk. Both of these birds



Chickadee
Can this bird whistle?



Downy Woodpecker
How does she build her nest?

devour enormous numbers of tiny insects and eggs that are overlooked by less observing birds.

Then there are the happy little *chickadees* which flit from tree to shrub calling their own names as they alight to capture their prey and protect your garden. They do their bit in the battle with the insects.

Except for the *humming birds*, the *kinglets* are among the smallest of our birds. They like the insects that are found on evergreen trees like the hemlock and spruce.

The *warblers* are not really good singers although they do sing very high notes, so high that some people's

THE BALTIMORE ORIOLE

We welcome, do we not, our timid guest;
Upon our tallest elm, if he will stay.
He and his mate will hang their hammock nest
Where the light zephyrs, that forever sway
The pendent leaves, shall rock their babes to rest.

— COBURN.

ears cannot hear them. There are many kinds of warblers, all small, beautiful birds. They keep very busy eating little insects and eggs.

The *woodpeckers* are all helpers, especially the big *hairy woodpecker* and the little *downy woodpecker*. These birds stay in many northern localities all winter and work incessantly, protecting our fruit and shade trees.

227. The Musicians in the Garden Army. — Nearly all birds are useful and nearly all eat insects, insect eggs, and seeds. You have become acquainted with some birds that have special likes for certain foods, but you should remember that they do eat a variety of foods just as you should. But they do not spend all their time eating. A few birds are good musicians and it will give you much pleasure to know these birds and their songs. Their songs cannot be described; you must hear them over and over again to appreciate them. Which do you think is the morning bugler? which the evening?

The songs of the *robins* and *bluebirds* you must know. Then try to hear a concert by a *wood thrush* or a *hermit thrush*. The hermit thrush is considered by many to be the finest singer of them all. The *mocking bird* of the South is a wonderful singer, which sings not only his own songs but imitates songs of other birds.

Field Research:

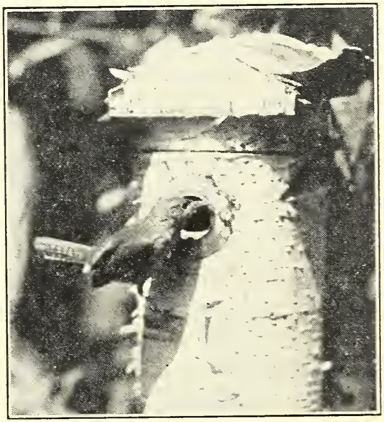
Before and during nesting time the birds sing their best. It will pay you to sit quietly near a wooded lake or stream or retreat in your park at sundown and listen to them. At sunrise, too, the bird concerts are in full swing.

Learn the songs and calls of your most common birds and then try to hear the hermit thrush, the wood thrush, or others of the great bird singers.

228. Bad Birds. — Probably all birds do some good, but a few have bad reputations because some, like the *English sparrow* and the *starling*, drive away other more useful birds. The *cooper's hawk*, the *sharp-shinned hawk*, and the *goshawk* are three bad birds because they rob other birds' nests of eggs or young and attack many smaller birds. Other hawks are most helpful because they eat large numbers of mice and similar animals, called *rodents*, and so prevent millions of dollars' damage to crops and fruit trees.

Cooper's Hawk
What harm does he do?

229. Bird Homes. — In many localities, the woods and forests have been cut away. Orchards and woodlots, if well kept, have no decaying branches and holes have been plugged. In such places, birds that build nests in holes have few suitable choices. Stone walls and fences that formerly furnished nesting places are disappearing from towns and villages, so that there are few natural home sites for birds.



Mrs. Wren at Home
Can you recognize her song?

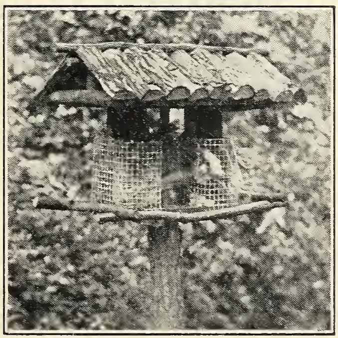
Some birds will nest in boxes put up for them, if the boxes are at a proper height from the ground and have a satisfactory size and entrance. Bluebirds and wrens will be likely to nest in your yard, if you provide living accommodations for them.

A BIRD-HOUSE BUILDING CONTEST

With the help of your science teacher, your bird club chairman, and your woodworking instructor, get up a contest for building bird homes, bird baths, and winter feeding stations. Make an exhibit of everything constructed, for the benefit of the judges and members of your school. In your Science Discovery Calendar you will find helpful suggestions.

230. Bird Baths and Feeding Stations. — In the summer, birds must have water for drinking and bathing. If you provide bird baths, many birds will visit your yard and help in its up-keep. A bird bath should not be very deep and should have sloping sides so that a bird may wade into deeper water gradually. It

A Rustic Bird Bath



Bird Feeding Station

should be placed on a standard, if near shrubbery, or away from shrubbery, if placed on the ground, so that the house cat cannot sneak up and capture an unsuspecting bird.

In parts of the country where winters are rather severe, birds that stay the year round may have difficulty in securing enough food. Therefore, to help these winter birds, you should build feeding stations and keep them supplied with food. Suet tied to a tree will coax the woodpeckers to visit your yard.

A Cute Kitten

Cuteness will not keep him from killing birds.

231. Bird Protection.—Cats destroy many millions of useful birds every year but do not, as many people believe, catch many mice and rats. The chief natural prey of cats is the bird. If you must have a house cat, keep him well fed and he will not be so likely to want to hunt for birds. Keep him shut in during the early morning and during the evening, since these are his natural hunting times. Tie a bell about his neck to attract the birds' attention if he tries to waylay them. Have all stray and homeless cats taken away by the Humane Society or other authorities. With your knowledge of the value of birds to your garden and how to attract and protect them, you should be able to do your share toward their conservation.

Field Research:

Get a copy of the bird and game laws and learn what birds are protected by law. Report violators to the proper authority in your locality.

General Problem 5. How Does Plant Life Continue?

232. Plant Reproduction. — The natural function of a plant is to reproduce more of its kind. The methods of reproduction vary in different kinds of plants. We are interested just now in the kind of plants that grow flowers. Such plants depend upon the flowers to produce the seeds from which new plants will grow, provided they receive the necessary care in planting, cultivation, and protection from disease and insects. Helping to provide proper conditions for flower and seed development are matters of great importance in the garden.

Cosmos

The three stages shown here in the development of the many-petaled variety are the result of plant breeding.

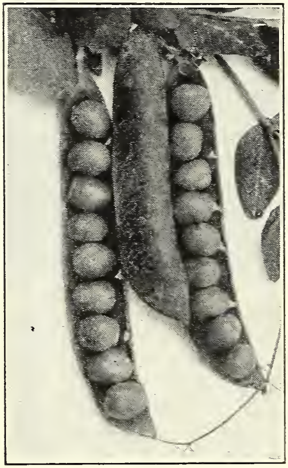
233. The Flower. — The plant obtains food-building materials through its roots from the soil, and through its leaves from the air. As the plant matures, flower buds appear and finally the flower opens and discloses the wonderful parts from which the seeds develop. Many flowers have color to attract helpful insects; others attract by a fragrance.

The colored part of the flower is usually a *whorl* of *petals*. Outside the petals may be found a whorl of green, leaf-like parts. Each flower has a particular number of petals which is a help in identifying it. In a row inside the petals are little slender parts called *stamens* and each stamen has a cap called the *anther*. In the center of a perfect flower is found the *pistil* with a head on top and an *ovary* (seed case) at the bottom.

Field Research:

Many flowers, for example, sweet peas and violets, have specially shaped parts. Collect as many different shaped flowers as possible, and try to identify each part. Flowers lacking either stamens or pistils are imperfect flowers. Some maples have imperfect flowers.

Have you ever dusted yellow powder from a lily or dandelion onto your hand? That yellow powder consists of tiny grains called *pollen*. It forms on the anthers of the stamens. If the flower develops properly, some pollen grains will be dusted onto the head of the pistil and will send a slender hair-like shoot down through the pistil to unite with little seeds-to-be, *ovules*, in the seed case, the *ovary*.



PEAS

What part of the flower forms the pea pod? the pea?

Field Research:

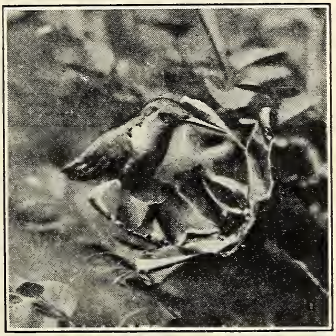
The pod is the ovary of the pea blossom. The ovules, when fertilized, become the seeds, and when they ripen, they can be planted to produce a new plant.

With a magnifier, examine a cross section of ovaries of two or more different kinds of blossoms to see whether the ovules are of the same shape and number in different blossoms. Try to discover whether they are alike in shape, arrangement, and number in blossoms of the same kind. Cherry and apple blossoms are suggested for study. What use could be made of the facts you have discovered?

The process by which pollen travels from the anther to the pistil is called *pollination*, and the process by which a part of the pollen (the nucleus) unites with the ovules is called *fertilization*. Unless the ovules are fertilized, they will not develop into seeds that can grow new plants. Pollination and fertilization, therefore, are two very important processes for the production of seeds, and anything that helps or hinders this process is of vital importance to the gardener.

Field Research:

If you have a microscope at home, or one at school which you are allowed to use, with the help of your teacher examine pollen from two or three different kinds of flowers to find out whether all pollen is alike in shape, size, and color.



A Humming Bird

Why do flowers welcome this little bird?

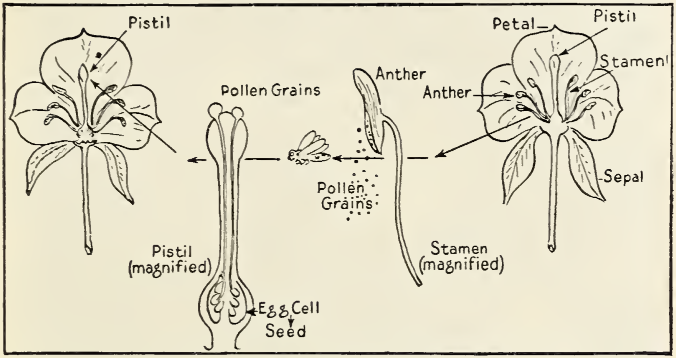
234. Flower Visitors. — Have you ever tasted clover-flavored or buckwheat-flavored honey? If you have, you must conclude that the bees that made the honey visited clover blossoms or buckwheat blossoms to obtain the *nectar*. Nectar is a sweet liquid which many flowers form and store near the base of the pistil and stamens, sometimes in little special cups. Its use is to persuade insects and small birds like the humming bird to pay the flower a visit. Colors and odors, you have learned, seem to attract some insects. There is a very good reason why Nature has planned this to be so.

235. Insects Help Pollination. — A few flowers are so arranged that the pollen of their stamens is likely to get to their own pistils. Such pollination is called *self-pollination*. However, in some flowers stamens may be missing or the pistil may be missing, or the flower may be arranged so that the pollen of one flower cannot

Pollen-Laden Bumblebees
Where do they carry the pollen?

fertilize the ovules in the ovary of the same flower. Sometimes the ovules and pollen in the same flower do not ripen at the same time, hence pollen from one flower is necessary to fertilize the ovules of the other. For these reasons the insects and birds are needed to help the process of pollination.

An insect, the bumblebee, for example, may light on a flower to drink its nectar. While doing so, some of the pollen rubs off the stamens onto his coat. Perhaps the next flower (of the same kind) which he visits needs this pollen which may drop from the bumblebee onto the pistil of the second flower. In this way the bumblebee



CROSS-POLLINATION
Explain how the bee helps. What is the function of each part of the flower?

aids pollination. Thus many insects aid pollination. While the wind helps by blowing pollen from one flower to another, the work of insects is very necessary. Such a transfer of pollen from one flower to another is called *cross-pollination.*

A BUTTERFLY SIPPING NECTAR
Are butterflies helpful or harmful?

In many cases cross-pollination produces improvements over self-pollination and, as you have read above, in some plants cross-pollination is absolutely necessary if parts of a flower are missing, or if the flower is so constructed that it cannot be self-pollinated. Cherry, plum, and peach

A Moth Visits a Lady's-Slipper

This is a Promethea moth. Are moths beneficial or harmful to plants?

blossoms require cross-pollination by means of insects. The honey-bee is the most essential insect for this work, so fruit growers frequently raise honey-bees in their orchards. Butterflies in the winged stage, moths, and flies are also helpful.

Your study of the insects and their relations to your garden has helped you to realize how important scientific knowledge is to the production of food for the world. Without knowledge of the habits of insects and birds, and of characteristics of soil, of seeds, plants, and flowers, gardeners and farmers generally would have a pretty hard task to feed mankind. In the next chapter we shall investigate the harvesting and care of our crops.

Key Words

anther
beetles
birds
bread mold
burdock
chlorophyl
cocoon
codling moth
cross-pollination
cutworm
dandelion
fertilization
flower
fly catchers
frogs
fungi
gills
goldenrod
grub
hawks
hibernate
honey-bee
ichneumon fly
insects
lady-bird beetle
larva
life history
medicinal
mildew
milkweed
mullen
mustard
nectar
nucleus
ovary
ovules
parasite
pests
pigweed
pistil
plant lice
poison ivy
pollen
pollination
ragweed
reproduction
root eaters
seeds
sperm cell
squash bug
stamen
tadpole
toads
toadflax
vegetarian
warblers
warts
weeds
woodpeckers

Key Statements

1. Weeds are difficult to control because they produce many hardy seeds, or hardy roots.

2. A knowledge of the life history of weeds is fundamental to their successful control.

3. There are hordes of insect garden pests which must be controlled, but others are very useful to the gardener.

4. A knowledge of the life history of insects is necessary to their control.

5. Plants may contract contagious disease in much the same way in which animals may.

6. Plants are attacked by other plants called fungi, which live on the host plant and eventually kill it unless the fungi are destroyed.

7. Some insects help in the control of other injurious insects by eating them, by eating their eggs, or by laying eggs in their bodies from which larvae hatch out and destroy the host.

8. Toads should be protected because they destroy great numbers of insects.

9. The toad lives the first part of his life as a water animal and the second part (adult stage) as a land animal.

10. Certain birds are especially active in eating seeds, and thus are very helpful in the control of weeds.

11. Many birds like grubs and worms, others like seeds (weeds), and still others like flies. Such birds are helpers of the gardener.

12. All birds have calls and a few have beautiful songs, by which you may know them.

13. There are a few varieties of birds classed as pests because they seem to do more harm then good.

14. Birds can be encouraged to stay in your neighborhood if you will provide them with nesting places, nesting material, water for bathing and drinking, and food.

15. Cats are the greatest destroyers of birds.

16. The natural function of a plant is to reproduce its kind.

17. Flowers contain the organs of reproduction in plants.

18. Pollination, one step in reproduction of plants, consists of the transfer of pollen from the stamens to the pistil.

19. Fertilization, the second step in plant reproduction, consists of the union of the nucleus of a pollen grain with the nucleus of an ovule (egg cell).

20. Birds and insects help transfer pollen and so aid the process of pollination.

21. When the pollen of one flower is transferred to the pistil of another flower, the process is called cross-pollination.

22. The honey-bee is essential to the satisfactory cross-pollination of many fruit trees.

Thought Questions

1. Account for the wide distribution of weeds.

2. How do control measures differ for weeds that are annuals, biennials, and perennials?

3. Account for the abundance of weed seeds.

4. Why are weeds objectionable?

5. How does a lady-bird beetle differ in customs and manners from a tomato worm?

6. Why are some insects called "biting" insects?

7. Why are some insects called "sucking" insects?

8. What difference in the use of insect poison is required for biting and for sucking insects?

9. Explain how it is possible for an animal to live first as a water animal and then as a land animal. Does a land animal ever change to a water animal?

10. What does hibernation mean?

11. What peculiarities of the phoebe cause it to be called a fly-catcher?

12. What sort of beak must a seed-eating bird possess? How would it compare with a fly-catcher's beak?

13. What characteristics, other than shape, size, color, and markings, should help you to identify birds?

14. Why will bird baths help to keep birds in your yard?

15. How does a plant take in water and minerals through its roots?

16. Where do plants get the energy to enable them to make their food from the raw materials?

17. Why must pollination take place before fertilization?

18. Why do flowers have colors and perfume?

19. How are new plant varieties produced? Consider cross-pollination.

20. Why is the honey-bee a most necessary insect?

Projects for Your Science Discovery Book

1. Make a collection of all the different kinds of weeds that grow about your house and tell how each one is propagated. Suggest a plan for the control or extermination of each.

2. Draw a picture of a dandelion seed and suggest a plan for controlling it. How can you put your plan into operation?

3. Make a list of poisonous weeds; of weeds that contain medicinal substances.

4. Examine the soil about a plant that has been cut off by the cutworm to see if you can find the cutworm larva. Put the larva into a cage with some soil and plants and observe it in its various stages. Describe your discoveries.

5. Make some labeled drawings of mold from your own observations.

6. Study the actions of a toad; find out what he eats and how he catches his prey, and if he has a home spot, and if so, when he stays there.

7. Observe the habits of a robin, bluebird, and oriole to find out what they eat, and what they feed their young at nesting time. What is the song of each?

8. Describe a woodpecker, what it does, how it flies, and why it is colored as it is.

9. Make a labeled drawing of the parts of an apple blossom, trillium, or other flower.

10. Report on how many kinds of flowers in your garden are visited by insects and what insects make the visits.

UNIT VI. CONSERVATION

LOOKING AHEAD INTO UNIT VI

The conservation of natural resources and of health is fundamental to the highest development of the human race. Such conservation is the great problem and opportunity of science.

Science has added many comforts and conveniences to our life. It has developed machines to labor for us; it is banishing disease from the earth; and it is helping us more and more to adapt ourselves to our environment.

Your study of the ways of the universe, the cause and effect of seasons, why the weather changes, the properties and uses of water, principles of sanitation, the growing and harvesting of foods, has helped you to understand your environment. Through this understanding you should be able to adapt yourself to your environment so that you may live a richer, more useful life.

Consider well the meaning and truth of the inscription in the dome of the National Academy of Science at Washington:

> *To Science — Pilot of Industry, Conqueror of Disease, Multiplier of the Harvest, Explorer of the Universe, Revealer of Nature's Laws, Eternal Guide to Truth.*

SURVEY OF TOPIC XVI

Is there anything lovelier than the sun shining through jars of ruby-red currant jelly, as it cools on the kitchen table? Or anything better than the odors of spices, and vinegar, and sweet, syrupy fruit juices, that fill many a kitchen throughout the land, after the autumn harvest?

The housewife has found many ways of storing the surplus of the garden and the orchard. Many a cellar is a sight to behold with its winter supply of foodstuffs — turnips, squash, and beets on the cool, earthy floor; potatoes and apples overflowing bins and barrels; jars of berries, fruits, and vegetables crowding the shelves hanging from the beams.

The magic of science has constantly improved these methods of conserving and preserving foods, until to-day we have the iceless refrigerator, the cold storage warehouses, the refrigerator cars, and the method of quick freezing of foods so that none of their flavor is changed or lost.

TOPIC XVI

FOOD CONSERVATION

They's something kind o'harty-like about the atmosphere
When the heat of summer's over and the coolin' fall is here —
Of course we miss the flowers, and the blossoms on the trees,
And the mumble of the hummin'-birds and buzzin' of the bees;
But air's so appetizin'; and the landscape through the haze
Of a crisp and sunny morning of the airly autumn days
Is a picture that no painter has the colorin' to mock —
When the frost is on the punkin and the fodder's in the shock!

— RILEY

Do you know:

1. What the word *conservation* means?

2. How to tell when potatoes are ready to dig?

3. The relation of temperature to the preservation of stored potatoes, cabbage, or carrots?

4. A food that cannot be satisfactorily stored fresh for very long?

5. What causes foodstuffs to spoil?

GENERAL PROBLEM 1. WHY GROW VEGETABLES IN YOUR GARDEN?

236. Fresh Vegetables. — Vegetables gathered from your garden are usually better than those from the store because they are fresher. More than that is the satisfaction of supplying your table with the product of your own work. If your garden plans for planting are right, your garden will supply you from early summer until late fall.

The unedible leafy parts of your vegetables should be placed in a *compost* hole and allowed to decompose.

The compost, as the decomposed matter is called, can be used as fertilizer for your garden next spring and so will return to the soil some of the materials taken from it by the plants.

237. The Harvest. — The time of harvest lasts from the pulling of the earliest onion or radish to the

A Harvest of Canteloupes

What kind of climate does this fruit need?

gathering of your latest product. However, the time of gathering the supply for winter is the harvest time of poetry and song.

Fruits and vegetables must be gathered when they are at the proper stage of development. Otherwise they will not keep well. Fruits for canning or for winter storage should be picked before they ripen too much. Hard-root vegetables are ready for gathering when they stop growing. Parsnips are not injured by freezing and so may be left in the ground all winter. Potatoes continue to grow until the tops dry down. They are injured by freezing and so should be harvested before frosts come. The successful harvesting of crops all over the country is a very important item in the amount and cost of our fruit and vegetable food supply.

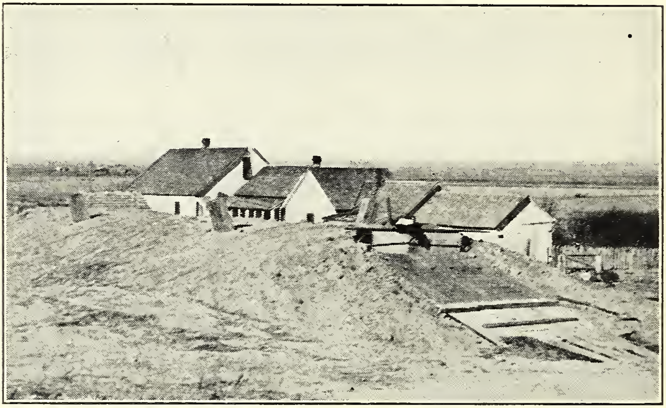
General Problem 2. How Should Foods Be Stored?

238. Air Conditions. — The proper storage of fruits and vegetables is a problem of ventilation, air temperature, and air humidity. The storage space should be clean, dry, and dark. The air temperature for most fruits and vegetables should be maintained between 33° F. and 40° F. (Why do you think the low temperature is necessary?) Certain fruits which contain considerable amounts of sugar can be kept at a temperature at or near freezing.

Field Research:

Secure a thermometer and determine the freezing temperature of samples of pure water, water with sugar dissolved in it (one pint of water to three tablespoonfuls of sugar), and apple juice. For a freezing mixture use two parts of crushed ice to one part of coarse salt, well mixed.

239. Stored Products. — Potatoes and cabbages should be placed in bins arranged to allow for ventilation. Near the end of cold weather they will need to be sorted over to take out any that are decaying and to remove sprouts from the potatoes, if such have started. Root vegetables such as carrots, beets, and turnips may profitably be placed in clean, dry sand in the storage room. It is best to leave a small portion of the stem on the vegetable.



Ewing Galloway

A Potato Cave

Four carloads of potatoes may be protected here from freezing weather.

Fruits such as apples, pears, quinces, and grapes should be kept very cold and well ventilated. It is more difficult to keep fruits in good, fresh condition for several weeks or months than it is to keep vegetables satisfactorily.

Field Research:

Take samples of carrots, potatoes, apples, pears, and grapes to school and accurately weigh each and record the weights.

Set each object on a side bench and weigh each again at the end of two days; and still again at the end of a week.

From the first and second weight and first and last weight of each object calculate the per cent of weight lost.

Which food lost the largest per cent by weight? What relation has the loss of weight to the character of the skin in each case?

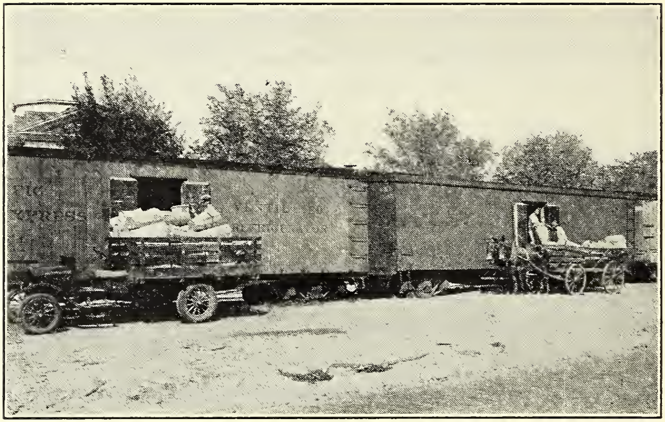
240. Cold Storage. — A cold storage place may be a building so constructed that the walls prevent, to a considerable extent, the passage of heat from the inside to the outside, or from the outside to the inside. Heat always tends to travel from warm objects to cold objects. Anything that obstructs the passage of heat is called a *heat insulator*. Therefore such a building, once it is cooled to the correct temperature at the beginning of the winter, will not ordinarily become cold enough to allow freezing to take place inside, neither will it warm up rapidly during warm spells or as spring advances. Hence some vegetables will keep very well in it.

The better cold storage plants are built with very efficient insulating walls, and the temperature inside is controlled by artificial means. In these places, low temperatures can be maintained at all times, even through the hottest weather. Furthermore, because different food materials require different air conditions, temperature, and humidity, they can be placed in rooms where the best conditions are maintained.

Application of scientific principles to the preservation of raw foods results in many savings; for example, bumper crops can be kept for long periods, or may be transported in cold storage cars to distant points.

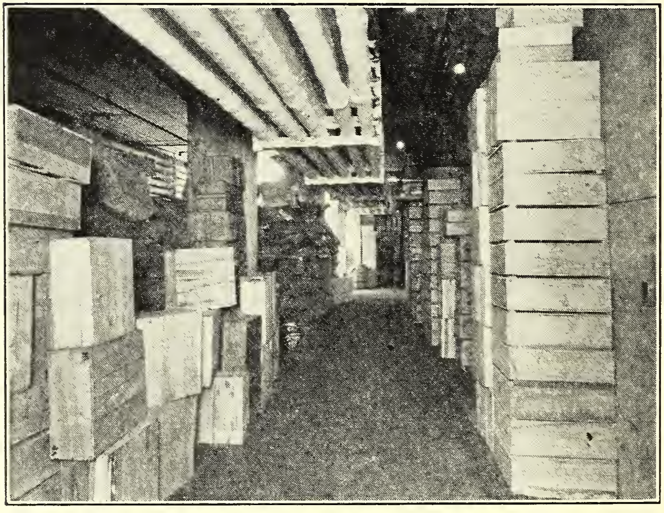
General Problem 3. How Are Foods Conserved in the Home?

241. Preservation Principles. — You have learned that decay is usually caused by germs, by fungi called molds, and by mildews. You have learned also that these organisms thrive best at warm temperatures and



Shipping Lettuce by Refrigerated Cars

How has refrigeration affected the marketing of vegetables and fruit?



A Cold Storage Warehouse

Explain how the pipes are used.

in the presence of moisture. The preservation of food, therefore, depends upon (1) a temperature so low that the organisms become inactive (they are not killed as a rule by low temperatures); or (2) upon the removal of moisture; or (3) destruction of the decay-producing organisms contained in the food; or (4) the addition of substances that prevent or retard the growth of decay-producing organisms. Frequently a combination of methods is used.

(KEY) EXPERIMENT 38
Why must the petri dishes have covers?

(Key) ***Experimental Problem 38: Will germs and molds grow best when cold (40°–50° F.), warm (90°–96° F.), or hot (212° F.)?***

What to use: Samples of stale moist bread; clean raw potatoes; 9 petri dishes and covers; agar solution; a refrigerator; an incubator (oven that can be kept at a temperature of 90°–100° F.); and a hot air oven that can be kept at a temperature of 212° F.

What to do: A. Place three samples of the moist bread in three petri dishes. Expose each one to dust and cover with a beaker. Label them "cold," "warm," and "hot," and place accordingly.

B. Cut three thin slices from the center of the potato and place one piece in each of three petri dishes. Cover each and place the covered dishes in a sterilizer and sterilize them for twenty minutes (heat them at 220° F. for 20 minutes).

Moisten your fingers and lightly rub a spot on each piece of potato, using a different finger for each slice.

Label the dishes respectively "cold," "warm," and "hot," and place along with the bread samples.

C. Place melted, sterile, nutrient agar in each of three sterile petri dishes with covers. Allow to cool and expose to the air in a dusty room, or allow a fly to track across the agar in each dish.

Label "cold," "warm," and "hot," and place the dishes with the others.

What happens: After 24 hours examine each material (by looking through the glass cover which should not be removed). Record your observations and continue the experiment another 24 hours.

Examine and compare your observations with those of the previous day.

The experiment with the bread may have to be carried on for several days.

Conclusion: Under what temperature conditions do molds and bacteria grow best?

Application: What may cause moist clothes to mold if they are rolled up and put away?

242. Heat Methods. — Vegetables and meats may be preserved by placing the food in a container and heating it to a temperature high enough to kill all the germs and spores of molds. The container is then closed air-tight while still hot. Heat kills the organisms, and the sealing prevents other organisms from entering.

The required temperature is usually secured by placing the can in boiling water, or in a pressure cooker which makes possible a higher temperature than that of boiling water. The pasteurizing of milk illustrates the effect of heat upon certain germs, although the temperature is not so high as is used for canning.

A MILK PASTEURIZING PLANT

How does pasteurizing milk help conserve community health?

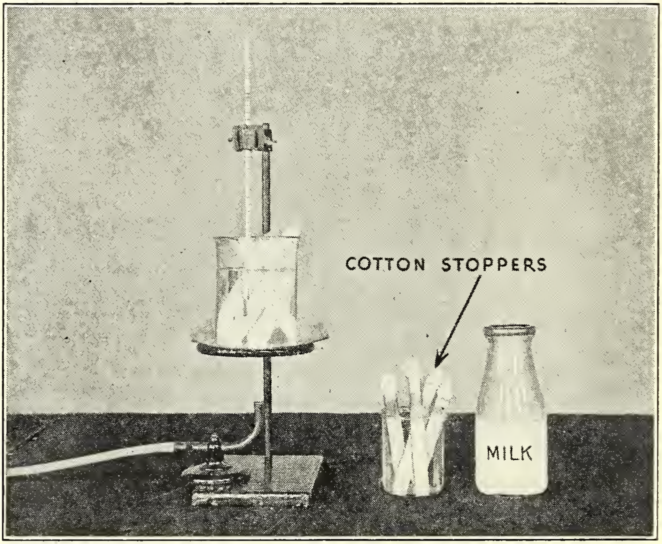
The pasteurizing temperature, 145° F., does not kill all the organisms in milk. It does, however, kill most of those which cause milk to sour, and it kills those organisms that might cause diseases such as typhoid fever and tuberculosis.

Experimental Problem 39. — *Will heated (pasteurized) milk keep longer without souring than unheated milk?*

What to use: Test tubes; a thermometer; cotton; a large beaker; wire gauze; a tripod; a Bunsen burner; fresh, raw milk.

What to do: Half fill ten test tubes with milk and close the ends with tightly packed cotton stoppers. Label the test tubes 1 to 10

Put tubes 1 to 5 in the beaker and add water until it reaches to the top level of the milk in the tubes. Place the beaker on a wire gauze on the tripod and apply heat. Heat the water in the beaker to a temperature of 145° F. and maintain that temperature for 20 minutes.



EXPERIMENT 39

Why are the tubes closed with cotton?

Remove the test tubes from the water and cool them rapidly. Set all ten tubes with the milk in them on a side bench or table in your science room.

After one day examine tubes 1 to 6, and on each succeeding day examine and record observations of tubes 2 and 7, 3 and 8, 4 and 9, 5 and 10.

What happens: In which set of tubes did the milk keep sweet longer?

Conclusions: State briefly how the souring of milk may be retarded.

Application: Why must pasteurized milk be cooled quickly?

Cooking has for one of its purposes the killing of organisms that might otherwise cause the food to spoil quickly. Meat especially will keep much longer after cooking. Moreover, disease-causing organisms are killed by thorough cooking.

243. Drying Methods. — Bacteria and molds need warmth, food, and moisture to grow. These organisms cannot live without moisture.

Field Research.

Prepare two beaker-covered dishes as in Experimental Problem 38, one with moist bread, and the other with dry bread. Set in a warm place for two to five days. In which case does mold grow better?

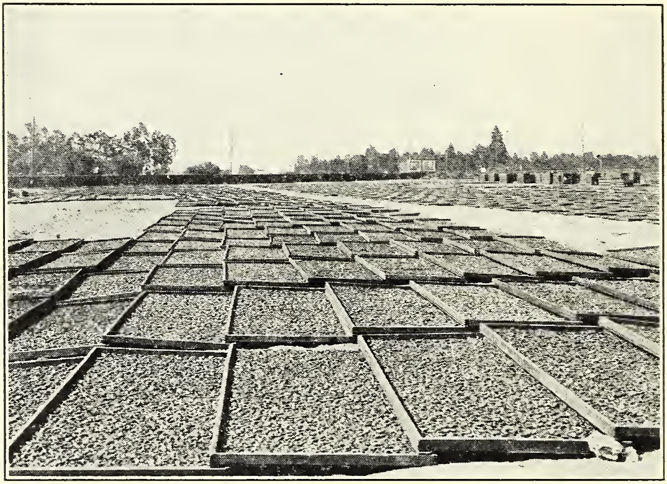
Secure some powdered whole milk. Dissolve one measure of powdered milk in the proper volume of water. Put it in a glass and set it where it will be warm for two or three days. Put a measure of the powdered milk by itself in another glass and set it with the first.

When the milk solution has turned sour, dissolve the dry milk in some water and find out whether it is also sour.

Apples are sometimes preserved by drying thin slices. For use later, the dried apple is placed in water, during which time it absorbs water and swells. It can then be used as a substitute for fresh apples.

Fruits, vegetables, and meats are dried by artificial means so that the water is removed rapidly without overheating the foods. They thus retain practically all of their essential substances, and when water is added, they are very nearly like the fresh foods of the same variety. Sun-dried fruits are considered better than those artificially dried. Drying is the oldest method for the preservation of food. Sometimes the drying is supplemented by smoking or salting.

244. The Chemical Method. — Common chemicals used for the preservation of food are salt, smoke acids, and sugar. The presence of large quantities of salt (in meats and vegetables) and sugar (in jellies, preserves,



Drying Apricots in the Sun
How is this a method of preservation?

and candied fruits) prevents or retards the growth of the organisms that cause decay. The use of salt and sugar as preservatives, for example, in pickling or making jellies, depends upon the process of *osmosis* (the mixing of two liquids by passage through a thin membrane or porous wall). All organisms depend upon the transfer of liquids by osmosis. Plants take water from the soil by osmosis through their roots. Land animals get oxygen into the blood and get rid of carbon dioxide from the blood by osmosis. One-celled plants and animals obtain their oxygen and food materials by osmosis.

Any organism that tried to work in concentrated salt or sugar solution would have its body liquids pass out by osmosis to dissolve the salt or sugar. In other words, the organism would dry up and die. On the other hand, molds can grow on the outside of substances like salt meats and jellies. The mold growth does not penetrate the material and so can be easily removed.

There are several chemical compounds, such as borax, sulfites, formaldehyde, salicylic acid, and sodium salicylate, which are used to preserve foods. Very small amounts of these substances dissolved in the food material will prevent the growth of germs and molds.

While salt and sugar used as preservatives are known to be harmless from long use, that fact is not known for certainty about the more recently used chemicals. Therefore their presence in a food must be indicated on the label. Also the amount of preservative put with the food must be stated on the label.

245. The Cold Method. — Most fresh meats, fruits, vegetables, and milk and cream are for immediate use in the home. Knowledge of the causes of decay enables us to care for such foods most efficiently. Not only do fresh foods need special attention, but opened canned goods need care to prevent waste. Even though the canned goods have a special preservative in them, the food will spoil quickly if left in a warm place.

You have learned that the organisms that cause decay and spoiling of foods are inactive at low temperatures; therefore the best method of caring for foods that are to be kept for a short time only is the cold method. The foods may be kept in a cold cellar, in which case the cellar should also be dry and free from mold growths on the walls and floors. Or they may be kept in refrigerators during warm weather, and in cold rooms during cold weather. In any case, foods such as milk, cream, and butter should be kept covered to prevent them from absorbing impurities.

Small fruits and vegetables, and sometimes fish and meat, are preserved for long periods by freezing. Special freezing methods result in very rapid freezing of the material without destroying the texture of the tissue. When thawed out, the food has retained its natural freshness. This method makes it possible to ship berries, cherries, peas, and other food products great distances without deterioration.

General Problem 4. How Does the Refrigerator Operate?

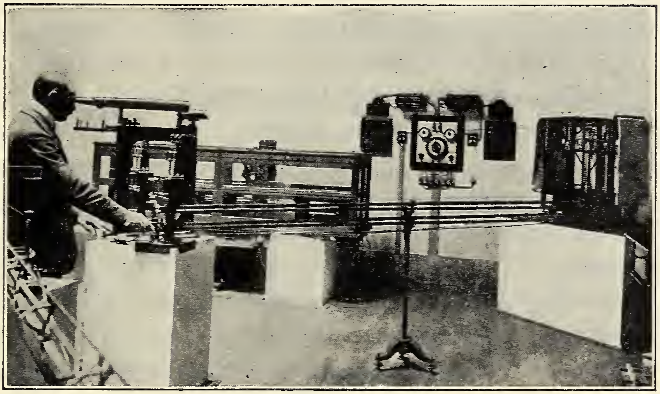
246. Heat Transfer. — The refrigerator is a small-sized cold storage plant. Its function is to keep perishable foods cold enough to prevent them from spoiling. The building of a good refrigerator depends upon a knowledge and application of the principles of *heat transfer*. You know from experience that if one end of a metal rod is heated for a few minutes, the other end becomes warm or hot. The heat is transferred from one end of the rod to the other. On the other hand, a stick of wood can be held in the hand by one end even though the other end is on fire. In the latter case, heat is not transferred from one end to the other. The metal is a *conductor* of heat and the wood is a *non-conductor* of heat.

Field Research:

Test samples of copper, aluminum, glass, stone, brick, and porcelain to find whether they are conductors or non-conductors of heat.

The terms "conductor" and "non-conductor" are relative, that is to say, all substances will conduct heat to some extent. Those that do so very poorly or slowly are called the non-conductors. Those that do so readily or quickly are called conductors, meaning good conductors.

The transfer of heat by *conduction* is from particle (molecule) to particle (molecule). Ordinary matter is



A Delicate Balance

To prevent the heat from the body from expanding the parts of this delicate balance, the operator handles the weights from a distance by means of long rods.

composed of very tiny particles called *molecules*. Molecules are too small to be seen even with powerful microscopes. The molecules in matter are all in rapid motion, something like little rubber particles bouncing against each other.

When a substance is heated, the molecules bounce faster and harder. When the substance is cooled, they bounce slower and with less force.

When some solids are heated hot enough, they melt and form liquids (example, ice to water). The molecules in liquids bounce faster and harder than in solids. When certain liquids are heated, they change to the gas state (example, water to steam). In gases the molecules bounce still faster and harder than in liquids.

The molecules of liquids and gases can move about much more freely than those in solids. In fact, in solids the molecules are confined to the particular shape and space occupied by the solid. In liquids, however, the molecules move freely enough to enable the liquid to pour, to flow to lower levels, to fill any shape of pail or tank. Except for slow loss by evaporation, liquids will stay in a container without a cover.

In gases, the molecules move so freely that they separate enough to fill any space offered. If half the molecules of the air are taken out of a bottle, the other molecules will at once separate enough to fill the bottle. They do not like to be crowded. To keep a gas in a container it must be tightly covered.

If a sample of a gas is heated, the molecules bounce faster and harder and therefore require more elbow room. In other words, in a warm gas the molecules are farther apart than in a cool gas. A certain portion of the warm gas will have fewer molecules in it than an equal portion of cooler gas. This explanation will help you to understand why warm gases are lighter than cold gases.

You have already learned that winds are due to the unequal heating of the air. The cold, heavy air exerts more pressure than the warm, light air and so the warm air is pushed up. This also happens when a portion of the air in a room comes in contact with a hot stove, steam radiators, or hot-water radiators.

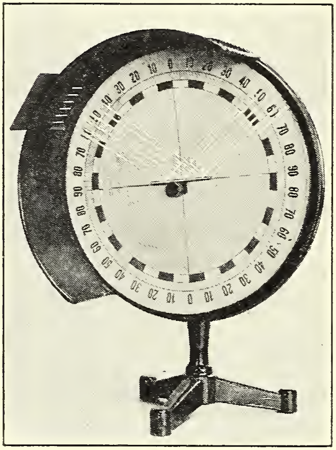
The transfer of heat from a hot object to other objects by a circulation of gases is called *convection*. The circulation of the gases results in currents called convection currents.

Convection is the principal method by which heat is transferred or distributed in liquids and gases. It is possible because the molecules are free to move from one place to another. *In convection, the heat is carried from one place to another by the molecules, while in conduction the heat is handed along from one molecule to the next.*

A third method by which heat is transferred you have already learned to know as *radiation* (page 49). You know that if you stand near a hot campfire, your face and the front of your body quickly become too hot, while your back continues to stay cold. The heat seems to come straight from the fire until it strikes you and there it stops. A wire screen placed between you and the fire cuts off the heat for a time. These facts are well known to you by experience.

Out-of-doors on a bright sunny day, the heat seems to come straight to you from the sun. While hot objects seem to give out heat, actually they are sending out a form of energy that does not heat up gases through which the energy passes, and the heat does not appear until the energy strikes a body. It then changes into heat energy. The body absorbs the heat and becomes warm.

Energy, called *radiant energy*, is given off in straight lines in all directions from hot solids. The hotter the body, the more energy it radiates. The radiant energy is changed to heat energy only when it is stopped and absorbed by another body. Radiant energy does not depend upon molecules to "carry" it along nor to "pass" it along; it can, therefore, pass through a vacuum. If this were not true, it is difficult to understand how we could derive heat from the sun or from burning fuels.



Reflected Light Rays

Can you give evidence that heat rays also can be reflected?

Radiant energy is in many respects like light. It can be reflected by surfaces and it can be focused (rays brought to a point) by a lens.

Field Research:

Focus the rays from the sun through a hand lens or magnifier on to your hand. Do the focused rays burn your hand more than the unfocused rays? Draw a diagram in your Science Discovery Book to illustrate how the sun's rays may be focused.

Try focusing rays from a red-hot object in the same way.

Try reflecting the energy from a fireplace with a mirror or piece of polished tin.

Knowing how heat is transferred through solids and through gases, we should be able to construct a wall that will largely prevent the transfer of heat by conduction, convection, or radiation.

247. Refrigeration Construction. — Since the refrigerator is a device in which to keep things cold, the sides, top, and bottom must be built to prevent the transfer of heat from warm outside air to the cold air and food inside the box.

The material used for the sides, top, and bottom is generally wood, since wood is a non-conductor of heat. The walls are hollow and filled with air. Air is a poorer conductor of heat than wood but heat is transferred through air by convection, if the air is free to circulate. Therefore, the air space in the walls is broken up into small air spaces by putting in packed, non-conducting porous material such as sawdust, broken-up charcoal, mineral wool, cork, or celotex.

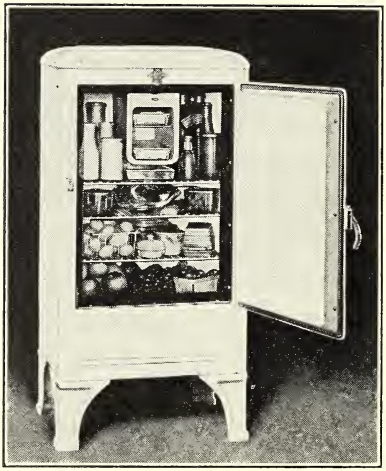
Moisture generally increases the ability of a substance to conduct heat; therefore the walls of the air space are lined on the inside with moisture-proof paper or other material. Material that helps to prevent the transfer of heat is called *insulation*. Lining the walls with aluminum helps to prevent loss of heat by radiation.

248. Cooling the Refrigerator. — Because the refrigerator is built with non-conducting walls, warm air inside will stay warm unless the heat is taken from the air and food in the refrigerator. This is usually done by placing ice in the box. When the ice melts, it takes heat from the air. The water from the melted ice drains out, carrying the absorbed heat with it.

When food is placed in the refrigerator, it is warmer than the air in the refrigerator; therefore the food gives up heat to the air and becomes cold. Ice melts and absorbs this heat from the air, keeping it cold. The water runs out, carrying with it the heat brought in with the food. Since ice melts at the surface only, the cooling of the air is more economical if the ice chamber is kept nearly full of ice.

Instead of ice for cooling, it is possible to use an artificially cooled tank placed in the ice chamber. This method is better than the ice method since it is possible to keep the air at a more uniformly cold temperature. Moreover, this method is automatic and therefore requires less attention.

The ice, or the cooling tank, is placed at the top of the refrigerator, preferably at one side. Air in contact with the ice gives up some of its heat and becomes cooler and heavier than other air in the refrigerator. Hence it sinks to the bottom and pushes the less cool air up the other side, where the latter takes heat from the foodstuffs. This warm air then moves to the ice, gives up its heat, and sinks. The heating of the air by the food and its cooling by the ice cause a continuous circulation of air in the refrigerator.



An Iceless Refrigerator
Is the arrangement of food a good one? Why?

A good refrigerator must maintain a temperature of about 42° F. under the ice, and not more than 50° F. at the top of the food chamber.

Explain why some foods should be placed in the colder parts and others in the less cold parts of the refrigerator.

If the refrigerator is built so that good air circulation occurs, the air will deposit much of its moisture on the ice or tank. Dry air results. You have learned that molds and bacteria grow best in warm, moist air; therefore if your refrigerator maintains a low temperature and dry air, you have removed two of the conditions under which food spoils.

Field Research:

Visit a store that sells a standard make of refrigerators and have the clerk explain its good points. The store may have a model of the side wall that you can study to learn how it is insulated.

249. Care of the Refrigerator. — The refrigerator ought to be kept very clean at all times and so its lining should be smooth, waterproof, and not easily stained. Enamel or porcelain lining is best. The inside of the refrigerator may be kept clean and "sweet" by frequently washing it with a cloth, dampened by a solution of washing soda. The surface should then be wiped clean with clear water. Scouring powders should not be used because the tiny scratches fill with dirt and are difficult to clean.

Field Research:

Study the refrigerator in your own home to find out whether it is satisfactory; that is, if constructed to permit good air circulation. Does it keep a temperature below 50° F. in the warmest part? Is the lining such that it can be thoroughly cleansed? Are the foods placed in the proper location in the refrigerator? Are foods allowed to cool off before they are put in the refrigerator? How does this affect the ice bill?

250. Care of Foods in the Home. — Your knowledge of the causes of the spoiling of fresh foods teaches you that the conservation of the food requires that it be given immediate attention. Milk bottles should be cleaned on the outside and placed in the refrigerator as soon as possible after delivery. At no time should milk be allowed to get warm unless you wish it to sour quickly.

Guarding against Food Spoilage

Meats also should be cleaned, if necessary, and placed in the refrigerator until needed for cooking. The meat should be kept covered to prevent drying. Green vegetables should be cleaned and wrapped in paper or placed in covered pails or jars in the refrigerator. They will then keep fresh and crisp.

General Problem 5. Why Is Food Protection Health Protection?

251. Pure Foods and Drugs. — Milk is one food that needs especial care because it is a splendid substance in which to encourage the growth of germs. Typhoid fever occurring in the family of a careless milk producer has been transmitted to other families where milk from his dairy has been distributed.

While milk and water are especially suited to distribute contagious diseases, other foods such as vegetables and meats may do so, too. Therefore, all foods for human or animal consumption should be carefully guarded against germs. Meat markets, grocery stores, delicatessen shops, and all other food stores should be required to observe sanitary regulations.

Not only are foods, including milk, required by law to be protected against flies and dirt and disease, but they must meet certain standards determined by the United States Pure Food and Drug Acts. Canned

A City Food Inspector
What service does this man perform?

foods must have labels which tell the weight of the contents and the names of any preservatives used.

Drugs and medicines must also meet standards established by the United States Pure Food and Drug Acts. All drugs are dangerous except as prescribed by a physician. Some drugs, such as narcotics, are so dangerous that druggists are not allowed to sell them without a doctor's prescription. All patent medicines must have a proper label stating the contents in case of dangerous drugs. Headache medicines, especially, are to be avoided because of the harmful drugs they are likely to contain.

Laws pertaining to foods and drugs are for the protection of the health of the people who cannot always be sure what a food or drug may contain, or what it may do. Alcohol and other narcotics are especially dangerous drugs, and their use is regulated by law. You are familiar with the effects of alcohol used in excess.

Field Research:

Pour a little medicinal alcohol on some white of egg. What happens?

Alcohol takes water out of delicate tissues and affects them somewhat as it affects the white of an egg.

Alcohol and other narcotics are habit-forming drugs and so should be used only on the advice of competent physicians.

252. The Health Department. — The health of the community is particularly the problem of its Department of Health and the chief health officer. This department is responsible for proper safeguards of the milk and water supply, the sewage and garbage disposal, sanitary stores and markets, and clean streets. It must be constantly on the alert to prevent the spread of disease from any source. The Health Department needs your coöperation in upholding its ideals and enforcing the laws of the country, state, and town.

Key Words

alcohol	compost	energy
annual	conduction	freezing
bacteria	conductor	germs
circulation	convection	heat transfer
cold storage	drugs	humidity

insulate
membrane
mildews
mirror
molds
molecule
non-conductor
osmosis
pasteurize
preservative
pressure
radiant
radiation
refrigerator
sanitary code
science
temperature
typhoid fever
vacuum
ventilation

Key Statements

1. The problem of food storage involves proper ventilation, proper temperature, proper humidity, and fresh quality of product to be stored.

2. The preservation of fresh foods for long periods depends upon killing bacteria and molds, and upon sealing to prevent entrance of additional organisms.

3. Foods may also be preserved by drying, smoking, or by the addition of substances that will destroy germs and molds and prevent more from growing.

4. The construction of efficient refrigerators depends upon a knowledge and an application of the principles of heat transfer.

5. Conduction is the transfer of heat from molecule to molecule of a substance. Conduction occurs most commonly in solids.

6. Heat is transferred by conduction more readily by some solids than by others.

7. Convection is the transfer of heat from one point to another by the movement of the heat-bearing molecules. Convection currents are due to unequal heating and occur most commonly in liquids and gases.

8. Hot bodies (usually solids) give off radiant energy. Their heat energy thus is changed to radiant energy. Hence the body cools off.

9. Radiant energy goes in straight lines and is changed back to heat energy, when it is stopped and absorbed by another body. It can be reflected the same as light.

10. Refrigerators are cool because the melting ice absorbs heat from the air. Ice cannot melt if there is no heat for it to absorb.

11. Only pure foods and drugs are sold in a healthful city.

12. In a healthful city, stores are sanitary and their foods are protected from dust, flies, and handling.

13. The laws pertaining to alcohol and other narcotics are observed in a healthful city.

14. Your health department is chiefly responsible for the health of your community, but you must do your part.

Thought Questions

1. Why do the problems of conservation involve science and economics?

2. What additional problem is involved in the conservation of foods?

3. Why can fruits be kept without freezing at a temperature of 32° F. or slightly below, while potatoes will freeze at 32° F.?

4. Why is the humidity of the air a problem in the construction of cold storage rooms?

5. In canning fruit or vegetables, why is it important to seal the can?

6. What are the conditions favorable to the growth of bacteria and fungi?

7. Explain why drying a food helps to preserve it.

8. What is a molecule?

9. Why will foods keep longer in cold air than in warm?

10. Explain the construction of the walls of a good refrigerator. What determines the efficiency of the refrigerator?

11. Where should a food having an odor be placed in a refrigerator? Why?

12. Why is 50° F. the maximum air temperature of a good refrigerator?

13. In markets you have seen refrigerating pipes in the counters. What makes them become covered with ice?

14. How is the preservation of food related to your health?

15. How are garbage and sewage disposal projects related to your health?

16. Why should streets be kept clean?

17. Why are laws pertaining to foods and drugs necessary?

18. Why is the production and distribution of milk especially a health problem?

19. Why should foods in stores be protected against flies and from handling?

20. What can you do to coöperate in maintaining a healthful city?

Projects for Your Science Discovery Book

1. Visit a cold storage plant and write an account of your observations. Tell what foods you saw and how the temperatures were controlled.

2. Visit a first-class dairy to find out how milk is handled and report your observations.

3. Make a report on the relation of moisture to the spoiling of foods.

4. Make a collection of labels from canned foods to find which ones contain special preservatives. Note what substance is used and how much.

5. Make a diagram of a heater in a room and indicate by arrows the direction in which the air will circulate.

6. Make a study of refrigerators and make a diagram of an efficient refrigerator wall.

7. If you can help with the canning at home, discuss the various methods used in canning.

8. Obtain samples of dried foods and experiment with them to learn how much water they will absorb.

SURVEY OF TOPIC XVII

Ewing Galloway

Back in kindergarten days someone always looked out for you to see that you ate proper food and wore proper clothing. Now that you are growing up, these responsibilities are more or less yours. To keep dry in wet weather, warm in cold weather; to eat enough of the right kinds of food and not too much of the wrong kinds; to take care of minor cuts and bruises have all become your job.

The whole world of manufacturing and advertising to-day has entered into a conspiracy to make us take care of ourselves, whether we want to or not. They offer the brightest, most colorful umbrellas and raincoats for rainy days; warm ski togs and plaid lumbermen jackets for winter sports. The foods we should eat are put up in attractive packages that tempt us to buy, and magazines and newspapers publish enticing menus for wholesome meals.

It is fashionable to be well and strong and healthy. Science keeps pace with changing conditions and forever points the way. If you accept the help that science gives, you will certainly be on the road of happy living.

TOPIC XVII

HEALTH CONSERVATION

The year's at the spring,
And day's at the morn;
Morning's at seven;
The hillside's dew-pearled;
The lark's on the wing;
The snail's on the thorn;
God's in his heaven —
All's right with the world!

— BROWNING

Do you know:

1. How your health is related to the change of seasons?

2. Why some people get a cold more frequently than others during weather changes?

3. How water and its contents affect your health?

4. How your health is safeguarded through sanitation?

5. What to eat to keep well?

GENERAL PROBLEM 1. HOW DO YOU ADAPT YOURSELF TO NATURAL CONDITIONS?

253. Adaptations to Changing Seasons. — You know how the plants and animals, anticipating winter, provide food and energy for the season. Man, too, must adapt his habits to such changes. He lays up food for the winter and adapts his home to withstand the cold of winter, the wind and rains of spring, and the heat of summer. By adaptations of his home, of clothing, and regulation of his diet, man protects and conserves his health. The careless, unthinking person who does not understand the need for adaptations does not provide for health conservation.

254. Adaptations to Changing Weather. — With indications of approaching weather changes you provide for rain, for wind, for snow, or for heat. Your provision seeks to protect your body against the weather changes that might otherwise influence your health.

A Sudden Shower

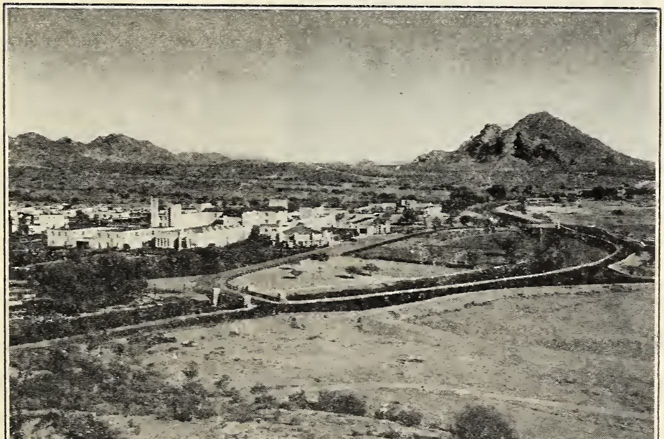
Even plants and animals take account of the weather for their well-being. Birds oil their feathers against rain and leaves close their pores as a protection of the plant water supply in dry weather.

In summer, light-colored clothing reflects more of the sun's energy than dark colors, and so helps to protect the body against overheating. Garments of cotton and silk permit the body to cool off better than woolen garments do.

Rubbers protect the feet during wet weather. In these and many other ways you can adapt your customs and daily habits to changing weather.

255. Adaptation to Water Supply. — In desert countries, drinking water is more precious than food. Indeed it may be more vital to health and to life itself than any other of our environmental factors. The

An Adaptation to a Dry Spell



Ewing Galloway

An Adaptation to Climate

In the high, dry climate of Arizona a desert playground has blossomed.

Indians made their trails to pass springs and streams of pure water. You have learned that the pioneers traveled first along the water courses, and that cities and industries have grown up near adequate water supplies. Man has always adapted his living to his need for water. He goes where water is, or spends millions of dollars to bring the water where he can use it to better advantage.

With increasing population, the crowding of people in cities, and the development of varied industries, Nature's methods of providing water, safe for drinking, have proved inadequate. Therefore, man again must make adaptation to an impure, unsafe water supply by providing great water purification plants. Science has pointed out the dangers that may lurk even in bright, sparkling water, and science has found the means to purify the water and safeguard your health. The conquest of disease is in a very large measure dependent upon the scientific purification of water. Many, many lives have been saved by the purification of water.

General Problem 2. What Adaptations Do You Make to Man-Made Conditions?

256. Adaptations to the Need for Sanitation. — Neglect, filth, and disease follow one another with terrible certainty. With disease comes suffering and loss of life. What a glorious chapter in science it is that tells us how to prevent that suffering!

The great Pasteur first pointed out the way to avoid the dangers of contagious disease, — every man, woman, and child owes him gratitude. Scientific men from the time of Pasteur on have added and are still adding to our knowledge of the prevention of disease.

Field Research:

Who in your town even now is working that you may have better health? Report on his activities.

Man builds his cities, his factories, schools, and homes, with careful provision for cleanliness. Clean streets, sewage and garbage disposal plants, smokeless chimneys, and parks are all signs of his adaptations to the need for sanitation.

Louis Pasteur

To what was his life devoted?

You have the knowledge to enable you to understand the need for sanitation. Apply that knowledge to your personal habits. As a scientist in the making, you should have confidence in your scientific discoveries. If you have this confidence, you will observe the laws of health; you will keep your body clean, your teeth clean, your hair and nails clean, your clothes clean, and with it all you will keep your mind clean.

257. Adaptation to Food Supply. — If you eat to satisfy an uncontrolled appetite, you will suffer. If you eat so as to produce growth, to maintain bodily vigor, and to develop mental strength, you will conserve your health and be able to do your full share of the world's work. Through your science studies you have learned how food is produced and how it is safeguarded and preserved. You have also learned something of the relation of food to health. You know that your diet must contain a proper balance of foods to furnish

Ewing Galloway

AN ADAPTATION TO FOOD SUPPLY

A ration of frozen fish seems to satisfy these Eskimos.

energy to your body and to furnish materials for the repair of worn-out cells and the building of new ones.

If you could compare your ordinary diet with that of boys and girls living near the Arctic Circle, or with those living near the sea in the region of the equator, you would find each group adapting its eating habits to the temperature of its environment. A man at hard, outdoor labor adapts his eating habits to the need of strenuous exercise, while an office worker must make adaptations to a life of moderate exercise.

General Problem 3. What Adaptations Can You Make to Safety and First Aid?

258. Accidents in the Home. — Every day, everywhere, accidents of one kind or another are occurring. Some are serious accidents, resulting in broken bones, asphyxiation (ăs-fĭk′sĭ-ā′shŭn), blood poisoning, and

Courtesy National Safety Council

A Too Young Tailor

How many hazards do you see?

even death. Others are minor accidents such as sprains, bruises, burns, or cuts. Accidents, whether big or little, are due to two causes: carelessness and misjudgment. Thoughtfulness will prevent those due to carelessness, and education will help to prevent the others.

Industry for a number of years has conducted a successful campaign to lessen accidents due to the carelessness of its workers. It is just as true in the home as in industry that accidents do not prevent themselves. Something has to be done about them. So if we are to prevent the many accidents that occur in the home (and they are far greater in number than you would suppose), we must know something about them, about what causes them, and then do something about them.

259. Kinds of Accidents. — In the home, accidents fall into several groups:

1. Those caused by falls from chairs or steps; on rugs that slip, or have worn places in them; over tools and playthings left in unexpected places; in slippery bathtubs; or in badly lighted places.

2. Those caused by burns or scalds from carelessness about stoves, heaters, worn-out electric cords, and cleaning fluids.

3. Those caused by asphyxiation from carelessness about open gas jets, leaky gas pipes, defective furnaces, gas and oil stoves, and air-tight garages.

4. Those caused by poisons and firearms from failure to label the poisons properly and to put both poisons and firearms out of reach of children.

5. Those caused by shock from handling electrical fixtures with wet hands.

6. Cuts caused by the careless use of sharp tools, broken glass, and so on.

260. First Aid for Accidents. — Broken bones, dislocated joints, sprains, and bruises result from falls. Bruises should be treated with disinfectants to prevent infection of any kind, for even the slightest bruise is a danger spot, particularly if the skin is broken. (Why?)

Broken bones and dislocated joints require the immediate attention of a physician. You should make the patient as comfortable as you can, where he fell. Moving him may make the fracture worse. Relieve the injured member from strain by protecting it from being jarred. Do not try to treat the patient in any other way, except by administering hot drinks in case of nervous shock.

Applying First Aid

Why do you think knowledge of First Aid is part of a Scout's training?

Strains and sprains should be tightly bandaged and treated with cold, wet applications (not ice) until the doctor comes.

Burns and scalds may be treated with oils, baking soda, or limewater. These relieve the pain and protect the spot from the air. Beware of infection. Blisters should not be broken. Severe burns require the advice of a physician.

Asphyxiation occurs from the shutting off of oxygen to the blood supply. Fresh air and artificial respiration should be given until the doctor arrives.

Poisoning is treated in various ways, according to the kind of poison taken. Labels on the bottles usually give the "antidote" or directions for treatment. A gunshot wound needs a physician's care.

Shock from electricity or lightning may be treated with artificial respiration.

Cuts are of two kinds: small, surface cuts which can be safely treated with a disinfectant, and deep, ugly cuts where a vein or an artery is severed. **Call a doctor at once** if a vein or artery is cut. These cuts will bleed heavily, the blood from an artery flowing in spurts and from a vein in a slow, steady stream. The bleeding in both cases must be stopped. Pressure applied between the wound and the heart in the case of a cut artery, and on the side of the wound away from the heart in the case of a cut vein will stop the flow of blood.

An Adaptation to Accident Prevention

Wayside signs like these caution the automobile driver to exercise care.

With a very bad cut, a tourniquet is sometimes applied. Because of the danger of blood poisoning, it should not be used until all other measures fail. It is a tight bandage, with a lump in it to press on the cut vein or artery, which can be twisted or untwisted at will. The tourniquet should be loosened a little every few minutes to permit some circulation of the blood.

261. Accidents Outside the Home. — Outside the home, accidents occur on the playgrounds, in the streets, in street cars, automobiles, and other moving vehicles, and in burning buildings. Whenever an accident occurs, do the sensible thing. Make the patient comfortable, send for a doctor, apply first aid if possible, and **keep your head.**

262. Prevention of Accidents. — If you are to make adaptations to safety against accidents successful, you should remember two things: that accidents do not just *happen*, and that most of them can be prevented. Make up your mind that, beginning today, you will try to prevent accidents in your home by observing the following rules:

Remove all hazards which might result in falls

Keep sharp knives in racks, scissors in sheaths

Take precautions to leave a door or window open where gas or oil stoves are burning or where an automobile engine is running

Label all poison bottles, keep them tightly covered, and located in places where they cannot be reached without a light at night-time

Never use gasoline in the house for cleaning

Throw away defective electric cords

263. Conclusion. — Our whole life is thus made up of adaptations to our environment. But our environment, you have discovered, is ever-changing. Therefore, if we are to progress, we must continually accommodate our habits and customs to meet the changes in environment. Most of these changes, the natural ones, have proceeded in an orderly manner. New changes will occur in a like orderly way and science will help us to make our adjustments in a correspondingly orderly fashion.

Your studies have helped you to discover, understand, and apply great laws of Nature for the better-ment of yourself, your family, and your community. With intelligent application of these laws, you will be able to control and use the factors of your environment to the continued progress of man. You will adapt yourself to your environment in such a way that your life will be as full of happiness, good health, and useful service as it is possible for a human life to be.

Courtesy Netherlands Railways

Adaptation to Environment

How many adaptations do you see ?

Key Words

accidents	contagious disease	laws of health
artery	diet	sanitation
asphyxiation	disinfectant	shock
blood poisoning	eating habits	sprains
burns	exercise	tourniquet
conquest of disease	food balance	vein
conservation	fracture	weather changes

Key Statements

1. Man adapts himself to changing seasons by changes in his shelter, clothing, and food.

2. In adapting himself to changes in weather man seeks to conserve his health.

3. Man's oldest and most important adaptation is to his need for water.

4. Increasing populations and crowded cities have made it necessary for man to make adaptation to impure and unsafe water supplies.

5. Scientists are constantly adding to our knowledge of the prevention of disease.

6. Science teaches the need for sanitation; thus community and personal hygiene become of great importance.

7. Over-eating results in suffering.

8. You must adapt your eating habits to the temperature of your environment and to the kind of life you lead.

9. Accidents in the home are often serious and are altogether too frequent.

10. Accidents are due to two causes, carelessness and misjudgment.

11. A knowledge of "first aid" is of value in the treatment of accidents until a doctor arrives.

12. Most accidents can be prevented.

13. Life is made up of adaptations to a constantly changing environment.

14. By intelligently applying the laws of Nature you can control and use the factors of your environment to the continued progress of man.

15. Proper adaptation to your environment means a life of happiness, good health, and useful service.

Thought Questions

1. How have added comforts in the home brought about a change in man's adaptation to weather and climate?

2. What effect will science's new discovery, air conditioning, have on adaptation to weather?

3. What branches of science have aided us in the purification of our water supply?

4. Where are epidemics of contagious diseases likely to start? Why?

5. Why are habits of personal cleanliness necessary to your well-being?

6. Why is variety in a diet necessary?

7. Do you think that accident insurance is a good kind of protection? Why?

8. Why should you know something about first aid?

9. What can you do to help prevent accidents in your home?

10. Why is our environment constantly changing?

Projects for Your Science Discovery Book

1. Write an account of your own adaptations to the change of seasons and tell how your knowledge of Nature's laws helps you to make these adjustments.

2. How can you use your knowledge of the cause and predictions of weather so as to adjust yourself to Nature's ways and thus retain your health?

3. Draw up a list of items which would make a good Code of Safety for your household.

4. Make a list of simple remedies to be kept in the medicine closet and explain the use of each and why you included it.

A Scientist and His Assistants Attempt to Solve Some Problems of Life under Seas

SPECIAL PROBLEMS

Topic 1

1. Read the story of some constellation and then rewrite it in your own words. Tell whether you think the story is truth or superstition.

2. If possible, get someone to let you look at Venus through a telescope.

3. Look up the biography of one of the great astronomers: Johann Kepler, Pierre Simon LaPlace, Copernicus, Galileo.

Topic 2

1. If a telescope or field glass is available, ask someone to show you the nebular in Andromeda.

2. With the help of your teacher and a small telescope, try to observe Jupiter or Saturn.

3. Try to identify the Pleiades with the naked eye. If you have someone with you, find out which of you can see the greater number of stars of the Pleiades.

Topic 3

1. On a piece of paper draw the position of a planet in relation to the brighter stars about it and check its position from week to week, indicating each time the new position of the planet. Do you find that the position of the planet changes among the stars?

2. Show how the work of Galileo and that of Newton were endeavors to find the truth.

3. Look up and read American Indian legends relating to the sun and planets.

4. Investigate, through library references, theories concerning life on Mars.

Topic 4

1. Darken the room, and with your flashlight and an old tennis ball, with a knitting needle stuck through it to represent the earth on its axis, demonstrate how rotation causes day and night.

2. Look at your calendar to find the date when the spring equinox occurs.

3. Do you regulate and conduct the affairs of your life as dependably as Nature does hers? Describe some things in Nature that are good examples for you to follow.

4. Using graph paper, plot the time of the rising and setting of the sun for a month. Start with the longest or shortest day of the year or one of the two days when day and night are equal. You may wish to make the

record for a whole year. An almanac will give you the time of rising and setting of the sun.

5. Using graph paper, plot the time of the rising and setting of the moon for a month.

6. Study the phases of the moon for a month and make a record of the relative positions of sun, moon, and earth for each phase.

Topic 5

1. To determine the true north from the sun, set up a stake about four feet tall where the ground is level. Make sure the stake is exactly vertical. When the sun shadow of the stake is shortest, the shadow is pointing due north.

2. Having determined the true north by the sun's shadow, compare with it the magnetic north direction as indicated by a compass. About how many degrees from the true north is the magnetic north?

3. Learn to determine the north and south direction, using a watch and the sun's shadow. Hold the watch in a horizontal position so that the hour hand points toward the sun; that is, so that it is in line with the sun's shadow made by a match or slender stick held exactly vertical.

When the watch is in this position, the north and south direction is a line which bisects the angle between the hour hand and the figure twelve.

4. Make a sun dial in a sunny place on your lawn and learn to tell time by it.

5. Learn how to tell the time by the stars.

6. Captain Kingsford-Smith on his successful non-stop flight from Oakland, California, to Honolulu sent

the following radio message:[1] "Position 32.35° north latitude, 132.05 west longitude." Locate this position on your map. This message was received at 1:43 P.M. Pacific coast time. At 9:50 P.M. he gave his position as "latitude 30.02 north, longitude 140 west." Locate this position on your map and measure the air line distance between the two places. From the difference in time calculate the speed of his airplane.

Topic 6

1. Make a list of the weather superstitions with which you are familiar.

2. Write an account of how the birds and animals prepare for winter. Library references will help you with this topic.

3. Make a rainbow by spraying water into the air when the sun shines. Remember the spray must be viewed from a particular angle.

4. Collect as many weather statements as possible relating to rings, rainbows, and other light appearances and examine each statement to determine whether or not it has any foundation in facts.

Topic 7

1. Write an account of some recent flights into the stratosphere.

2. Make an air thermometer and compare it with a house thermometer.

3. Make a mercury thermometer.

4. Using Magdeburg hemispheres and an exhaust air pump, prove that the atmosphere exerts a pressure.

5. Make an anemometer.

[1] As reported in the Rochester *Times-Union*, June 1, 1928.

6. Make a wind vane.

7. Make a hygrometer and use it to determine the relative humidity of the air.

8. Find out why water is not a suitable liquid to use in a barometer.

9. To show air pressure, place a pint of water in a gallon tin can and heat the water to boiling so that the steam will drive out most of the air. Discontinue the heat and close the opening of the can so that it is air tight. Pour cold water over the can to condense the steam. What happens? Explain.

Topic 8

1. Investigate the artificial lightning experiments carried on by the General Electric Company at Pittsfield, Massachusetts.

2. Explain why sometimes in the winter you get a discharge of electricity on touching another person who has just walked across a rug or carpet.

3. Prepare a class report on the various climates of the world, including a discussion of their effects on civilization.

Topic 9

1. At night sink a shallow glass dish in the earth so that the top is level with the surface of the soil. Fill it with water. It should be located where the sun will shine on it next morning.

Early in the morning place one thermometer in the dish of water and stick one in the soil near it.

Note the temperatures of each and after the sun has shone on them for two hours, again note the temperatures. Explain your observations.

2. Put two shallow dishes of water out overnight in a place where they will receive sunlight in the morning. In the early morning place a thermometer in each and cover one with a white cloth and one with a black cloth. Note the temperatures at the beginning and at the end of one hour of the sun's heating. Explain your discoveries.

3. Determine the relation between wind direction and air temperature.

4. Make a study of four different industries to determine their dependence on the weather.

5. Study the effect of weather and climate on six leading crops.

6. Find out how it happens that many fruits, flowers, and vegetables can be grown successfully north of the Arctic circle, in spite of the very short growing season of that region. *Hint:* Consider the influence of sunlight on plant growth; also, the varying lengths of day and night in the Arctic region.

Group or Class Project:

Form a weather study club and arrange a contest to find out each month which member is the best weather forecaster.

Topic 10

1. Report on the part water has played in the development of your own home town.

2. Carefully weigh exactly one quart of water and calculate the weight of one cubic foot of water (one quart equals 57.7 cu. in.).

3. Determine the boiling point of carbon tetrachloride.

4. Place ice with a little water in one beaker, and ice with a little water and some salt in another beaker. Determine the temperature of each after a few minutes. Does this explain why salt and ice are used in freezing ice cream?

Topic 11

1. Would a spring be likely to have a greater force of flow if the opening were near the water table or below it? If a well is dug or drilled for some depth below the water table, how high do you think the water would stand in the well? Explain your answers.

2. If you have a leaking faucet at home, place a pint jar or measuring glass under the drip. Note the time. Keep track of the jar and note the time when it becomes full. From your data calculate how much water (gallons) leaks from that faucet in 24 hours. How many gallons would this be in 3 months (the usual period for a water bill)? What does the waste cost you?

3. Learn all you can about the dangers of getting typhoid fever from drinking polluted well or spring water. Find out the facts about vaccination against typhoid. Ask your doctor for information.

4. Measure the pressure of water at a water faucet.

5. Learn to read a water meter and calculate your water bill.

6. Find out how many days water would be available for your town if the source were cut off.

7. Find out the area of the watershed of your water supply source. Is it adequate?

8. Construct a model of a community water supply system.

Topic 12

1. Take a sample of soap (in its wrapper) recommended for a special use to class for further investigation.

2. Make a collection of as many samples of tooth pastes and powders as you are able. Read the labels and advertising material that comes with them. Criticize the statements in the light of your knowledge. Are all the claims just, do you think? Is each paste or powder safe to use?

3. Investigate the traps about school. Are they all of the same kind? Do they all work in essentially the same way? Compare them with the traps at home. Are they different? Illustrate each kind of trap.

4. Make some soft soap.

5. Make an emulsion using salad oil, egg yolk, vinegar, and lemon juice. Which is the emulsifying agent?

6. Compare the hardness of samples of water from two sources, using a soap solution as the testing agent.

7. Help someone work a laundry machine to discover how it saves the clothes and labor.

Group or Class Project:

Make a collection of all the brands of washing powders and water softeners available in your community.

Study the labels to determine what claims are made for each product, and then decide by experimenting and by your knowledge of the facts about such materials, whether or not the claims are valid.

Weigh the contents of each package and from the price of the package and its weight calculate the cost per ounce of each. Try to account for the differences in cost. Compare the cost per ounce with that of washing soda.

Topic 13

1. Design a good garbage container and make one if you have access to a sheet metal shop.

2. Visit a community swimming pool and tell just what you think are its advantages to community life. Have you any criticisms of it?

3. Locate breeding places of flies and start a community campaign to eliminate them.

Group or Class Project:

Organize a trip to a near-by sewage disposal plant. As you inspect it and ask questions of the attendant, keep in mind the fundamental principles of sewage decomposition. Take notes and make a report of your trip.

Topic 14

1. Learn to recognize "stands" of wheat, oats, rye, barley, and buckwheat.

2. Find out what is meant by certified seed.

3. In your garden, keep a part of one row well worked, and neglect a similar part for one week. Compare the two rows as to moisture retained, growth of plants, and growth of weeds.

4. Try placing black building paper between some of the rows of your garden. What happens?

5. Start corn, wheat, and bean seedlings in the laboratory, and then transfer them to water solutions

(see Appendix) containing in one case all needed minerals, and in the other case no nitrogen, phosphorus, or calcium.

6. Help to care for the plants in the school and on the school grounds.

7. Organize a garden club and plan for landscaping a yard belonging to some one of your homes.

8. Try making green wood-cuttings.

9. Try propagating a plant by grafting or budding.

10. Visit a commercial rose garden to observe the method of budding and rose culture.

11. Make observations of the opening of a flower, and follow the progress until seeds are formed.

Topic 15

1. Learn to identify garden and lawn weeds. How can they be controlled?

2. Learn to identify ragweed, goldenrod, and poison ivy. How can they be destroyed?

3. Make a study of the life history of a sucking insect, a biting insect, and a root eater. How can each be controlled?

4. Find out how the eggs of some aphids are cared for by certain ants and how the ants are paid for their care.

5. Learn to identify three helpful insects. How can they be protected?

6. Visit near-by farms, and try to find examples of apple- or pear-tree blight, or black rot on the cabbage or turnip. Learn what the farmer does to control the diseases. If you find diseased material, go back again with your teacher, taking along several petri dishes

with prepared culture medium. Dust materials of the diseased plant on to the petri dishes. Keep one dish closed for a control. Take the dishes back to school and incubate them for 24 hours at 37° C.

7. Learn how to use spraying and dusting materials for the control of insects, plant disease, and fungi.

8. Go to the library for information about the Australian lady-bird beetle and how it helped to control the cottony-cushion scale of California. Try to find out about other beetles and their work. The squash lady-bird beetle and the bean lady-bird beetle are harmful. Find pictures of them so that you may know these two beetles when you see them.

9. Find a specimen of ichneumon fly and observe its actions.

10. Visit someone who keeps honey-bees and study the bee's methods of work and living.

11. Make a bird house and place it where a bird will use it.

12. Make a bird bath.

13. Plan for a winter feeding station for birds.

14. Make a collection of the flowers of fruit trees to discover which parts, if any, are missing from each flower, making cross-pollination necessary.

15. Look up the story of the Passenger Pigeon, now extinct. Do you think other valuable birds may become extinct if they are not protected? Explain.

Group or Class Project:

Make a bird house census of your neighborhood early in the spring. Start a campaign to have more bird houses put up. During the nesting season, canvas the houses to find how many pairs of each kind of birds have taken the homes. Keep a record of all data. Perhaps two or more neighborhoods may have a contest to see which can attract the largest number of nesting pairs.

Topic 16

1. By visiting a fruit store, determine good methods of packing fruit.
2. Study the cold pack method of preserving vegetables.
3. Study the effect of low temperature on the keeping of apples, by selecting two apples nearly alike and placing one in the refrigerator and one in the kitchen. Examine them from day to day for at least two weeks.
4. Build an ice box, insulating it properly. Test its efficiency.
5. Determine the temperatures and humidity of the air in a refrigerator.
6. Devise and work an experiment to illustrate the conduction of heat.
7. Devise and work an experiment to illustrate convection currents.
8. Make a trip to your city health department to learn about its activities.
9. Make up a score card for a healthful city and score your city to find how its health may be improved.

Group or Class Project:

Obtain a copy of the Sanitary Code of your city or state. Become familiar with it and then inspect markets, groceries, milk houses, and the like to find out whether they are meeting the requirements. Discuss your findings in class.

Topic 17

1. Read about the great Roman aqueducts to find out why they were built. How do we know so much about them?

2. Look up the life of Pasteur and find out just what his contributions to the service of mankind were.

3. Find out about other men who have devoted themselves to making it possible for us to lead healthier lives.

4. Find out what sort of tests for First Aid girl and boy scouts have to pass.

5. Make a chart for a family safety drive, or for a "No Accident This Month" campaign. Perhaps your family will coöperate in actually keeping it for a month.

6. Read in a biology about blood circulation to discover why a cut artery spurts blood and a cut vein lets out the blood in an even flow.

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:[1]

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.

Bring old flower pots to the laboratory.

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.[2]

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 references to the time of rising, setting, and the position of the planets are suggestive only. Current star maps should be consulted.

[2] 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?

Watch for frosts. Protect tender plants in the home garden.

Plant snapdragons in the plant laboratory for winter flowering.

Visit a well-cared-for and a poorly-cared-for orchard to discover the advantages of scientific spraying.

Visit a truck garden to learn what vegetables are harvested during this month.

Plan a home garden.

Write to the Department of Agriculture, Washington, D. C., or your local Farm Bureau for pamphlets relating to landscaping.

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 about 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. Cutting soil should be all sand. Potting soil for the rooted cuttings 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.

It is better to transplant garden perennials in the fall than in the spring.

Wood pewees 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.

Order bulbs for a bulb sale. Arrange with your florist to supply ferns.

Get calla bulbs and pot them for the plant laboratory. (*Godfrey* is a good variety.)

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.

Water all potted bulbs frequently.

Make most of your geranium cuttings; use plants that are full of flowers to produce early blooming.

Visit a farm and learn how farm products are sold, where they are shipped, and why.

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.

Make a survey of the industries of your town. Which ones are basic industries? Why?

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.

Fumigate the plant laboratory, using nicofume powder.

Conduct bulb and fern sale.

Darwin tulip bulbs may be planted five inches deep. They will take longer to bloom if planted six inches deep.

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 Cassiopeia. 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, Cassiopeia, and Pegasus.

Winter birds are here. Put out suet and grain for them.

Make a collection of organic and inorganic materials.

Control temperatures and ventilation in the plant laboratory. Prevent plants from being chilled at night.

In the plant laboratory start seeds of baby primrose.

On your way to school make a mental note of all the different kinds of machines you see doing work.

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.

For Easter bloom, pot tulip bulbs now.

If hydrangea plants can be obtained, root planting may be made.

Green wood cuttings should be started from roses, forsythia, and hydrangeas.

Perennials, shrubs, and small trees can be transplanted safely.

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	Ironwood
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).

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 partridges berries are waiting for Mr. Bobwhite.

Put out food for birds.

Begin to clear up the flower garden.

Dig canna, gladiolus, and dahlia bulbs.

Bulbs and tubers should be dry for storing.

Gather winter vegetables from the garden. Store root crops.

Examine a vacuum cleaner to discover what causes the vacuum.

Second Week

Shrikes have come from the north.

Pegasus is a prominent constellation high up in the southern sky.

When is the sun nearest the earth? When is the highest tide?

Be on the lookout evenings for "shooting stars." What are they?

Transplant hardy roses.

Choose one industry of your town for a thorough investigation. Try to find out its principal products. Are they necessities or luxuries?

Find out how fruit jars are sealed.

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.

Visit a fire house and find out why the engine has a force pump.

Referring further to your selected industry, find out what raw materials are needed for its purposes. Are they produced locally or elsewhere? How is the industry affected by weather conditions?

What trees still retain their leaves?

Locate a place where you can hear an echo. Explain what causes it.

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, *e.g.*, 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.

Bulbs potted in September should be brought into the heat gradually for Christmas flowering.

Again visit a farm to discover what treatment the farmer has given the fields that are to be planted next spring.

What Is Diphtheria Antitoxin?

From September Rochester Health Bulletin

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 in its body of its own making to protect him against diphtheria.

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.

Compare compass north with the true north.

Find out how to tell time by the stars.

Keep the bird free lunch counter well supplied.

Make weather observations relating to the first cold spell. List weather factors noted.

What manufactured materials are used by your industry? Where are they made?

From the newspaper learn the wholesale and retail prices of three main farm products. In what way, if any, are the prices related to weather conditions at the time of planting or harvesting?

Second Week

Take trips to commercial greenhouses.

Make more stem cuttings.

Identify four kinds of clouds. Do they indicate anything about the weather?

Observe the effect of lack of sun on plant growth. Explain.

Investigate the heating plant in your house. How does the heat from the fuel get to the rooms?

Investigate the system used for heating and ventilating the plant laboratory.

Third Week

The shortest day of the year is about December 21. Explain.

Look for a blue jay.

The nuthatches are hunting their food in the bark of trees. Do they work up or down the trunk and in or out along the branches?

What wind direction occurs with cold spells?

Make a study of the kind of power used by your industry.

Fourth Week

Make a Christmas Day bird census.

Easter lily bulbs should be started for forcing.

All the potted narcissus bulbs should be brought into the conservatory to prevent freezing and a portion of the hyacinths should be brought in.

"Bedding Plants," *e.g.*, 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.

Take a walk in the parks or woods during vacation. Observe trees, birds, and small animals. If there is snow on the ground, observe bird and animal tracks.

JANUARY

First Week

Note from newspaper, almanac, or observations, the time of sunrise and sunset, one day each week.

Venus rises about what time? Is it visible just before daylight in the east? Is Venus the morning star now?

Saturn rises at what time? Is it visible just before daylight? Is Saturn the morning star now?

Jupiter sets about what time? Where is it visible after dark? Is Jupiter the evening star now?

Locate the constellation Ursa Major (Big Dipper) and the Polar Star. 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 N. E. U. S.*)

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 near-by stars and make as accurate a drawing as possible of their positions. Preserve the drawing in your Science Discovery Book. Always record the time and date of your observation.

Identify the constellation Cassiopeia. 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, daffodils, jonquils.

Send for seed catalogues.

Fourth Week

Observe direction and velocity of winds.

Observe temperature and sky conditions at 8 A.M. each morning. Learn to read a hygrometer.

Form a Weather Forecasters' Club.

Have you seen a winter bird other than the English sparrow this month? Bobwhites, partridges, tree sparrows, chickadees, pheasants, downy woodpeckers, and crows may be seen.

Start verbena seeds.

Plant gladioli in the plant laboratory. Bring in a few white hyacinths and early tulips.

Determine the natural resources of your locality. Is your industry developing any natural resources?

Take note of the time it takes for the sound to reach you after you see steam from a whistle.

Test your ears, one at a time, by comparing your hearing for outdoor sounds with that of another person.

Observe three methods by which heat is transferred or distributed.

FEBRUARY

First Week

The sun rises and sets at what hours? Compare with January 1.

Note the horizon position of the setting sun each week for four weeks.

Venus rises at what time? When and where is it visible?

Saturn sets 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 schoolroom. 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).

Bring in a few more bulbs. Put them in a warm, dark place until the tips have developed and the buds show.

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 near-by 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.

Visit the commercial greenhouse again. Many things of interest are happening.

Start cannas in sphagnum moss.

Make a study of the power used in your industry.

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?

Visit your local Health Bureau. How are its activities related to your health?

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: tulips, hyacinths, crocus. Keep dark and cool until they begin to show green.

Fourth Week

Make nest boxes.

Find and study a 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.*)

Sow seeds for early asters.

How and where are the products of your industry marketed?

Visit a large cold storage plant to learn what farm products of the previous harvest are still on hand.

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.

You have been observing Orion. Has it changed its position in the sky? Why?

Continue weather observations and records.

Try to discover the date of the latest killing frost.

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.

What are the by-products and waste products of your industry? How are they utilized?

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 sparrows and purple grackles may be seen.

Sow seeds in boxes for early transplanting: peppers, celery, cabbage, and melons.

The spring equinox occurs about 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-winged 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.

Determine the reasons for the location of your industry in your town.

Investigate a water storage dam to learn how it is constructed. Is it likely to withstand spring floods?

Observe how a fireplace draws. Learn how to construct a fireplace and chimney that will not smoke.

Make plans to observe Arbor Day.

APRIL

First Week

The sun rises and sets at what hours? Compare with previous observations.

Determine temperatures in the sun and in a shadow. What difference do you observe? Explain.

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, and 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.

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 thrushes may come back this week.

Woodpeckers, partridges, and crows are here.

Red maples are blossoming. Shadbush is in flower. (Latitude of New York.)

Begin making plans for Bird Day.

Sow asters, zinnias, calendulas, cosmos, verbenas, and snapdragons.

Determine some of the fundamental science laws which are applied in your industry. Are they in the main physical, chemical, or biological principles?

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 sized 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.)

Watch for maple and elm tree blossoms. Are the bees flying now? Where do you find them?

Begin making plans for Arbor Day.

Pull up weeds.

Make window boxes and hanging baskets.

Observe the difference in shadows made by electric lights and by the sun.

MAY

First Week

Compare the times of rising and setting of the sun with those of previous months.

Observe weather factors related to the first warm spell.

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.

Observe the colors of shadows produced by different light sources.

Visit a telephone office.

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.

Write to the Department of Agriculture, Washington, D. C., for pamphlets relating to the care of the garden.

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.

Have you observed a thunderstorm this spring? Describe the weather factors preceding and following it.

Make a collection of samples of different varieties of woods. Examine the cross sections with a magnifier.

Observe auto headlights on a foggy evening. What does your observation prove to be true about light rays?

Test your eyes (one at a time) by comparing what you can see outdoors with what another person can see.

Fourth Week

Violets are blossoming in the meadows and woods.

Baby robins leave their nests. *Watch the cat.*

In your library read an account of the life and work of a great scientist.

Visit a water power plant.

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 rosebushes, 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.

Make a list of foods which you eat in one day. Group them according to whether they produce an acid or alkaline effect in the body. Which ones have good mineral content?

Second Week

Kingfishers may be laying their eggs.

Barn swallows are nesting.

Pheasants are nesting in the fields.

Note outdoor evidences that the sun's energy causes chemical changes.

Third Week

June 21 — Summer solstice about June 21. What does it mean?

Promethea moths come out of cocoon.

Lady's-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*, and 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	42	39	**78**
79	96	91	87	83	79	75	71	68	64	60	57	53	50	47	43	40	**79**

NUTRIENT SOLUTION FOR PLANT GROWTH

The following solution contains the necessary minerals for plant growth. For testing, make three solutions as follows:

1. Containing all minerals
2. Containing all minerals except potassium nitrate
3. Containing all minerals except calcium sulfate. Compare growth of seedlings in each of the three solutions and in distilled water.

Water (distilled)	2 quarts
Sodium chloride (table salt)	$\frac{1}{32}$ oz.
Calcium sulfate	$\frac{1}{32}$ oz.
Magnesium sulfate	$\frac{1}{32}$ oz.
Calcium phosphate	$\frac{1}{32}$ oz.
Potassium nitrate (saltpeter)	$\frac{1}{16}$ oz.

Add one drop of a dilute solution of iron chloride.

COMPARISON OF BOILING POINTS OF WATER, ATMOSPHERIC PRESSURE, AND ALTITUDE[1]

Boiling Points of Water	Barometer Readings Inches of Mercury	Approximate Altitudes in Feet
200° F.	23.45	6650
201° F.	23.94	6070
202° F.	24.44	5510
203° F.	24.95	4950
204° F.	25.46	4390
205° F.	25.99	3830
206° F.	26.52	3280
207° F.	27.06	2730
208° F.	27.62	2170
209° F.	28.18	1620
210° F.	28.75	1080
211° F.	29.33	530
212° F.	29.92	Sea Level 0
213° F.	30.52	− 550

[1] Taylor Instrument Co. calculations.

TABLE OF MELTING AND BOILING POINTS OF COMMON SUBSTANCES[1]

Substance	Melting Point	Boiling Point
Alcohol (ethyl)	− 179° F.	172° F.
Butter fat	100°–107° F.	
Carbon tetrachloride	− 10° F.	214° F.
Crisco	71°–87° F.	
Lard	104°–116° F.	
Paraffin	122°–131° F.	
Tallow	109°–114° F.	
Aluminum	1216° F.	3272° F.
Brass	1652° F.	
Bronze	1922° F.	
Copper	1981° F.	
Gold	1945° F.	4698° F.
Iron	2786° F.	4442° F.
Lead	620° F.	2777° F.
Mercury	− 37° F.	675° F.
Nickel	2645° F.	
Phosphorus (Yellow)	111° F.	554° F.
Sodium chloride	1473° F.	2627° F.
Sulfur	235° F.	833° F.
Water	32° F.	212° F.
Zinc	786° F.	1706° F.

[1] *Chemical Annual*, Olson. D. Van Nostrand Co.

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GLOSSARY

Many of the following words were selected and defined by a committee of Rochester science teachers under the chairmanship of Miss M. Elizabeth Tuttle. The list was then submitted to many other science teachers for criticisms and corrections. To these teachers the authors are grateful for the use of the list.

How to define and use necessary technical words in such a way that they will be understood by pupils of junior high school age and yet not violate the need for scientific accuracy is a problem the teacher must face. How the problem has been solved tentatively by the above committee for the eighth-grade level is indicated by the meanings given here. Needless to say, this list is not exhaustive. Neither should it be used as a memoriter teaching device.

acid — a substance which has a sour taste and turns blue litmus red.

adaptation — fitness to live in a particular place or to do a certain thing.

aeration — the process of putting air into water or soil.

air pressure (*atmospheric*) — the pressure exerted by air against objects due to its weight.

alcohol (*grain*) — a liquid having narcotic properties; used in some thermometers, and as a solvent.

algae — simple forms of plant life sometimes found in water.

alkali — a substance which has a slippery feeling and a bitter taste, and turns red litmus blue.

altitude — distance above sea level; in astronomy, the angular distance of a star above the horizon.

ammonia (*household*) — a solution of ammonium hydroxide in water.

anemometer — an instrument used to measure the speed of the wind (velocity of air currents).

annuals — plants that complete their life cycle of growth, reproduction, and death within a single year or season.

anther — the part of the flower which produces the pollen.

anticyclone — (as seen from above in the northern hemisphere) a *clockwise*-whirling mass of air having a high air pressure area.

apparatus — the materials used in carrying on experiments.

area of high pressure — an anticyclone area.
area of low pressure — the center portion of a cyclonic storm.
atmosphere — the gases surrounding the earth.
atmospheric pressure — air pressure; 14.7 lbs. to the square inch at sea level.
axis — a line about which a body turns.
bacteria — plants too small to be seen with the naked eye; one-celled plants.
balance — an instrument for accurate weighing.
barometer — an instrument which measures changes in atmospheric pressure.
  aneroid — a barometer without liquid.
  mercurial — a barometer in which mercury is used.
beetles — insects having armor-like wings.
Big Dipper — a portion of the constellation Ursa Major, in the form of a dipper, in the northern sky. It is called Big to distinguish it from a similar but smaller constellation.
blue vitriol — copper sulfate; a solution sometimes used to kill algae in water, and as an ingredient of spray materials for the control of insects.
boiling point — the temperature to which a liquid must be heated to cause it to change rapidly to a gas (this temperature is constant for each pure liquid).
borax — a white alkaline powder often used for softening water.
budding — propagating plants by inserting a bud into the growing part of the stem of another plant.
bulb — a special stem structure in which food is stored by a plant to start the growth the next season.
burdock — a weed.
capillarity — the lifting of certain liquids by means of small, tube-like spaces.
carbohydrates — sugar, starch, and cellulose compounds made of carbon, hydrogen, and oxygen.
carbon tetrachloride — a non-combustible liquid commonly used for cleaning cloth and putting out fire and sold under various trade names.
Cassiopeia — a constellation forming a "W" in the northern sky. In certain positions it appears inverted.
cause and effect — a cause is a happening that always precedes

another happening (the effect) and without which the second happening could not occur.

caustic soda — sodium hydroxide; an alkaline substance used in making soap.

celestial — referring to the heavens, the apparent sky sphere.

centigrade — a thermometric scale divided into one hundred divisions between the freezing temperature and the boiling temperature of water.

centripetal force — a force drawing a body toward the center about which it revolves.

cesspool — an underground tank with drain, for the disposal of sewage.

characteristics — the features which distinguish one substance from another and by which we recognize it.

chemically pure — the condition of a substance when it contains no foreign material.

chloride of lime — a white powder containing chlorine and used both to kill germs and as a deodorizer.

chlorination — putting chlorine into a water supply for the purpose of killing bacteria.

chlorine — a greenish-yellow gas or liquid, sometimes used to destroy germs.

chlorophyll — green coloring matter of leaves and bark.

chronometer — a ship's clock.

circle — a line all points of which are at equal distances from the center.

cirrus — a feathery cloud, high above the earth.

clinical thermometer — a fever thermometer.

cloud — a visible mass of fog some distance above the earth's surface.

cumulus — a cloud having a rounded or dome-shaped top.

nimbus — a storm cloud.

storm — those clouds which have a dark gray appearance and bring rain or snow.

thunder — dark cumulus clouds which give rise to thunder storms.

cocoon — a nest-like covering in which a larva rests while changing its form.

codling moth — an insect whose larva is best known as the "worm" in the apple.

cold wave — a period of continued cold weather.

compass — a magnetic needle free to swing above a dial with the directions marked on it.

compost — a heap of decomposing (decaying) vegetable matter.

compound — a substance composed of two or more elements chemically combined.

condensation — the process by which a gas is changed to the liquid form.

condenser — a piece of apparatus used to cool a gas and so change it to a liquid.

conduction — the transfer of heat through solids from particle to particle.

conductor (electrical) — a metal rod that transmits electricity efficiently.

conduit — a pipe used to conduct water from its source to a reservoir.

constellation — a group (configuration) of prominent stars.

contamination — making food or water unfit to be taken into the body.

contract — to draw together ; to occupy less space because of cooling.

convection — the transfer of heat by the movement of gases and liquids.

corona — a ring of colored light appearing close around the sun or moon.

cotyledon — the part of a seed which contains the food needed to start the new plant.

cross-pollination — the transfer of pollen from one flower to the pistil of another.

cutting — a part of the stem of a plant which can be made to develop roots.

cutworm — an insect larva which eats stems of young plants.

cyclone — (as seen from above in the northern hemisphere) a *counter-clockwise*-whirling mass of air having a low air pressure at the center.

declination — angular distance in degrees north or south of the celestial equator.

decompose — to break up by some form of decay or chemical action.

degree — one three-hundred-sixtieth of a circle, also degree of heat.

density — the closeness or compactness of the particles composing a substance.

dentine — bone-like substance of a tooth just inside the enamel.

deposit — sediment.
dew — moisture which collects on the surface of cool bodies.
diameter — the distance through the center of a body.
dilution — the addition of large quantities of a liquid such as water to a solution to make it more dilute.
diphtheria — a contagious bacterial disease attacking the throat, appendix.
disinfectant — a chemical substance used to kill germs or to render them harmless.
disposal — getting rid of material such as wastes of various kinds, *e.g.*, sewage, garbage.
dissolve — to cause a substance to be equally distributed throughout a liquid, so that it will not settle out and cannot be separated by filtering; *e.g.*, oxygen, sugar, or salt dissolved in water.
drainage area — all land drained by a river system.
Earth — the third planet in the solar system.
eclipse — the cutting off of the light from a lighted body.
effluent — the liquid products of treated sewage.
electric charge — a quantity of electricity on a body.
electricity — a form of energy.
element — a substance which cannot be separated into simpler substances by ordinary chemical means.
ellipse — an oval figure with both ends alike.
elliptical — shaped like an ellipse.
emulsion — a liquid mixture containing small fat particles equally distributed throughout.
enamel — the hard outer covering of the teeth.
energy — the ability to do work; manifest as heat, light, electricity, and mechanical and chemical energy.
epidermis — the outer layer of the skin.
equator — an imaginary great circle about the earth, midway between the poles.
equinox — time of equal day and night all over the earth.
evaporation — to change from liquid to gas; the process by which a liquid is changed to a gas.
expand — to grow larger in volume or size; to take up more space.
Fahrenheit — a thermometer scale divided into 180 divisions between the freezing temperature and boiling temperature of water.

fat — a greasy, easily melted or liquid compound, found in animal and vegetable tissues.

faucet — the part of the plumbing that controls the flow of water from pipes.

fertilization — the second step in plant reproduction, consisting of the union of the nucleus of a pollen grain with the nucleus of an ovule (egg cell).

fertilizer — a substance used to enrich the soil to improve plant growth.

filter — a device used for straining out undissolved materials from liquids.

flats — shallow boxes filled with soil in which seeds can be started indoors.

flushing — washing out waste by means of a flow of water.

fog — fine drops of water visible in the atmosphere near the earth.

freeze — to change from a liquid to a solid state.

freezing point — the temperature at which a liquid changes to the solid state.

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.

fungus — a kind of plant which gets its food from other organic material. Because it contains no chlorophyll, it cannot make its own food as do the green plants.

galaxy — an astronomical system made up of vast numbers of suns.

garbage — food waste from the kitchen.

gas — a form of matter which has no definite shape and no definite volume; *e.g.*, air, hydrogen.

sewer — gas arising from the decaying matter in a sewer.

gasoline — an inflammable, volatile liquid used as fuel and as a solvent.

germ — a one-celled plant or animal.

germinate — to start to grow.

gills — organs needed to enable fish, tadpoles, and similar animals to get oxygen from water.

glands, sweat — glands in the skin which secrete sweat (perspiration).

glycerine — a by-product of soap making.

grafting — to propagate plants by inserting a piece of the stem of one plant into the growing layer of another plant.

gravitation — the attraction that every body has for every other body in the universe.
gravity, force of — the attraction or pull between the earth and other objects.
gravity pressure — the pressure exerted by any substance due to its weight (or to the force of gravity).
gravity system — a method of obtaining a water supply from a higher source by means of the force of gravity.
grease — fats and oils.
Greenwich — a city, near London, England; the prime meridian passes through it.
grubs — larvae of some insects.
hail — ice globules built up of ice layers deposited on a frozen raindrop.
halo — a ring of light similar to a corona but appearing farther away from the sun or moon.
hardness, permanent — hardness of water due to the presence of dissolved minerals that cannot be removed by boiling.
hardness, temporary — hardness of water due to the presence of dissolved minerals that may be removed by boiling.
hard water — contains minerals in solution which combine with soap and retard the formation of suds.
heat capacity — the quantity of heat which a definite quantity of a given substance can absorb before it changes its temperature one degree.
hemisphere — half a sphere.
hibernate — to pass the winter season in a state of sleep or near sleep.
horizon — the line where the sky and earth seem to meet.
hot wave — a period of continuing hot weather.
house fly — the fly most common in and about houses.
humidity — the invisible gaseous moisture in the air.
relative — the ratio of the amount of moisture in the air to the amount needed to saturate the air at a given temperature.
hydrogen — the lightest known gas; a combustible gas.
hygrometer — an instrument for measuring the relative humidity of the air.
ichneumon fly — a useful insect.
illuminate — to light up or make visible by reflected light.
impurities — substances not belonging in (foreign to) the substance where they occur, *e.g.*, minerals dissolved in water.

insoluble — impurities which are not dissolved.
soluble — impurities found in a dissolved state.

incinerator — a special firebox or oven in which to burn garbage and rubbish.

inclination — the tipping of the earth's axis toward the plane of its orbit.

insect — a small animal that lives in various stages and has six legs at the final stage.

insect pests — insects of such habits and occurring in such abundance that they are harmful to man.

insoluble — not capable of being dissolved in a particular liquid. (No substance is absolutely insoluble. The terms *soluble* and *insoluble* are relative.)

insulate — to prevent the transfer of heat (or electricity).

iron, galvanized — iron (sheet or wire) coated with zinc.

irrigation — artificial watering of land by means of ditches, sprinkling pipes, etc.

isobar — a line drawn on a weather map through places having the same barometric reading (air pressure) at a given time.

isotherm — a line drawn on a weather map through places having the same thermometer reading (temperature) at a given time.

Jupiter — the fifth and largest planet.

lady-bird beetle (sometimes called lady-bug) — a useful insect which helps to control the cottony-cushion scale of California.

land breeze — a breeze moving from the land toward the water.

larva — the second stage of development in many insects; *e.g.*, caterpillar, grub, maggot.

latitude — distance in degrees north or south of the equator.

life history — the history of any organism (living thing) from the beginning to the end of its life.

lightning — a discharge of electricity between two or more clouds or between clouds and objects on the earth.

lightning rod — a metal rod that attracts and conducts to the ground any lightning charges which may strike in the near vicinity of the building to which it is attached.

light year — the distance that light travels in a year (about six trillion miles).

lime — a common name for substances (calcium bicarbonate or calcium sulfate) that cause hardness in water.

liquid — a substance which takes the form of the containing vessel and fills a definite part of it. One of the three states of matter, *e.g.*, water, mercury.

litmus — a chemical substance used for detecting acids and alkalies; it turns red in acid and blue in alkali.

longitude — distance in degrees east or west of the prime meridian.

magnet — a piece of iron that can attract other iron.

magnitude — in the astronomical sense magnitude means relative brightness of the stars.

Mars — the fourth planet; earth's second nearest planet neighbor.

matter, inorganic — that which has never had life.

matter, organic — that which forms a part of, or has come from, living things.

melting point — the temperature at which a solid changes to the liquid state.

mercury (*quicksilver*) — a heavy, silver-white, liquid metal.

Mercury — the smallest planet and nearest the sun.

meridian — any great circle about the earth which passes through both poles.

migrate — to move from one locality or place of living to another.

mildew — a variety of fungus.

Milky Way — a luminous band encircling the heavens, composed of many stars so distant that they are separately invisible to the naked eye.

mineral — inorganic matter of which rocks and soil are composed, usually occurring as crystals.

molar — a tooth adapted for grinding, located at the back of the jaw.

mold (*bread*) — a variety of fungus.

molecule — a very tiny particle of matter.

moon — a satellite of the earth.

mulching — covering surface soil with a layer of dust, humus, dead leaves, straw or paper, in order to break up capillary spaces or to protect plant roots.

negative — in the electrical sense, having relatively low potential.

Neptune — the planet second farthest from the sun; not visible to the naked eye.

nitrify — to produce nitrogen compounds as in the case of certain bacteria on plants.

non-conductor — a substance that prevents to a considerable extent the transfer of heat (or electricity).

node — the part of a stem from which a bud grows.

noon — the exact time at which the sun passes across the zenith meridian of a given place.

North Star (*pole star*) — the star toward which the north end of the axis of the earth points.

nucleus — the center of development of a cell.

oil — a liquid fat usually of vegetable origin.

oil, kerosene — an inflammable liquid sometimes used as fuel, obtained from petroleum by distillation.

orbit — the path of a planet or other body around the sun or other heavenly body.

organism — any living thing.

Orion — a constellation.

osmosis — the process by which liquids or gases pass through a membrane and become mixed.

ovary — the seed case of a flower.

oxidize — to combine with oxygen as in burning, rusting, decaying.

oxygen — the active gas which makes up about 21% by volume of the air.

parallels — circles about the earth running east and west, parallel with the earth's equator.

parasite — an organism which gets its food from other living things, living within or upon it.

pasteurize — to heat a food (milk) to 145° F. for thirty minutes to destroy bacteria.

perennials — plants that form flowers and seeds year after year.

perspiration (*sweat*) — water, containing other substances, given out by sweat glands.

phases of the moon — the different forms that the lighted half of the moon appears to have during each month.

pistil — the part of a flower which receives the pollen.

plane — a level surface.

planet — a heavenly body shining by reflected light and revolving about the sun.

plumbing — the pipes, traps, etc., which carry fresh water into a house and waste water out.

Pluto — farthest known planet from the sun.

Pointers — two stars of the Big Dipper that are in line with the North Star.

polar regions — regions near the north pole and the south pole.

pollen — cells formed in the anthers of flowers and necessary for fertilization.

polluted — made impure; capable of producing sickness.

positive — in the electrical sense, having relatively high potential.

potential — stored-up electrical energy, similar to water pressure.

precipitation — moisture falling from the clouds or separating from the air; *e.g.*, rain, snow, sleet, hail, fog, frost, dew; or solids separating from solution.

predict — to foretell; to tell what is likely to happen.

preservative — a substance added in small quantities to food to keep it from spoiling for a time.

pressure (*air*). See *atmospheric pressure*.

prime meridian — the meridian which passes through Greenwich.

propagation — producing new plants or animals.

property — a characteristic of a substance which helps one to recognize it.

pumping system — the method of obtaining a water supply from a source by means of force pumps.

pupa — the resting stage of an insect before it becomes an adult.

pure — containing no foreign or other material.

radiant — energy as heat or light, given off in all directions from a highly heated body.

radiation — sending out energy (heat or light) in all directions from a body.

rain — drops of water falling from clouds.

rainbow — an arch of light, showing the colors of the spectrum.

rain gauge — an instrument to measure the amount of rainfall or snowfall.

rays — imaginary lines representing the direction or motion of energy (heat or light).

reduce — to separate certain parts of a compound in order to obtain some desired product; *e.g.*, fertilizer from garbage by removal of fats. — (in chemistry) to remove oxygen from a compound.

reflect — to turn something back, as a body turns back, reflects, light or heat directed against it.

reproduction — the process by which plants and animals produce offspring.

reservoir — a large tank or basin where water or other material is stored.

retort — ovens in which coal or wood or other substances can be heated without burning, to drive off gases.

revolution — the movement of a body in its orbit traveling around another body.

right ascension — degrees east of a celestial prime meridian.

rotation — the turning of the earth or some other body on its axis.

sanitation — the scientific control of conditions required to produce healthful surroundings.

saturated — the condition of a substance when it can hold or absorb no more of another substance; *e.g.*, a sponge filled with water; air filled with moisture.

Saturn — the sixth planet; the planet with rings.

sea breeze — a breeze moving from the sea towards the land.

season — a division of the year, as determined by the earth's position with respect to the sun.

seed — a ripened ovule which will produce a new plant if placed under suitable conditions.

septic tank — a tank containing sewage in which bacteria are allowed to decompose the organic matter.

sequence — events or happenings following one another in a regular order, as cause and effect.

sewage — water containing wastes from the body.

sextant — an instrument used to determine when the sun crosses the zenith meridian of a place.

sidereal day — a twenty-four-hour day as measured by reference to a star.

sleet — very small, frozen raindrops.

sludge — sediment from sewage.

snow — ice crystals formed from frozen water vapor.

soap — a chemical compound made from an alkali and a fat.

sodium hydroxide. See *caustic soda.*

solar system — the sun and the planets as well as about one thousand smaller, invisible bodies.

solar time — time measured by reference to the sun.

solid — a form of matter that holds its shape under ordinary conditions.

soluble — capable of being dissolved in water or other liquids.

solute — a dissolved substance.

solution — a clear even mixture of a soluble substance and its solvent. (See *dissolve*.)

solvent — a liquid or gas which is able to dissolve another substance; *e.g.*, alcohol is a solvent.

sperm cell — male reproduction cell.

sphere — a solid object on whose surface all points are at equal distance from the center.

spring — the season between winter and summer; underground water appearing in a stream at the surface.

stars — other suns like ours generating (producing) their own light.

storm — an atmospheric disturbance, usually accompanied by rain, or snow, or hail, and wind.

storm area — cyclone area — a "low."

storm paths — the route followed by a storm area, cyclone.

sucking insects — a class of insects whose mouth parts are adapted for sucking liquids from plants or animals.

suns — stars.

superstition — belief in happenings having supernatural explanations, or coincident relations instead of scientific cause and effect.

telescope — an instrument for magnifying distant objects such as ships at sea, or stars.

tellurian — a device to demonstrate the motions of the earth and its moon.

temperature — the degree of heat of a substance.

thermometer — an instrument to measure the temperature.

thunder — the report following a lightning discharge.

tide — the raising and lowering of ocean water due to the attraction between the earth and the sun and moon.

time, standard — the clock time for a time zone.

time zone — a belt (region) of the earth, running north and south, using the same clock time throughout.

toad — a small animal having a warty skin and living on insects found in gardens and fields.

tornado — a storm with very high wind.

torrid (*tropical*) *zone* — the part of the earth between the tropics of Cancer and Capricorn.

transplanting — transfer of a plant from one position to another.

trap — a U or S bend in a waste pipe of a plumbing system, provided to prevent entrance of sewer gases into the room from which the pipe serves as a waste outlet.

twilight — diffused light between sundown and darkness.

typhoid fever — a contagious disease attacking the digestive system (intestines), and commonly spread through water or milk, or by the house fly.

universe — the great system of galaxies.

unsanitary — not healthful.

Uranus — the seventh planet; not visible to the naked eye.

velocity — speed.

Venus — the second planet in distance from the sun; the Earth's sister planet.

vernal — belonging to springtime.

volatile — easily changing to a gas when exposed to the atmosphere.

volume — the size of anything, the space (room) it occupies.

warts — small growths formed on and rooted in the skin.

washing soda — sodium carbonate — used to soften water for household and industrial uses.

water — a compound of hydrogen and oxygen.

water cycle — the circulation of water in nature through the processes of evaporation, condensation, and precipitation.

water, distilled — pure water obtained by the process of distillation (evaporation and condensation).

water, hard — water containing a large amount of dissolved minerals such as sulfates and bicarbonates of calcium and magnesium.

water pressure — the force of water exerted against objects due to its weight, or pressure of water caused by mechanical means.

water, soft — water containing little hardness-causing minerals.

water table — the level or surface of underground water.

weather — the condition of the atmosphere for any part of the country at a given time.

weather factors — conditions which make up the weather; *i.e.*, precipitation, temperature, humidity, wind velocity and direction, condition of the sky, and atmospheric pressure.

weather map — a map upon which weather factors at United States Weather Stations are indicated for a given hour of the day.
weather vane — an instrument for indicating the direction from which the wind is blowing.
well — a hole dug deep enough to obtain water or oil.
wind — air in motion.
zenith — the point in the sky directly overhead.
zinc — a bluish-white metal, used to coat iron to prevent rusting.

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OUR ENVIRONMENT
Clemens Gretter

HOW WE ADAPT OURSELVES